THE EFFECT OF LAW CHANGES ON THE MATCH PROFILE OF INTERNATIONAL AND NATIONAL RUGBY UNION BETWEEN 2007 AND 2013

Wilbur Julio Kraak

Dissertation presented in fulfilment of the requirements for the degree

Doctor of Philosophy in Sport Science

in the Department of Sport Science, Faculty of Education

at

Stellenbosch University

Promoter: Doctor Ranel Venter

Co-promoter: Professor Frederik Coetzee

December 2015

DECLARATION

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated), and that I have not previously submitted it in its entirety or in part for obtaining any qualification.

The co-authors of the three articles that form part of this dissertation, Dr Ranel Venter (promoter) and Prof Frederik Coetzee (co-promoter), hereby give permission to the candidate, Mr Wilbur Kraak, to include the three articles as part of a PhD dissertation. The contribution (advice and support) of the co-authors was kept within reasonable limits, thereby enabling the candidate to submit this dissertation for examination purposes. This dissertation therefore serves as fulfilment of the requirements for the degree Doctor of Philosophy at Stellenbosch University.

_____

Mr Wilbur Kraak

_____ _____

Dr Ranel Venter Prof Frederik Coetzee

ACKNOWLEDGEMENTS

I would like to express my appreciation and gratitude to the following people who contributed towards this study:

- Firstly to our Heavenly Father, thank you for walking this road with me, for without you I am nothing.
- To my wife, thank you so much for your love and support throughout this journey. It has been tough, but I believe it has been worth it.
- To my big boy Wilrique, thank you for being my inspiration and reason for waking up each morning.
- To my parents, sister, Caitlin, Lirah and Larah and family, thank you for supporting and always believing in me.
- Ranel, thank you so much for your guidance, belief in me and personal support, and for allowing me to do it my way.
- Dok Derik, thank you for always believing in me and supporting me. I enjoyed the rugby chats and motivation.
- Shaun Owen, Heinrich Painczyk, Bradley Nel and Simon de Waal for your assistance in data capturing.
- Prof Martin Kidd statistician at Stellenbosch University, for your time and assistance.
- Mr Carel du Plessis and Mr Jaco van der Westhuizen of Fika for providing me with the match videos and software support.
- Dr Kallie van Deventer for assisting with the technical requirements of the dissertation.
- All the coaches, referees and players for your time with the interviews.
- To all my family, friends and colleagues, thank you for your advice and support in everything I have done. It has meant the world to me.

DEDICATION

This dissertation is dedicated to my grandfather, my biggest role model.

You have always kept me strong and never stopped believing in me. You have continuously supported me throughout my studies.

"Dit is belangrik om te weet waarheen jy oppad is, maar selfs meer belangrik om te weet waarvandaan jy kom."

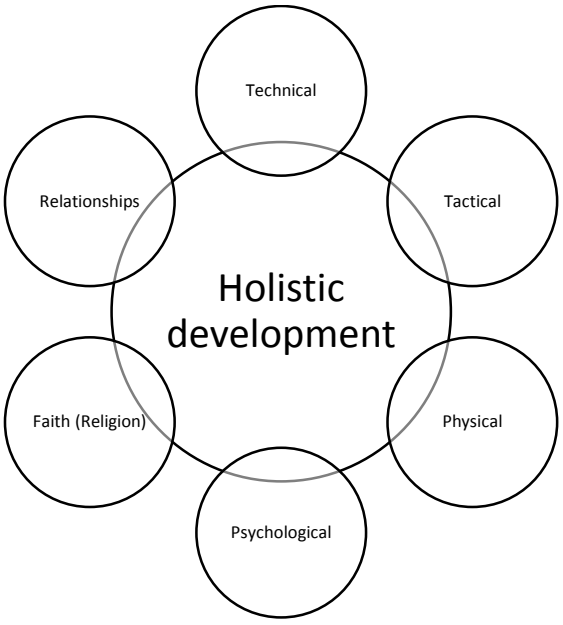
Willie Kraak

PREFACE: PERSONAL JOURNEY

This section is dedicated to my personal growth as a coach. The journey to the completion of my PhD has led me to meeting great coaches, referees and players from whom I have learnt a lot – not just about improving as a coach, but also about improving as a human being.

I need to mention certain individuals who have made a huge impact on me as a coach during this journey. Firstly, Eugene (Loffie) Eloff for showing me that rugby is not always about winning trophies but more importantly is about being honest at all times and building special relationships with players and fellow-coaches, no matter what their race, religion or cultural background. Thank you for becoming a mentor to me, not just as a coach but also in my personal life. Secondly, Peter de Villiers for assuring me of the importance of one's faith and the role it plays in the forming of successful teams and individuals.

Based on the experience and knowledge gained through this journey I have adapted my holistic approach towards building successful people, rugby players and teams.



This has been an incredible and worthwhile journey.

VENI VIDI IVI – *I came. I saw. I went.*

Wilbur Kraak

December 2015

SUMMARY

Rugby union has changed continually since the inception of professionalism in 1995. For example, to increase the appeal, continuity and safety of the game several law changes were introduced after the 2007 Rugby World Cup. The primary aim of this study was to determine the impact of these law changes on selected performance indicators on the match profile of international rugby union between 2007 and 2013 and national rugby union between 2008 and 2013. To this end, three specific objectives were set. The first was to compare the scoring profile of international rugby between 2007 and 2013. The second was to compare the changes in the general match profile of international rugby and the third was to compare the scoring and general match profile of Super Rugby between 2008 and 2013. The study followed a mixed-method study design for data collection. A total of 248 international and 646 national matches were recorded by the Fika Coding Centre and analyzed by the researcher using the Fairplay video analysis software package. Semi-structured interviews were conducted with 30 international- and national-level coaches, referees, specialist coaches and players.The year 2007 was used as baseline for international matches and 2008 for national matches in order to compare and track the changes over the different years.

Results indicate that law changes over the years have indeed had an influence on the profile of international and national rugby. The scoring profile of international rugby revealed a significant increase in the number of penalty kicks ($p<0.01$). With regard to the origin of tries, there was a decrease in the number of tries from structured play (47 to 43%) and an increase from turnover possession (27 to 43%). The duration of the international matches increased owing to the increase in the number of stoppages, mainly as a result of greater use being made of the Television Match Official (TMO), substitutions and on-field concussion tests. There was a small practical significant increase in total match time ($d=0.34$), and a moderate increase in ball-in-play time ($d=0.87$). Results of the study show that the profile of international rugby has changed to a more continuous game dynamic with a moderate practical significant increase in the number of passes ($d=0.73$), large ball carries ($d=1.22$) and tackle breaks ($d=2.03$), and a very large increase in line breaks ($d=3.00$), which has led to a moderate increase in the number of tackles ($d=0.65$). The number of rucks ($d=0.86$), mauls ($d=0.90$) and scrums ($d=1.03$), scrum resets ($d=0.74$) and line-outs ($d=0.61$) showed a moderate

practical significant decrease. Both penalty kicks (d=0.98) and free kicks (d=1.22) decreased significantly.

The scoring profile of national rugby indicated fewer tries (p<0.01), conversion kicks (p<0.01) and significantly more penalty kicks (p<0.01). The duration of national matches decreased due to fewer stoppages, mainly thanks to the improved skill level of the players. There was a small practical significant decrease in total match time (d=0.41). The ball-in-play time (d=0.91) showed a moderate practical significant decrease. Results of the study show that the profile of national rugby has changed to a game with more contact situations, with a small practical significant increase in the number of passes (d=0.43), a large practical significant increase in the number of ball carries (d=1.34), tackle breaks (d=1.59) and line breaks (d=2.40), and has led to a moderate practical significant increase in the number of tackles (d=0.63). A large practical significant decrease in the number of rucks (d=1.73) and scrum resets (d=1.36) was found. A moderate practical significant increase in penalty kicks (d=2.04) and a moderate practical significant decrease in free kicks (d=4.53) between 2008 and 2013 were observed.

By analyzing the scoring and match profile of international and national rugby, coaches and trainers could be better informed in order to develop training programmes that are specific to the technical, tactical and physical demands of modern rugby. Based on the findings of this study, coaches and trainers should develop individual and team performance profiles to better understand the demands experienced by the players and teams. This type of information could assist with implementing more specific periodization models, strategic planning, drill design, recovery strategies and planning of training loads.

Keywords: *Law changes; Performance indicators; Performance profiles; Set pieces; General play*

OPSOMMING

Met die koms van professionalisme in rugby het die spel sedert 1995 vinnig en aanhoudend verander. Een van hierdie veranderinge was verskeie reëlveranderings wat ná die 2007 Rugby Wêreldbekertoernooi ingestel is om die aantreklikheid, kontinuïteit en veiligheid van die spel te verhoog. Die primêre doel van hierdie studie was om die impak van reëlveranderinge op die wedstrydprofiel van internasionale rugby tussen 2007 en 2013 en nasionale rugby tussen tussen 2008 en 2013 te bepaal. Vir hierdie doel is drie doelwitte gestel. Die eerste was om die profiel van puntetoekenning van internasionale rugby tussen 2007 en 2013 te vergelyk. Die tweede was om die veranderinge in die algemene wedstrydprofiel van internasionale rugby te vergelyk en die derde was om die puntetoekenning en die algemene wedstrydprofiel van Super Rugby tussen 2008 en 2013 te vergelyk. Die huidige studie het 'n studie-ontwerp met gemengde metodes vir data-insameling gebruik. Altesaam 248 internasionale en 646 nasionale wedstryde is deur die Fika Coding Centre opgeneem en deur die navorser met behulp van die Fairplay video-ontledingsprogrammatuur ontleed. Die jaar 2007 is as basislyn vir internasionale en 2008 vir nasionale wedstryde gebruik om veranderinge oor die verskillende jare te vergelyk.

Die resultate toon dat reëlveranderinge oor die jare heen 'n beduidende impak op die profiel van internasionale en nasionale rugby gehad het. Die tellingprofiel van internasionale rugby het 'n afname getoon in die aantal drieë gedruk (p=0.07). Die oorsprong van die drieë toon dat daar 'n afname in drieë vanuit gestruktureerde spel (47 tot 43%) en 'n toename vanaf omgekeerde balbesit (27 tot 43%) was. Die tydsduur van die internasionale wedstryde het toegeneem as gevolg van die toename in die aantal spelonderbrekings, hoofsaaklik as gevolg van die groter impak van die televisiewedstrydskeidsregter (TWS), plaasvervangers en konkussietoetse wat op die veld uitgevoer word. Dit kom duidelik na vore in die beduidende toename in totale wedstrydtyd (d=0.34) en bal-in-spel-tyd (d=87). Die resultate van die huidige studie toon dat die profiel van internasionale rugby meer na 'n aaneenlopende speldinamika verander het met 'n toename in die aantal bal-draers (d=1.22), aangeë (d=0.73), laagvatbreuke (d=2.03) en lynbreuke (d=3.00), en aanleiding gegee het tot 'n toename in die aantal laagvatte (d=0.65).

Die resultate van die huidige studie toon dat die profiel van internasionale rugby na ŉ meer aaneenlopende speldinamika verander het, met ŉ toename in die aantal baldraers. ŉ Afname in die aantal losskrums (d=0.86), losgemale (d=0.90) en skrums (d=1.03), skrumhervatte (d=0.74) en lynstane (d=0.61) is aangetoon. ŉ Afname in straf- (d=0.98) én vryskoppe (d=1.22) is tussen 2007 en 2013 waargeneem.

Die tellingprofiel van nasionale rugby het ŉ afname in die aantal drieë ($p<0.01$) en doelskoppe ($p<0.01$) en ŉ beduidende toename in die aantal strafskoppe ($p<0.01$) getoon. Die tydsduur van die nasionale wedstryde het as gevolg van die afname in die aantal onderbrekings verminder, hoofsaaklik danksy minder foute deur spelers en beter vaardighede. Dit kom duidelik na vore in die beduidende afname in totale wedstrydtyd (d=0.41). Die bal-in-spel-tyd (d=0.91) toon ŉ matige afname. Die resultate van die huidige studie toon dat die profiel van nasionale rugby na ŉ meer ononderbroke speldinamika verander het, met ŉ toename in die aantal baldraers (d=1.34), aangeë (d=0.43), laagvatbreuke (d=1.59) en lynbreuke (d=2.40) en tot ŉ toename in die aantal duikslae (d=0.63) aanleiding gegee het. ‘n Beduidende afname in die aantal losskrums (d=1.73) en skrumhervatte (d=1.36) het voorgekom. ŉ Matige toename in strafskoppe (d=2.04) en ŉ matige afnamein vryskoppe (d=4.53) is tussen 2008 en 2013 waargeneem.

Deur die tellings en wedstrydprofiel van internasionale en nasionale rugby te ontleed, soos wat met hierdie proefskrif gedoen word, kan afrigters en mede-afrigters beter ingelig wees om inoefeningsprogramme te ontwikkel wat spesifiek gerig is op die tegniese, taktiese en fisieke vereistes van moderne rugby. Gegrond op die resultate van hierdie studie moet afrigters en mede-afrigters individuele en spanprestasieprofiele ontwikkel om die eise wat deur die spelers en die span ervaar word, beter te verstaan. Dit sal hulle in staat stel om meer spesifieke strategiese periodisasiemodelle, strategiese beplanning, oefeningontwerp, herstelstrategieë en die beplanning van inoefeningsladings te implementeer.

Sleutelwoorde: *Reëlveranderinge; Prestasie-aanwysers; Prestasieprofiele; Vaste fasette; Algemene spel*

TABLE OF CONTENTS

LIST OF TABLES

Chapter One

Chapter Two

Chapter Three

Chapter Four

Chapter Five

LIST OF FIGURES

Chapter Two

LIST OF ABBREVIATIONS

IRB	International Rugby Board
WR	World Rugby
PA	Performance analysis
PIs	Performance indicators
PPs	Performance profiles
ELVs	Experimental law variations
TMO	Television match official
N	Total number of matches
n	Total number of matches per year
s	Seconds
min	Minutes

APPENDICES

CHAPTER ONE

INTRODUCTION AND PROBLEM STATEMENT

Referencing within the chapter and the list of references at the end thereof has been done in accordance with the guidelines of the International Journal of Performance Analysis in Sport (Appendix A).

1.1. Introduction

Rugby union (rugby) is currently one of the most popular spectator sports and participation has grown worldwide (Williams *et al.,* 2013). Owing to rugby's increasing level of professionalism, rugby performance analysis (PA) is evolving rapidly. The science of examining the sport and participants' performance has grown quickly to meet the increasing demand for knowledge of game tactics and player characteristics (Duthie *et al*., 2003). Coaches, specialist coaches, media, administrators, referees and players are demanding greater access to more detailed analysis of team and player performance. Owing to the dynamic nature of rugby and the high frequency of events, nobody can adequately recall all aspects of the game, therefore performance analysts are playing an increasingly important role in rugby. In any kind of sport the main goal as a player or coach is to win the match. Therefore they want to be ahead of their

opponents. To always be ahead, they need to know their opponents as well as themselves and how both counterparts interact within the game.

O'Donoghue (2006) states that the primary aim of performance analysis (PA), in a coaching context, is to provide information about actual performances to assist coaches and players with their decision making. According to Hughes and Franks (2007) video analysis can be used to analyze general match, technical, tactical and biomechanical indicators. Hughes and Bartlett (2002) indicate that notational analysts are inclined to study the patterns of play by analyzing the action variables that should relate to performance. These action variables are known as performance indicators (PIs) or match profile variables and it is suggested that research should focus on the development and utilisation of PIs (Hughes and Bartlett, 2002; Jones *et al*., 2004). The development and utilisation of PIs can consequently lead to the creation of performance profiles (PPs) which, according to Jones *et al*. (2004), can be a description of a pattern of performance formed by a team or an individual profile (Hughes and Bartlett, 2002, Jones *et al*., 2004). Such profiles can lead to a better understanding of various situations and tactics implemented by teams, and offer some prediction of future performances (Jones *et al*., 2004; Robertson and Joyce, 2014). However, little research has been done on the construction of PIs and PPs for coaching purposes in rugby (Jones *et al*., 2004). Computerized notational analyses (CNA) are used to analyze PIs (Jones *et al*., 2004; Hughes and Bartlett, 2002). The major purposes of CNA are to indicate which areas or activities in a match require improvement, as well as the evaluation of players and to predict future performance (Jones *et al*., 2004; Robertson and Joyce, 2014).

Sheridan (2007) reminds us that sport consistently changes over time as a result of technological advances and/or law changes. Changes to the laws are fundamental to the development of rugby and are introduced for several reasons (Eaves *et al*., 2008; Kraak and Welman, 2014). Some of the reasons why law changes and amendments are implemented are in response to player performance, to ensure safety, enhance participation and enjoyment, promote game continuity, technological advancement and commercial pressures, as well as to retain game integrity and development (Eaves *et al*., 2008). World Rugby (WR), formally known as the International Rugby Board, is responsible for delivering safe, enjoyable and entertaining rugby events. Therefore laws provide a framework by which the WR ensures these aspects (Murray *et al*., 2008). With the advancement of technology in rugby, coaches can now scrutinise

player activities and match play (Eaves *et al*., 2008). Evaluation of the effects of these law changes on the match profile has focused on technical, tactical and physical aspects of the game.

Using CNA, Williams *et al*. (2005) and Eaves and Hughes (2003) identified the changes that occurred within the game and found that the match and ball-in-play time as well as ruck frequency increased significantly during match play. It was suggested that this was largely due to the law changes introduced over the period of the research. Van den Berg and Malan (2012) investigated whether the experimental law variations (ELVs) were effective in making rugby matches more appealing to spectators by improving continuity. They analyzed Super Rugby from 2006 to 2008 and found that the number of scrums (d=0.94) and line-outs (d=2.18) had decreased but that the number of tackles made (d=0.97), metres gained (d=1.09) and penalties conceded (d=0.86) had increased significantly. The study by Van den Berg and Malan (2012) revealed no change in the number of tries scored. They concluded that the increase in player activities that promoted continuity suggested that the ELVs implemented have succeeded in enhancing the appeal of the game. It has therefore been well established that the game has become more physically demanding. However, the studies by Van den Berg and Malan (2012), Williams *et al*. (2005) and Eaves and Hughes (2003) fail to mention the effect of the law changes on coaching the game or the training implications thereof for players or teams.

Quarrie (2009) analyzed the impact of ELVs on match activities during 2000 and 2008 for the Air New Zealand Cup (level below Super Rugby) in New Zealand. The report indicated that the total match time had increased from 2000 to 2008 (85.6±2.7 vs 88.5±3.0), the ball-in-play time showed a decrease before the introduction of the ELVs and was reversed after the introduction (37.6±2.5 vs 38.9±2.8). The scoring profile showed a slight decrease (-6%; 905 CI±8%) in the total points scored and did not reveal any differences between the number of tries scored from 2000 to 2008. The set piece profile revealed a decrease in the number of line-outs (27±5.4 vs 26±5.5), scrums (30±7.5 vs 27±6.4) and number of scrum resets (7.4±3.1 vs 5.2±2.5). The report showed an increase in the number of rucks (147±20 vs 160±24) and kicks (48±14 vs 64±17), a decrease in the number of passes (48±14 vs 257±39), mauls (22±5.1 vs 10±3.6) and no change in the number of tackles (336±39 vs 4.3±7.0). The infringement profile revealed an increase in the number of penalties, free kicks (21±5.4 vs 26±4.8) and yellow cards (2.9±638 vs 4.3±7.0).

Vahed *et al*. (2014) and Vahed *et al*. (2016) investigated the effect of the law changes on the scoring, time interval, general skills and contact profiles of the South African Currie Cup (level below Super Rugby) during the 2007 and 2013 seasons. The scoring profile revealed that fewer tries had been scored ($p=0.07$), while the number of successful penalty kicks had increased significantly ($p<0.01$). The time interval profiles indicated that the total match time and total stoppage time had increased significantly ($p<0.01$), while the total ball-in-play time had decreased significantly ($p<0.01$) and the number of stoppages had also decreased significantly ($p<0.01$). The skills profile revealed a significant increase in the number of passes ($p<0.01$) and a decrease in the number of handling errors, offloads and kicks ($p<0.01$). The contact profile showed a significant increase in the number of rucks/mauls and tackles completed ($p<0.01$) and a decrease in scrums and line-outs ($p<0.01$). The studies by Vahed *et al*. (2014 and 2016) firstly indicated that the profile of the game has changed to one that is more physical and continuous, with an increased number of player actions (passing, tackling and rucks/mauls) and a reduced number of stoppages, predominantly in the second half. Secondly, a trend revealed that teams are adopting a more defensive playing style, whereby they sacrifice committing numbers to the breakdowns and rather commit players on defence. This approach by teams has created a more physically intense game with fewer tries being scored.

1.2. Problem statement

Since professionalism in rugby in 1995, rugby has undergone changes both on and off the field. Several rugby laws and amendments were introduced after the 2007 Rugby World Cup and a number of these laws were implemented in various international and national tournaments from 2007 to 2013. The main problem is that, to date, it has not yet been established how these changes to the laws have affected the profile of the game. The implications for coaches and trainers to improve performance of teams and players during training and match play could therefore not be determined. According to Eaves and Hughes (2003), it is important for coaches and trainers to adapt their training programmes to accommodate and take advantage of changes in the scoring and general match profile of the game. To optimize training and preparation for matches and thereby improve performance, researchers, coaches and trainers should frequently study performance characteristics of opposing teams (Ortega *et al*., 2009; Wheeler *et al*., 2010; Hendriks *et al*., 2013).

1.3. Aim of the study

The primary aim of this study was to determine the impact of law changes on selected performance indicators in the match profile of international rugby union between 2007 and 2013 and national rugby union between 2008 and 2013.The specific objectives of the articles were to investigate and compare:

Research article one: the scoring profiles of international rugby between 2007 and 2013.

Research article two: the changes of the general match profile of international rugby between the 2007 and 2013 seasons.

Research article three: the effect of law changes on the match profile of Super Rugby between the 2008 and 2013 seasons.

1.4. Motivation for the study

The analysis of the effect of law changes on PIs in international and national rugby will give coaches and trainers a better understanding of which PIs occur more in the modern rugby game due to the law changes, how often each variable appears and the effect each PI has on the outcome of the game. These answers may help the role players to prioritize the amount of time they intend spending on the different PIs in their training programmes, depending on the importance of these PIs for competitive match play. This may lead to the better evaluation of players and teams according to improved application to the technical, tactical and physical demands of the modern game. Due to limited literature on the effect of law changes on the scoring and general match profile of rugby, internationally and nationally, it is important to expand this area of research. The significance of the study is, firstly, to give better insight to coaches and trainers into the effect of law changes on selected PIs of international and national rugby. Secondly, to provide clarification from international and national expert coaches, referees (including referee coaches and advisors) and players of the impact of the changes on the scoring and general match profile and, thirdly, to provide role players with practical information to adapt their training or training methods (see practical application sections in Chapters 2 to 5), taking into consideration the specific changes in rugby between 2007 and 2013.

1.5. Research methodology

Study design

The study followed a mixed-method design during the research process. Mixed-method research combines elements of qualitative and quantitative research approaches (e.g. the use of qualitative and quantitative viewpoints, data collection, and analysis and inference techniques) to gain in-depth understanding and corroboration (De Vos *et al*., 2005).

Quantitative approach

Performance analysis of 248 international (Table 1.1) and 646 national matches was done by an accredited performance analyst (Level 6 International Society of Performance Analysis (ISPAS), who is also an accredited WR coach educator and Level 3 coach.

Table 1.1: Number of video recordings per international tournament from 2007 - 2013

Year	World Cup	Tri-Nations	Rugby Championships	Six Nations	Total
2007	n = 37	n = 6	No competition	n = 11	n = 54
2008	No competition	n = 9	No competition	n = 15	n = 24
2009	No competition	n = 9	No competition	n = 15	n = 24
2010	No competition	n = 9	No competition	n = 14	n = 23
2011	n = 48	n = 6	No competition	n = 15	n = 69
2012	No competition	No competition	n = 12	n = 15	n = 27
2013	No competition	No competition	n = 12	n = 15	n = 27
Total	**85**	**39**	**24**	**100**	**N = 248**

Television video recordings of international and national rugby matches were supplied by the company Fika (Cape Town, South Africa). The performance indicators (PIs) were analyzed by means of the coding function of the Fairplay (Canberra, Australia) (4.08.287) software package. The PIs that were analyzed are shown in Table 3.1 (Chapter 3), Table 4.1 (Chapter 4) and Table 5.1 (Chapter 5). The video files were viewed and coded in the tagging panel. The same researcher analyzed all the games to prevent inter-rater variability in the different observations and interpretations of activities.

Qualitative approach

Malterud (2001:483) explained that qualitative research methods involve the systematic collection, organization and interpretation of textual material derived from talks or observation. For the purpose of the study the researcher wanted to include the perceptions of expert coaches, specialist coaches, referees, referee coaches, advisors and players. The researcher decided on semi-structured interviews in preference to focus groups for the current study due to the demographic locations of the experts. The researcher contacted the experts (based on their expertise and level of involvement in rugby) by email, telephone or LinkedIn well in advance and explained in detail the aim of the project and interview. For the experts to be included in the study they had to have been involved in coaching, refereeing and playing at international and national level. Based on the information and aim of the study provided, the expert could accept of decline the invitation. After the initial contact an interview was scheduled (in person, by telephone or Skype) between the researcher and the expert. Three days prior to the interview the researcher emailed the expert the list of law changes and proposed law changes between 2007 and 2013, as well as the trends of the quantitative part of the study. All the interviews (in person, telephonic or Skype) were audio recorded and transcribed by the researcher. The researcher checked the transcriptions with the audio files and notes for accuracy. The interviews were semi-structured with four open-end questions prepared by the researcher. A total of 50 experts were contacted but only 27 were available for an interview (Table 1.2)

Open-end questions:

1. Based on the list of law changes provided between 2007 and 2013, what is your opinion on the law changes and how have they changed the match profile (scoring and general match play of international and national rugby from your perspective?
2. Based on the list of law changes provided, World Rugby (formerly known as the International Rugby Board) had some intended changes to the match profile of the game internationally and nationally. Do you believe this was achieved? Please elaborate.
3. Based on the list of trends found by the quantitative study, what law change(s) contributed to change the specific PIs in the match profile of international and national rugby?

4. Owing to the change in rugby since professionalism, what other factors or other law changes have contributed to the change in the match (scoring and general match) profile? Please name the factor and elaborate.

Table 1.2: Experts used in the semi-structured interviews

Experts	International	National
Coaches	5	6
Specialist coaches	7	6
Referees, referee coaches and advisors	4	5
Players	4	4

1.6. Structure of the dissertation

The dissertation is presented in research article format. The three research articles (Chapters 3, 4, and 5) were prepared in accordance with the guidelines of different journals. Consequently the referencing style used in the different chapters of this dissertation will differ.

Chapter One: Introduction and problem statement: The chapter is included herewith in accordance with the referencing guidelines of the **International Journal of Performance Analysis in Sport** (Appendix A).

Chapter Two: Theoretical background: The chapter is included herewith in accordance with the reference guidelines of the **International Journal of Performance Analysis in Sport** (Appendix A).

Chapter Three: Research article one: How did law changes affect the scoring profile of international rugby union between 2007 and 2013? This chapter is included herewith in accordance with the guidelines of the **European Journal of Sport Science** (Appendix B).

Chapter Four: Research article two: Game analysis of the general match profile of international rugby union between 2007 and 2013. This chapter is included herewith in accordance with the guidelines of the **Journal of Sport Sciences** (Appendix C).

Chapter Five: Research article three: Comparison of scoring and general match profile of Super Rugby between 2008 and 2013. This chapter is included herewith in accordance with the guidelines of the **International Journal of Performance Analysis in Sport** (Appendix A).

Chapter Six: Summary and conclusions.

1.7. References

De Vos, A.S., Strydom, H., Fouche, C.B. & Delport, C.S.L. (2005). Research at grass roots the social science and human service professions (2nd Eds). Pretoria: Van Schaik Publishers.

Duthie, G., Pyne, D. & Hooper, S. (2003). Applied physiology and game analysis of rugby union. **Journal of Sports Medicine**, 33(13): 973-991.

Eaves, S.J. and Hughes, M. (2003). Patterns of play of international rugby union teams before and after the introduction of professional status. **International Journal of Performance Analysis in Sport**, 3(2): 103-111.

Eaves, S.J., Lamb, K.L. & Hughes, M.D. (2008). The impact of rule and playing season changes on time variables in professional rugby league in the United Kingdom. **International Journal of Performance Analysis in Sport**, 8(2): 45-54.

Hendricks, S., Roode, B., Matthews, B. & Lambert, M. (2013). Defensive strategies in Rugby Union. **Perceptual and Motor Skills**, 117(1): 65-87.

Hughes, M. and Bartlett, R.M. (2002). The use of performance indicators in performance analysis. **Journal of Sports Sciences**, 20: 739-754.

Hughes, M. and Franks, I.M. (2007). Notational analysis of sport. In M. Hughes and I.M. Franks (Eds.), *Notational Analysis – A Review of the Literature* (pp. 59-106). London and New York: Routledge.

Jones, N.M.P., Mellalieu, S.D. & James, N. (2004). Team performance indicators as a function of winning and losing in rugby union. **International Journal of Performance Analysis in Sport**, 4(1): 61-71.

Kraak, W.J. and Welman, K.E. (2014). Ruck-play as performance indicator during the 2012 Six Nations Championship. **International Journal of Sports Science & Coaching**, 9(3): 525-537.

Malterud, K. (2001). Qualitative research: standards, challenges, and guidelines. **The Lancet**, 358: 483-488.

Murray, A.D., Murray, I.R. & Robson, J. (2008). Rugby Union: Faster, Higher, Stronger: Keeping an Evolving Sport Safe. **British Journal of Sports Medicine**, 2012 (In Print).

O'Donoghue, P. (2006). The use of feedback videos in sport. **International Journal of Performance Analysis in Sport**, 6(2): 1-14.

Ortega, E., Villarejo, D. & Palao, J. M. (2009). Differences in game statistics between winning and losing rugby teams in the Six Nations Tournament. **Journal of Sports Science and Medicine**, 8(4): 523-527.

Quarrie, K.L. (2009). An evaluation of the Experimental Law Variations in Air New Zealand Cup Rugby. New Zealand Rugby Union.

Robertson, S.J. and Joyce, D.G. (2014). Informing in-season tactical periodization in team sport: development of a match difficulty index for Super Rugby. **Journal of Sports Sciences**, 30: 1-9.

Sheridan, H. (2007). Evaluating technical and technological innovations in sport: Why fair play isn't enough. **Journal of Sport and Social Issues**, 31(2): 179-194.

Van den Berg, P. and Malan, D.D.J. (2012). The effect of experimental law variations on the super 14 rugby union tournament. **African Journal for Physical Health Education, Recreation and Dance**, 18(3): 476-486.

Vahed, Y., Kraak, W. & Venter, R. (2014). The effect of the law changes on time variables of the South African Currie Cup Tournament during 2007 and 2013. **International Journal of Performance Analysis of Sport**, 14(3): 868-885.

Vahed, Y., Kraak, W. & Venter, R. (2016). Changes on the match profile of the South African Currie Cup Tournament during 2007 and 2013. **International Journal of Sport Science and coaching**, (in print).

Wheeler, K.W., Askew, C.D. & Sayers, M.G. (2010). Effective attacking strategies in rugby union. **European Journal of Sport Science**, 10(4): 237-242.

Williams, J. Hughes, M.D. & O'Donoghue, P. (2005). The effect of rule changes on match and ball-in-play time in rugby union. **International Journal of Performance Analysis in Sport**, 5(3): 1-11.

Williams, S., Trewartha, G., Kemp, S. & Stokes, K. (2013). A meta-analysis of injuries in senior men's professional Rugby Union. **Sports Medicine**, 43(10): 1043-1055.

CHAPTER TWO
THEORETICAL BACKGROUND

Referencing within the chapter and the list of references at the end thereof has been done in accordance with the guidelines of the International Journal of Performance Analysis in Sport (Appendix A). The literature from this chapter will further be used to construct the problem statement for each of the four research articles to follow (Chapters 3 to 5).

2.1. Introduction

Since rugby union (rugby) gained professional status in August 1995, there have been many changes both on and off the field (Mellalieu *et al*., 2008). These changes can be attributed to the increase in the level of competition between teams. The interest in rugby has increased exponentially as can be seen from the newly developed European Cup in the Northern Hemisphere in 2015 and the expansion of the Southern Hemisphere Super Rugby competition to 16 in teams 2016. Moreover, the increased media coverage has attracted widespread spectator support by showcasing more games since the introduction of rugby into the professional era. This has played a role in the subsequent financial investment into the sport. A clear improvement in the game

has been noted, which can be attributed to factors such as the increase in the level of competition and higher-quality training programmes (Fuller *et al*., 2009).

Rugby is a contact sport between two teams, each consisting of 15 players who are divided into eight forward players (forwards), and seven backline players (backs) (Reid *et al*., 2013). The game is played over two 40-minute halves separated by a break of between 10 and 12 minutes at international and national level. According to Murray *et al*. (2012), rugby has shown a dramatic growth among men, women and children worldwide. This is evident in World Rugby (WR), formerly known as the International Rugby Board (IRB), boasting 117 affiliated unions. Due to rugby's increasing level of professionalism, rugby performance analysis (PA) is evolving rapidly. The use of technology, in particular PA, has assisted with developing and understanding new methods and processes of training (Duthie *et al*., 2003; James *et al*., 2005). Recently, the use of PA has become increasingly accessible across all levels of rugby (Wright *et al*., 2012).

Several law changes and amendments have been implemented to increase the appeal of the game and to improve it as a spectacle. Evaluating changes on the match profile has focused primarily on specific technical and tactical aspects and very little on the profile and its implications for the coaching and training of players (Bartlett, 2001; Hughes and Bartlett, 2002; O'Donoghue, 2006; Wright *et al*., 2012). However, Quarrie and Hopkins (2007) stated that law changes, improved physical conditioning and improved match analysis resulted after rugby turned professional post the Rugby World Cup (RWC) in 1995. These progressions have resulted in an increased game pace, time of ball in play and level of physical contact, combined with a reduction in the amount of participation time per player. It is also apparent that the levels of physical conditioning for the players have improved. With the profile of rugby changing, it is important for coaches and trainers to identify and understand the demands of the modern game in order to implement more specific training programmes that meet these demands.

The profile of competitive sport rarely remains the same and evolves continuously (Eaves *et al*., 2008a). Rugby is frequently pushed to the limit by both players and coaches. In order to gain the competitive edge over the opposition, coaches and trainers need to adapt their training programmes to accommodate and take advantage of these profile changes (Eaves *et al*., 2003; Eaves *et al*., 2008a; Eaves *et al*., 2008b). Since professionalism (Malcolm *et al*., 2004), the science of assessing the game and

participants' performance has grown rapidly to meet the increasing demand for knowledge of game tactics and player characteristics (Duthie *et al*., 2003). In addition, the use of PA services, more specifically the use of computerized notational analysis (CNA), has become increasingly accessible to coaches and trainers. Since professionalism there have been a significant change in the demands made on players, the physical fitness profiles and attributes of elite players, and major advances in computer and video technology. Most time-motion analyses (TMA) in rugby have used the notational method. The recent introduction of global positioning system (GPS) technology to rugby has allowed for the communication of real-time information and the ability to monitor the physical game demands on multiple players in different positions simultaneously.

This chapter will firstly study the changes in the match profile due to law changes, changes in player attributes and changes in match demands of international and national rugby. Secondly, it will look at the current state of the use of performance analysis in rugby, as well as the growth of this field. Thirdly, it aims to provide coaches and specialist coaches with better information from which they can make more informed decisions regarding training regimes in order to improve performance.

2.2. Law changes and amendments in rugby

The laws of rugby have changed more frequently than those of similar sports. Law changes and amendments are fundamental to the development of rugby and are introduced for a variety of reasons (Kraak and Welman, 2014). Some of the reasons why law changes are implemented in rugby are in response to player performance, to ensure player safety, enhance participation and enjoyment, promote continuity of the game, technological advancement and commercial pressures, as well as to retain game integrity and development (Eaves *et al*., 2008a). WR is responsible for delivering safe, enjoyable and entertaining rugby events. Therefore laws provide a framework by which WR ensures these aspects (Murray *et al*., 2012).

The next section of the chapter will cover the process to conduct law changes and the laws that have changed since 2006. The laws of rugby are controlled by a standing Laws Committee established by the WR Council. The laws are formulated by WR and then circulated to the national unions. The official laws of the game are written in English, French, Russian, Afrikaans and Spanish. There are variations for under-19

and Sevens rugby. There are 21 regulations in total, covering definitions, eligibility, advertising, disciplinary action, anti-doping and a number of other areas. WR also approves equipment, which is tested at an approved testing centre.

In 2006, the IRB initiated proposals for variations to the laws, which were formulated and initially tested at Stellenbosch University in South Africa. Further trials were set for 2007 and 2008. The law variations aimed to push the balance between defensive and attacking play more in favour of attacking play, and to reduce stoppages for penalties and infringements. The IRB tested 23 changes to the modern laws in 2006 and some competitions in Scotland and Australia adopted them in 2007. The problems observed with the previous laws mostly revolved around the fact that in practice the contest for the ball was often halted through law infringements. Different referees used different interpretations of the complex laws, resulting in many games being decided by penalty goals awarded by referees for infringements that were not immediately obvious to observers or even the players.

The Stellenbosch experimental law variations (ELVs) were based on proposals made in the mid-2000s, and came to wider prominence following the 2007 RWC. The following reasons were advanced for the proposed changes: a) amendments were needed because delays in the release of the ball from the contest for possession were having adverse effects; and b) domination of defence over attack was slowing the continuity of play. The game needed to be made faster, easier to play, easier to referee, easier to understand and needed to produce more options for the players. The amendments concentrated on rucks and mauls, but included other aspects that would keep the ball in play for longer and reduce the number of stoppages for infringements and penalties.

In 2007, ZANZAR (Governing body of rugby in the Southern Hemisphere), granted permission for certain ELVs to be tested in the 2008 Super Rugby competition. Table 2.1 provides a summary of the laws tested during the competition and a description of each.

Table 2.1. ELVs that were tested during the 2008 Super Rugby competition (IRB, 2008c)

Law	Law description
Posts and flags around the field	The corner posts are moved so that they are outside the junction of the touchline and goal line. A player will also not be in touch if he touches the corner post unless he also touches either the touchline or ground over the touchline.
Inside the 22-metre line	When a defending player receives the ball outside the 22-metre line and passes, puts or takes the ball back inside the 22, the following can occur: If the ball is kicked directly into touch, the line-out is in line with where the ball was kicked. If a tackle, ruck or maul is subsequently formed and the ball is kicked directly into touch, the line-out is where the ball crossed the touchline.
Breakdown (tackle/post tackle)	Players entering the breakdown area must do so through the gate. Immediately when the tackle occurs there are offside lines. The halfback should not be touched unless he has his hands on the ball.
Line-out	A ball may be thrown backwards on a quick throw-in rather than having to be thrown straight.
Scrum	During a scrum, with the exception of forwards in the scrum, and each team's scrum half, the offside line will now be 5 metres behind the hindmost foot of a scrum.
Sanctions	With the exception of offside, not entering the breakdown through the gate, and foul play, the punishment will be a free kick.

The introduction of the ELVs resulted in a significant decrease in the number of scrums and line-outs during the period 2006 to 2008, as well as an increase in the number of tackles made, metres gained and the number of penalties conceded (Van den Berg and Malan, (2012). The researchers suggested that the decrease in the number of line-outs and scrums indicated that the new laws were effective. The researchers also observed that the new laws did not lead to greater continuity within the game and that ELVs would appeal more to the spectators once the players have fully adapted to the changes.

Table 2.2. ELVs that were accepted as laws in all competitions in 2009 (IRB, 2008c)

Law	Law description
Match Officials	Assistant referees are able to assist the referee in any way the referee requires.
Maul	Remove reference to head and shoulders not being lower than hips. Players are able to defend a maul by pulling it down.
Touch and Line-out	If a team puts the ball back into its own 22 and the ball is subsequently kicked directly into touch, there is no gain in ground. A quick throw-in may be thrown in straight or towards the throwing team's own goal line. There is no restriction on the number of players from either team who can participate in the line-out. The receiver at the line-out must be 2 metres away from the line-out. The player who is in opposition to the player throwing in the ball must stand in the area between the 5-metre line and the touchline but must be 2 metres away from the 5-metre line. Line-out players may pre-grip a jumper before the ball is thrown in. The lifting of line-out players is permitted.
Scrum	Introduction of an offside line 5 metres behind the hindmost feet of the scrum. Identification of scrum-half offside lines.
Corner Posts	The corner posts are no longer considered to be touch-in-goal except when the ball is grounded against the post.

On 1 May 2008, WR announced that its Council had approved a global trial of ELVs for a period of 12 months in all competitions, starting on 1 August 2008. The trial, which applied at all levels of rugby, involved 13 of the 23 ELVs that had been tested in approved tournaments around the world in the preceding two years. Table 2.2 provides a summary and a description of the laws.

After the 2011 RWC tournament, the undermentioned laws and amendments were added to the law book. Table 2.3 provides a summary of the laws, as well as a description of each.

Table 2.3. Summary of the laws changes after the 2011 Rugby World Cup (IRB, 2012c)

Law	Law description
Players nominated as substitutes	For international matches a Union may nominate up to eight replacements/substitutes.
Referee consulting with others	Extension of the jurisdiction of the television match official (TMO).
Taking a conversion kick	The kick must be taken within one minute and 30 seconds (90 seconds) after a try was scored.
Outcome of a knock-on or throw forward	Knock-on or throw forward into touch. When the ball goes into touch from a knock-on or throw forward, the non-offending team will be offered the choice of a line-out at the point the ball crossed the touchline, or a scrum at the place of the knock-on or throw forward. The non-offending team may exercise this option by taking a quick throw-in.
Unsuccessful end to a ruck	When the ball has been clearly won by a team at a ruck and the ball is available to be played, the referee will call "use it", after which the ball must be played within five seconds. If the ball is not played within the five seconds the referee will award a scrum and the team not in possession of the ball at the ruck will be awarded the throw-in.
Unsuccessful end to a maul	If the ball carrier in a maul goes to ground, including being on one knee or both knees or sitting, the referee will order a scrum unless the ball is immediately available. When the ball is available to be played the referee will call "use it", after which the ball must be played within five seconds. If the ball is not played within the five seconds the referee will award a scrum and the team not in possession of the ball at the ruck will be awarded the throw-in.
Quick throw-in	For a quick throw-in, the player may be anywhere outside the field of play between the line of touch and the player's goal line.
Forming a scrum	The referee will call "crouch" then "touch". The front rows crouch and, using their outside arm, each prop touches the point of the opposing prop's outside shoulder. The props then withdraw their arms. The referee will then call "set" when the front rows are ready. The front rows may then engage. The "set" call is not a command but an indication that the front rows may come together when ready.
Penalty and free-kick options and requirements	Line-out alternative. A team awarded a penalty or a free kick at a line-out may choose a further line-out (their throw-in). This is in addition to the scrum option.

Law changes are a common feature in sport today and objective assessments are required to ascertain the impact of such changes (Williams *et al*., 2005). One such measure is to use PA, which involves quantifying performance and strategies of teams

or individuals in sport. PA is concerned primarily with investigating various aspects of player and/or team performance (O'Donoghue, 2005). The next section of the chapter will discuss the use of PA in rugby research and coaching.

2.3. Performance analysis in rugby

It is often stated that in professional sport the smallest of margins regularly dictate the outcome of performance. While this may be true in some performances, and indeed in certain sport, it must not be generalized in all contexts (Butterworth *et al*., 2013). PA is a commonly used information source for the coach; in fact, coaching is said to be the main practical application area and use of PA (O'Donoghue and Mayes, 2013). PA involves assessing performance to evaluate the effectiveness of the strategies of teams or individuals in a sport. Through the analysis of movements and patterns of play, coaches, trainers and players are able to interpret and understand various situations in the game (Hughes and Bartlett, 2002). This process has also been described as a combination of biomechanics and notational analysis in the study of how movements relate to sports performance (Bartlett, 2001). PA generally involves the analysis of a match performance; however, if a particular skill is critical to the sport, for example the kick at goal, then PA can also be conducted in a practice setting (O'Donoghue, 2006). It is therefore considered to be on a continuum, depicted by the current study in Figure 2.1, ranging from technical analysis of an individual's closed skills (biomechanics orientation) at one end through to game analysis (notational analysis and time-motion analysis orientation) at the other. Research on PA in rugby has explored aspects of the game such as patterns of play, analyzing breakdowns, analyzing technical skills and identifying physiological estimates of players' work rates (Van Rooyen *et al*., 2008; Van Rooyen *et al*., 2010; Austin et al., 2011; Van den Berg and Malan, 2012; Hendricks *et al*., 2013; Quarrie *et al*., 2013;).

Figure 2.1. Performance analysis continuum

The use of PA (both CNA and biomechanical analysis) techniques is increasing within professional rugby. Although many software analysis systems are available, the following systems are currently being used by most professional rugby teams: Fairplay, ProZone, Verusco, Sportscode, Dartfish and EncodePro. Coding is the current term for the modern-day equivalent of notational analysis, whereby a performance (training session or match) is viewed on a computer, with key events electronically recorded for statistical purposes or simply for convenient reviews of selected video clips in order to improve performance of individual players and teams.

The computer-based software that analyzes performances using video image is highly customizable and can be tailored to analyze any aspect of the game using performance indicators (PIs) (O'Donoghue, 2006). PIs are a selection or combination of action variables that aim to define some or all aspects of a performance. In order for the PIs to be useful, they should relate to successful performances (Hughes and Bartlett, 2002; James *et al*., 2005). Four categories of PIs have been proposed for use in the PA of sport, namely 1) match classification indicators, 2) tactical indicators, 3) technical indicators, and 4) biomechanical indicators (Hughes and Bartlett, 2002). Such indicators can be applied to an individual player or a team. Each of these categories will be discussed in the following section.

Match classification indicators report the frequency of key structural events within a game. Examples within rugby include scoring (tries, penalty kicks and drop kicks), line-outs, scrums and turnovers. Vahed et al. (2016) compared the scoring profile of the 2007 and 2013 South African Currie Cup tournament to determine the changes in match profile. The study indicated that the total points scored between the seasons did not show any significant change (26.1±11.7 vs 25.7±9.6, p=0.81); however, the scoring mode of points changed from tries to penalty kicks. The total number of tries scored showed a decreasing trend from 2007 to 2013 (p=0.07), particularly in the 2nd half of a match in 2013 (p=0.05). There were no significant differences between the source of the tries (scrum p=0.13, line-out p=0.25 or open play p=0.26). The decrease in tries consequently led to a decrease in the number of conversion kicks (p=0.07). The main scoring mode of points was penalty kicks, which showed a significant increase from 2007 to 2013 (2.3±1.8 vs 3.5±1.9, p<0.01). The accuracy of the penalty kicks also changed, with the success of penalty kicks increasing significantly (1.4±1.3 vs 2.6±1.5, p<0.01). The success of penalty goals therefore increased from 63% in 2007 to 75% in 2013.

In their analysis of the effect of alternating home- and away-field advantages on selected PIs during the Six Nations Rugby Championship (2005-2009), Vaz *et al*. (2012) found a tendency for teams who played at home to achieve better results. Significant differences were seen in the number of penalty kicks and the success thereof, the number of rucks/mauls won and the number of passes completed. The results also indicate that 50% or more of the total points scored were scored when teams played at home. Vaz and his co-authors (2012) concluded that there was a tendency in the Six Nations Rugby Championship (2005-2009) for teams to be more successful when playing at home. Sasaki *et al*. (2007) analyzed the scoring profile and defence performance in the Japanese domestic competition from 2003 to 2005. The results indicate that the number of points decreased over the three seasons and that most tries (over 50%) came from scrums and line-outs. There was an increase in the number of tackle turnovers, which suggests that there had been improvements in the defensive performance by the teams.

Technical indicators reflect the level of success at performing a specific skill. Error or success frequencies should be normalized against the total number of times the technical skill was attempted, and represented as a percentage or ratio (Hughes and Bartlett, 2002). Examples in rugby include percentage of successful kicks at goal, line-out throws won, tackles made and missed, successful passes completed, handling errors and total number of turnovers. The study by Hendricks *et al*. (2014) analyzed a total of 2 092 tackles during 18 matches of the 2010 Super 14 rugby competition. The aim of their study was to identify tackler characteristics and its association with tackle performance during match play. The study analyzed different PIs pertaining to the tackle, such as head position – in motion, up and forward; type of tackle – shoulder tackle, arm tackle or ball-carrier fend (also referred to as handoff), absent, moderate, strong and leg drive; absent, moderate, strong or shoulder usage, and association with tackle outcomes. The results of the study revealed that having the head in motion decreased the tackler's chances of a successful tackle (RRR 2.24, 95% CI 1.72–2.92, $p<0.001$) relative to an up and forward head position. Further analysis revealed that when ball-carriers used a fend, there was a significant decrease in the tackler's probability of success (moderate fend RRR 2.97, 95% CI 2.04–4.31, $p<0.001$). Moderate leg drive (RRR 0.36, 95% CI 0.26–0.50, $p<0.001$) by the tackler increased the likelihood of tackle success. Head up and forward, counteracting the ball-carrier fend, shoulder tackles targeted at the ball-carrier mid-torso, using the arms to wrap or

pull, and leg driving were key tackler characteristics associated with positive tackle outcome in matches. Hendricks *et al*. (2014) recommended that these technical characteristics be emphasized and incorporated into training to effectively prepare players for match play.

Kraak and Welman (2014) analyzed a total of 1 479 rucks during 15 matches of the 2010 Six Nations Championship. The study indicated that at 92% of the rucks the ball was successfully retained by the attacking team, with no difference between the ruck success rate and final team ranking, regardless of whether teams were attacking ($p=0.74$) or defending ($p=0.95$). The study further revealed that four players (both attacking and defending) were generally involved at the ruck. The players involved during unsuccessful and successful retention of the ball differed significantly ($p=0.03$, $d=0.21$). Attackers involved mostly two players (50%), whereas defenders had typically one player (68%). Attacking teams were particularly successful in retaining possession if they had one more attacker involved than the defenders ($p<0.05$). Most rucks were formed in zone B and fewer rucks were formed by the top three ranked teams. Van Rooyen *et al*. (2010) evaluated the 2007 RWC tournament to determine whether ruck occurrence could predict successful performance. The authors found a greater number of rucks per game in the knockout stages of the tournament (121 range 71-164) than in the pool stages (116 range 65-172). Matches during the pool stages were won (58%) by teams with the highest number of rucks. In the knockout stages the team with the fewest rucks won 100% of the matches. The data suggests that during the pool stages of the tournament the more rucks a team created, the more likely it was to win the match, while avoidance of rucking was associated with success during the knockout stages.

Tactical indicators reflect the style of play of the individual player or teamwork of units, by indicating the options taken at certain interchanges of the game. They may also reflect the pace, fitness and movements and the ability to target specific technical strengths and weaknesses of opponents. In rugby, tactical indicators include percentages or ratios to represent the options of passes, kicks and tackles, and the number of players committed to attacking or defending situations. Hendricks *et al*. (2013) assessed 21 matches of the 2010 Super Rugby competition to look at the defensive strategies used. A total of 2 394 tackle situations were coded and analyzed. The researchers concluded that the likelihood of the defending team winning the breakdown (the post-tackle contact situation where opposing teams compete for

possession of the ball) increased as the match progressed. Defensive speed, measured as the speed of the defence in response to the attacking line, was a statistically significant predictor of breakdown wins and preventing the attacking team from advancing towards the gain line. Identifying the relative effectiveness of such strategies allows understanding of rugby match behaviour and could be applied to improve organizing, designing, training, teaching and learning the game.

Furthermore, Prim *et al*. (2006) compared various performance parameters (ball possession, tries scored, PIs associated with successful ball retention, and effectiveness of tackle situations) of the four South African Super Rugby teams and the winners of the 2005 Super 12 tournament. The results revealed no significant differences between the teams' ball possession, tries scored or numbers committed to the breakdowns; however, there were noticeable differences between the styles of play of the teams. The winners of the tournament had the lowest defensive and offensive recycling times, which indicated a higher tempo of play. Despite the winning team conceding a similar number of tries to the South African teams, they scored the most tries, thus their attack might have been key to their success. Wheeler *et al*. (2013) examined the association between defensive strategies and ruck outcomes in rugby. Defensive tactics at the ruck contest were analyzed during 60 games of the 2011 Super Rugby competition. The PIs analyzed were the attacking width, territory gained by the attack, defensive strategy used at the ruck, and ruck outcome. The analysis showed that both early counter-ruck (competing for the ball without hands) and jackal (competing for the ball with hands) were effective at turnover possession behind the advantage line (60 and 39% respectively). Early counter-ruck was also effective at turning over possession when the ruck contest occurred in the wide attacking channels (18%), while a jackal was used at ruck contests occurring in the central part of the field (13%). Late counter-rucking was a poor strategy as it was more likely to concede a penalty.

Biomechanical indicators concentrate on mechanically breaking down technical skills and identifying specific movements crucial to the successful execution of the technique. Technical skills that could potentially benefit from such analysis in rugby include evasive running (sidestepping or swerving), kicking, passing, tackling, line-out jumping and support, and hooker throwing. This analysis allows coaches and trainers to gain a better understanding of the various aspects of the game, including information processing and the control and coordination of complex multi-segmental movements.

Sinclair *et al*. (2014) assessed 20 male participants performing maximal velocity place kicks. The lower extremity kinematics were obtained using an optoelectric motion capture system operating at 500Hz to identify the important technical aspects of in-step rugby kicking pertinent to the generation of ball velocity using 3-D kinematic modelling and regression analyses. The results showed that a single kinematic measure, knee extension velocity of the kicking limb $R2=0.48$, $p \leq 0.01$, was obtained as a significant predictor of ball velocity.

The study by Wheeler and Sayers (2011) examined the running technique of eight highly trained rugby players during three rugby-based reactive agility conditions (non-contact, contact and fend). The results showed a deduction in the relative height of the centre of mass (% CM) at the straighten step during contact conditions, compared to the non-contact conditions. The fend condition was then shown to increase the % CM at the straighten step when compared to the contact condition. Further analysis showed the number of steps displayed between the sidestep and straighten step (transition phase) altered the % CM, with one step increasing the % CM compared to two steps or no transition phase steps. According to Wheeler and Sayers (2011) the change in running technique during agility conditions involving tackle situations highlighted the importance of running programmes that meet the specific demands of match-play activities.

Developing and utilizing PIs can lead to the creation of performance profiles (PPs) for specific sporting codes. PPs are a description of a pattern of performance by an individual or team and are created from collected frequencies of PIs. Such PPs can lead to a better understanding of situations and tactics implemented by teams, which offers some prediction of future performances (James *et al*., 2005; Robertson and Joyce, 2014). However, according to O'Donoghue (2006), when developing PPs, choosing the correct PIs to analyze sport is crucial. Examples of tasks in rugby include goal kicking and cover tackling, which could then be grouped with other similar actions into skill sets such as kicking and defence. Groups of four or five PIs can be reduced to a single performance measure for a given match. However, these performances cannot be established after a single match (one execution of performance), as performances and execution of skills vary between matches and individuals (Bracewell, 2003).

Research by Vaz *et al*. (2010) assessed 18 PIs in order to determine game-related statistics that discriminated between winning and losing teams in international and

national rugby (N = 324). A total of 120 international and 204 Super 12 matches played between 2003 and 2006 were analyzed. The researchers conducted a cluster analysis to establish three different match groups, based on the final score of the matches. Only the close-games group was selected for further analysis (international n = 64 under 15 points difference and Super 12 n = 95 under 11 points difference). The discriminant functions were statistically significant for Super 12 games (CS=33.8, $p<0.01$), but not for international matches (Chi-square=9.4, p=n.s.). Firstly, winners and losers were different with regard to possessions kicked (SC=0.48), tackles made (SC=0.45), rucks and passes (SC=-0.40), passes completed (SC=0.39), mauls won (SC=-0.36), turnovers won (SC=-0.33), kicks to touch (SC=0.32) and errors made (SC=-0.32). This study concluded that rugby game-related statistics were able to discriminate between winners and losers in Super 12 close games and suggested that a kicking-based game supported by an effective defensive structure was more likely to win matches than a possession-based one.

Research conducted by Ortega *et al*. (2009) investigated the differences between winning and losing teams in the Six Nations. The authors analyzed 58 matches from the 2003 to 2006 seasons. The study identified 28 PIs and grouped them into 3 PPs. The groups of PIs were: 1) “points scored”, which described the number of points scored and the way in which the points were scored, 2) “phase of play”, which described the way teams obtained the ball and how they used it, and 3) “game development”, which described technical and tactical aspects. The results showed that the winning teams scored more points, and had more conversions, successful drops, mauls won, line breaks, possessions kicked, tackles completed and turnovers won. Losing teams lost significantly more scrums and line-outs on their own feed. Ortega and his co-authors concluded that: a) winning teams were more effective in gaining possession from set pieces with a 90% efficiency; b) winning team tended to kick more from hand and utilized the maul better and used it as a way to attack and break the defensive line; c) on defence, winning teams recovered more balls and completed more tackles than losing teams; and d) winning teams completed 94% of tackles. This study concluded that PPs could be used as a reference for monitoring training and competition performances.

2.4. Changes to the match profile

The next section of the chapter will address the changes to selected PIs in order to reveal the changes in the match profile of rugby since professionalization in 1995.

Table 2.4 indicates the average points and scoring modes per match during the 2011 RWC, and a decrease in the number of tries and an increase in the number of successful penalties when compared to the previous tournaments.

Table 2.4. Comparison of the average points and scoring modes for the RWC since 1995 (IRB, 2011a)

Year	Average points	T	% points from T	CK	PK	DG
1995	54	5.8	53	^^	5	0.5
1999	60	5.9	59	^^	6.2	0.5
2003	59	6.9	59	5.0	4.3	0.5
2007	52	6.2	52	4.4	3.7	0.3
2011	47	5.5	58	3.8	3.6	0.4

Note: T – tries, CK – conversion kicks, PK – penalty kicks, DG – drop goals ^^ - data was not available

A decrease in the number of points and tries was also observed when comparing the 2007 and 2013 South African Currie Cup tournaments. The results of this study showed a decrease in the number of tries scored ($p=0.07$) and a significant increase in the number of successful penalty goals ($p<0.01$) (Vahed *et al*., 2016). The report by Quarrie (2009) revealed a decrease in the total points scored (44±18) and no change in the number of tries scored (5.6±2.8) during the Air New Zealand Cup when determining the effect of ELVs between 2000 and 2008. Sasaki *et al*. (2007) analyzed the scoring profile in the Japanese domestic competition from 2003 to 2005. The results indicate that the number of points decreased over the three seasons and that most tries (over 50%) came from scrums and line-outs. The study by Quarrie and Hopkins (2007) revealed an increase in points and tries scored when comparing the Bledisloe Cup between 1972 and 2004.

Williams *et al*. (2005) analyzed the effects of the January 2000 law changes on the match and ball-in-play time across five years during the major international and national competitions of the Southern and Northern Hemispheres between 1999 and 2003. The findings of the study showed a significant increase in the total match time for all matches. Total match time increased from 87 minutes (±3min 16s) in 1999 to 90min 52s (±4min 23s), which would imply that the rule changes had an effect on the

game. The greatest incline in the data appeared to be from 1999 to 2001, with the increase between 1999 and 2000 being especially steep. This study also revealed a significant increase in the ball-in-play time for all the matches over the five years, with an increase from 1999 to 2000 and another increase from 2001 to 2003. There was a decrease from 2000 to 2001, but the overall increase for the time period was 3min 09s. The decline in the mean of the ball-in-play time between 2000 and 2001 was 1min 03s, which reduced the time from 32min 37s (±3min 6s) to 31min 34s (±3min 30s). The increase in the subsequent three years climbed to 33min 16s (±2min 55s), an increase of 1min 42s. The overall increase in the ball-in-play time underlined the effect of the law changes on the game.

Figure 2.2 shows the ball-in-play time for the RWC from 1995 to 2011. The findings of the report suggest that there had been a 33% increase in the ball-in-play time since the introduction of professionalism in 1995 (IRB, 2011a).

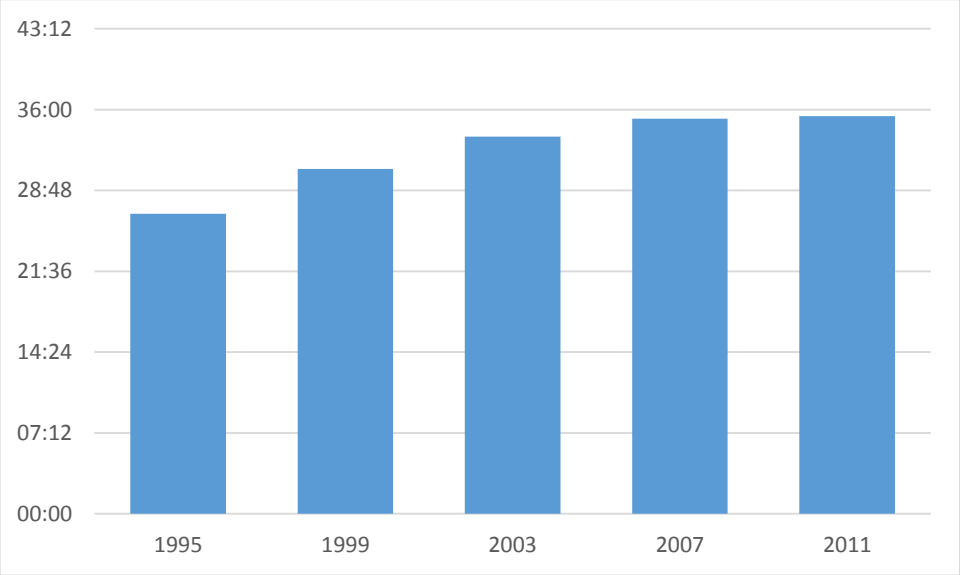


Figure 2.2. Ball-in-play time for the RWC since professionalism in 1995

Figure 2.3 compares the ball-in-play time for major Northern Hemisphere and Southern Hemisphere tournaments. The research revealed a decrease in the ball-in-play time for both hemispheres from 2007 to 2011. The reports revealed that over the eight years the ball was in play longer during the Northern Hemisphere tournaments than in the Southern Hemisphere tournaments (IRB, 2007a, 2007b, 2008a, 2008b, 2009a, 2009b, 2010a, 2010b, 2011b, 2011c, 2012a, 2012b, 2013a, 2013b, 2014a, 2014b).

With regard to the total match time (85±3.6) and ball-in-play time (34.5±1.8), the study by Quarrie and Hopkins (2007) revealed an increase for both when comparing the

Bledisloe Cup matches before and after the introduction of professional rugby in 1995. The report by Quarrie (2009) on the impact of ELVs on match activities in the Air New Zealand Cup revealed that the total match time increased mainly due to the number of injury stoppages, substitutions and referrals to the Television Match Official (TMO). The ball-in-play time increased by 3min 6s from 2007 to 2008. Vahed *et al*. (2014) revealed that the total match time increased significantly from 2007 to 2013 (46:34 ± 03:08 vs 47:28 ± 03:42, p=0.01), particularly during the 2nd half of both years (p=0.02, p<0.01). Interestingly, the study revealed a significant decrease in the ball-in-play time during the South African Currie Cup from 2007 to 2013 (17:21±02:27 vs 16:02±02:22, p=0.01).

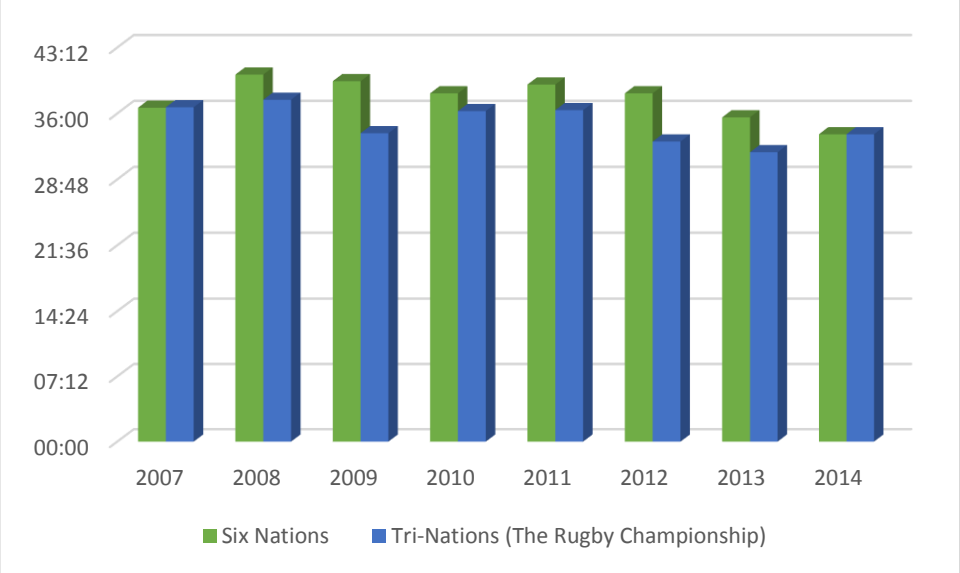


Figure 2.3. Comparison of the ball-in-play time for the Six Nations and Tri-Nations (replaced by The Rugby Championship in 2013)

The study by Quarrie and Hopkins (2007) observed a decrease in the number of scrums (26±7) and line-outs (28±10) during the Bledisloe Cup before and after the introduction of professional rugby in 1995. The authors indicated that the reason for the decrease in the scrums was that players in the professional era have more time for practice and will thus spent more time on skills training, which will lead to a decrease in the number of handling errors. Quarrie (2009) analyzed selected PIs to determine the effect of the ELVs on the Air New Zealand Cup. The report showed a decrease in the number of line-outs (26±5.5), scrums (27±6.4) and scrum resets (5.2±2.5). In addition, research by Van den Berg and Malan (2012) investigated the effects of ELVs

on Super Rugby. The study revealed that the number of scrums (d=0.94) and line-outs (d=2.18) decreased significantly from 2006 to 2008. More recently Vahed *et al*. (2016) found a decrease in the number of scrums (p<0.01), scrum resets (p<0.01) and line-outs (p<0.01) when comparing the 2007 and 2013 South African Currie Cup seasons.

The study of the Bledisloe Cup by Quarrie and Hopkins (2007) showed an increase in the number of rucks (178±27) after professionalism in 1995; however, there was a decrease in the number of mauls (22±9) observed during this period. Research by Vahed *et al*. (2014) combined the number of rucks and mauls into one PI and revealed an increase (p<0.01) during the 2007 and 2013 Currie Cup Competition. Quarrie (2009) observed an increase in the number of rucks (160±24) and a decrease in the number of mauls (10±3.6) before and after the introduction of the ELVs during the Air New Zealand Cup. Van den Berg and Malan (2012) also reported an increase in the number of rucks (d=0.49) during the 2006 and 2008 Super Rugby competition. In addition, with the increase in the number of rucks, teams retained possession for more than 90% of the time (Quarrie, 2009; Van Rooyen *et al*., 2010; Wheeler *et al*., 2013; Kraak and Welman, 2014)

Due to the change in the profile of modern rugby, the number of tackles has increased significantly across different levels of competition since professionalism in 1995 (international rugby (270±25) and Super Rugby (d=.97). There has also been an increase in the number of successful tackles in the Currie Cup (94.2±17.8)) (Quarrie and Hopkins, 2007; Van den Berg and Malan, 2012; Vahed *et al*., 2016).

Many changes have been reported with regard to the number of kicks, line breaks, offloads and passes. During the 2007 and 2013 Currie Cup competition the number of passes showed a significant increase (p<0.01). A decrease in the number of handling errors, offloads and kicks (p<0.01) was also shown. When analyzing the Super Rugby competition (2006 & 2008), an increase in passes (d=0.49) and defence beaten (d=0.42) was revealed (Van den Berg and Malan, 2012). During the Air New Zealand Cup an increase in the number of passes (257±17) and kicks (64±17) was found. The study by Quarrie and Hopkins (2007) revealed that the number of passes increased (247±32) and the number of kicks decreased (45±13) during the Bledisloe Cup before and after professionalism.

Game demands

With the evolution of increased competitiveness in rugby, the requirements of bigger, faster and stronger players have become ever more apparent. Recent research in the field of strength and conditioning has focused on identifying physiological characteristics of players during competition and training, which has led to the introduction of PA tools in the form of TMA and notational analysis. With the implementation of technology in rugby, the field of PA seems to overlap with that of strength and conditioning in the pursuit of developing sport-specific conditioning programmes. With the understanding of movement patterns that biomechanics principles provide, and the potential for notational analysis to determine physiological demands during training and competition, PA can assist strength and conditioning coaches and trainers to develop programmes that can meet the specific demands for the individual player and team (Gabbett *et al*., 2008). The next section of the theoretical background will address the movement demands of rugby during training and match play, as well as player attributes.

During 2014 Owen *et al*. (2015) quantified the accelerations, decelerations, and impacts and aggregated body demands during the first half of match play in a Super Rugby game. The aim was to determine whether these characteristics were position-specific. Forwards sustained more (d=0.44) high-intensity impacts and had greater (d=0.26) aggregated body demands, while backs had more moderate (d=0.55) and heavy accelerations (d=0.76), and moderate (d=0.23) and heavy decelerations (d=0.54). The results of the study could be applied practically by rugby coaching staff, where conditioning programmes and recovery strategies could be individualized to meet position-specific characteristics of players. Forwards should be conditioned with skills that focus on impacts and collisions. Backs should have more rapid accelerations and decelerations in their movement patterns. Individualizing the conditioning and skills will allow players to be better prepared for their position-specific roles. After a match, forwards require more time for recovery because they have greater aggregated body demands than backs. Tailoring recovery strategies and adjusting training demands to meet individual needs reduce the likelihood of insufficient recovery and therefore allow players to train optimally and reduce the risk of injury.

Research by McLellan *et al*. (2013) examined the physiological demands made on five elite male rugby players during the Super 15 rugby tournament match play, using portable GPS and integrated accelerometry to monitor the demands of match play and

to examine the positional differences. The study revealed a significant (p>0.05) difference in the total and relative distance travelled and between the backs and forwards during match play. Backs achieved greater maximum running speed, completed a greater number of sprints, had more time between sprints and covered more distance sprinting than forwards. According to McLellan *et al*. (2013) forwards experienced significantly (p>0.05) more total impacts than backs during match play, while the number of impacts recorded in zone four (7.1-8.0 G), zone five (8.1-10.0 G) and zone six (≥ 10.1 G) was significantly (p>0.05) greater for forwards than backs.

The study by Quarrie *et al*. (2013) analyzed the movements and activities of New Zealand players during international rugby matches from 2004 to 2010. They observed and coded actions of 763 players during 27 of these matches via a semi-automated player-tracking system. The players were divided into five subgroups for the forwards (props, hookers, locks, flankers, number 8's) and backs (scrum half, fly half, midfield backs, wings and fullbacks). The study revealed that the forwards experienced much higher contact loads per match than backs, through scrums, rucks, tackles and mauls. The mean distances covered per match ranged from 5 400 to 6 300 metres, with backs generally running further than forwards. The study also revealed clear differences between positional groups in the distance covered at the various speed zones. Quarrie *et al*. (2013) concluded that the amount of play per match varied by position due to differences in rates at which players were substituted. The distance covered by players at relatively fast running speeds (in excess of 5ms (-1)) appeared to be higher during international matches than at lower levels of the professional game.

Austin *et al*. (2011) analyzed the movements of 20 players from four different positional groups (front-row forwards, back-row forwards, inside backs and outside backs) of a Super 14 rugby team during the 2008 and 2009 seasons. The players covered between 4 218m and 6 389m during the matches. With regard to the maximum distances covered, the front-row forwards covered 5 139m and the back-row forwards 5 422m, while the inside backs and outside backs covered 6 389m and 5 489m respectively. The back-row forwards spent the greatest amount of time in high-intensity exercise (1 190s), followed by the front-row forwards (1 015s), the inside backs (876s) and the outside backs (570s). Average distances covered in individual sprint efforts were: front-row forwards 16m, back-row forwards 14m, inside backs 17m and outside backs 18m. Work to rest ratios of 1:4, 1:4, 1:5 and 1:6 were found for the front-row and back-row forwards, and inside and outside backs respectively. The study revealed an increase

in total high-intensity activities, sprint frequency and work--rest ratios across all the different playing positions when comparing the two seasons.

Cunniffe *et al*. (2009) evaluated the physiological demands made on two elite rugby players (forward and back), using GPS tracking. The data of the study revealed that players covered on average 6 953m during play (83min). Of this distance, 37% (2 800m) was spent standing and walking, 27% (1 900m) jogging, 10% (700m) cruising, 14% (990m) striding, 5% (320m) high-intensity running, and 6% (420m) sprinting. Greater running distances were observed for both groups of players (6.7% backs; 10% forwards) in the 2nd half of the game. Positional data revealed that the backs completed a greater number of sprints (>20 kilometres (km) x h(-1)) than the forwards (34 vs. 19) during the match play. Conversely, the forwards entered the lower speed zone (6-12km x h(-1)) on a greater number of occasions than the backs (315 vs. 229) but spent less time standing and walking (66.5 vs. 77.8%). In the study players were also found to perform 87 moderate-intensity runs (>14km x h(-1)) covering an average distance of 19.7m (SD = 14.6). Average distances of 15.3m (backs) and 17.3m (forwards) were recorded for each sprint burst (>20km x h(-1)) respectively. Players exercised at approximately 80 to 85% VO2 max during the course of the game with a mean heart rate of 172 b x min(-1) (approximately 88% HR max).

The study by Roberts *et al*. (2008) assessed the physical demands of elite English rugby match play. Movements based on speed were categorized as standing, walking, jogging and medium-intensity running (low-intensity activity), and high-intensity running, sprinting and static exertion (scrummaging, rucking, mauling and tackling) (high-intensity activity). Backs covered more total distance than forwards (6 127m, s=724 vs. 5 581m, s=692; P<0.05) and greater distances in walking (2 351m, s=287 vs. 1 928m, s=2 342; P<0.001) and high-intensity running (448m, s=149 vs. 298m, s=107; P<0.05). Forwards performed more high-intensity activity than backs (9:09min:s, s=1:39 vs. 3:04min:s, s=1:01; P<0.001), which could be attributable to more time spent on static exertion (7:56min:s, s=1:56 vs. 1:18min:s, s=0:30; P<0.001), although backs spent more time on high-intensity running (0:52min:s, s=0:19 vs. 1:19min:s, s=0:26; P=0.004). Players covered a greater distance in the first 10min compared with 50-60 and 70-80min, but there was no difference in the amount of high-intensity activity performed during consecutive 10min periods during match play.

The data of the studies referenced under the game demands section shows the change in the physical profile of rugby and could assist coaching and performance staff to

develop and implement individualized and position-specific training regimes to optimize on-field performance. For players and teams to remain competitive in international and national rugby, training should reflect the current demands of the game and the specific match demands for positional groups need to be considered when managing player workloads.

Body composition and size of players

Body composition and size are important attributes, particularly in contact sport. Rugby is unique in this regard as the sport accommodates players of all shapes and sizes (Fuller *et al*., 2013). There have been significant changes in these attributes in rugby over the past decade. In the 1998 New South Wales Super 12 rugby team, the front row (112.8 ± 5.7kg) and the remainder of the forwards (108.3 ± 5.3kg) were significantly heavier than the backs (89.0 ± 6.8kg). Differences were also observed between the positional groups. Hookers (89.7 ± 8.1kg) were found to weigh less than props (102.8 ± 8.1kg). Among the backs, the inside backs (75.0 ± 6.9kg) were substantially lighter than the centre pair (85.9 ± 6.9kg) and the outside backs (83.4 ± 6.9kg). A larger body size has correlated significantly with scrumming forces and competition success, and therefore body mass is naturally greater for forwards than backs (Duthie *et al*., 2003).

Smart *et al*. (2013) studied the body composition and physical performance of different levels of New Zealand rugby players from 2004 to 2007. Props had the highest mass, percentage body fat and strength, and were slower in speed tests compared with the other positions, whereas outside backs were the fastest during speed tests and had the lowest percentage body fat. For most measures, there were small to moderate differences (range, 1.1-14%) between players selected and not selected for provincial teams and small to large differences (range, 1.8-15%) between provincial and Super Rugby (professional) players. The faster 20m sprint times of international players compared with Super Rugby players was small in magnitude for both the forwards (1.9%) and backs (2.2%). The average annual improvements were small to moderate for strength (range, 2.1-15%) and small for repeated sprint ability at the lower playing levels (~1.5%). Small increases occurred in lower body strength (~7.0%) as players moved from Super Rugby to provincial competition. Small decreases in sprint time (~1.6%) and small increases in strength (~6.3%) occurred as players moved from

Super Rugby to mid-year international competition. According to Smart *et al*. (2013) the differences between levels in performance provide level-specific characteristics for Super Rugby players and below, but international players may be selected because of greater skill and experience. Changes in physical performance between competitions may be a result of reduced training loads because of regular high-intensity matches and greater travel involved in the Super Rugby competition. Fuller *et al*. (2013) evaluated the changes in the stature, body mass, age and number of players by playing position in the first-team squads of English Premiership rugby teams from 2002 to 2011. Although the mean stature of players in all positions increased during the period, only the stature of the flyhalf and prop showed a trend towards statistical significance. While the mean body mass of players increased in most positions, again only the fly half and back-row players showed a trend towards statistical significance.

2.5. The implications of changes to the match profile for preparation of teams

Rugby laws have changed or have been amended on a regular basis since 1995. According to Eaves and Hughes (2003) it is important for coaches and trainers to adapt their training programmes, especially when changes occur in the profile of the sport. This implies that, if the effects of law changes are analyzed, the preparation of teams and individuals (coaches and trainers) to improve performance and gain the competitive edge over opponents, could be enhanced. Furthermore, teams have been placing greater emphasis on finding new ways of improving players and performance in order to gain a competitive advantage over their opponents. The speed of the game has also increased. In the modern game there are many variations when compared to how rugby was before the professional era, and there has been a demand for bigger, stronger, faster, better skilled and more durable players due to the increased number of games played throughout the calendar year (Green *et al*., 2011; Smart *et al*., 2013). This is why coaches and coaching specialists need to find new ways to improve the quality of their teams.

Williams *et al*. (2005) describe the role of PA in the study of law changes. One issue with the use of PA or any other observational analysis is that effects of rule changes are only confirmed after those changes have been made. This is often useful where experimental laws are applied for a period in a certain tournament before decisions are taken to implement law changes or not across the sport. There is an alternative to PA,

which can be used before rule changes are introduced, and that is simulation. Where substantial knowledge of the sport is available and it is assumed that all other aspects of the game are unaffected by law changes, it is possible to simulate the effect of those rule changes on characteristics of interest.

Rugby is a game of many facets. The same applies to rugby coaching. Rugby coaching is multifaceted, comprising many interrelating factors that aim to produce a superior sporting performance by a performer. This multifaceted nature refers to the complex ecology of relational social, psychological and physiological factors that develop an expansive culture in which coaches attempt to practise (Jones *et al*., 2006). Coaches and trainers use PA to evaluate four major areas of player or team performance, namely physical, mental, technical and tactical skills (Figure 2.4) (Pool, 2008).

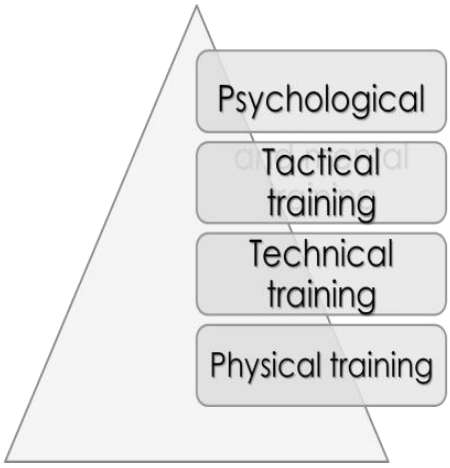


Figure 2.4: Coaching model adapted from Pool (2008)

The ability to observe and assess performance can be considered one of the primary roles of the coach. In recognition of this, research has highlighted the potential limitations to the coach's ability to observe, recall, give feedback and analyze key events (Wright *et al*., 2013). Coaching is the main application area of PA. PA processes used in coaching depend on a number of factors, including the nature of the sport, level of the participants and access to technology.

Rugby is based on two main principles, namely attack and defence (IRB, 2013c). Attack is when a team have possession of the ball and defence when the team are not in possession of the ball (IRB, 2013c). These principles of play identify what has to be achieved by a team to play successfully in a match. The principles provide the coach with a checklist that can be used to analyze the team's play. They also provide a coach

with categories in which to analyze the strengths and weaknesses of a team. These will help determine the team's game plan and patterns of play.

PA involves categorizsing what events or actions have occurred within a match, enabling coaches and trainers to create an objective statistical account of the match to use when giving feedback (Carling *et al*., 2008). The coaching process comprises a number of steps or cycles and the importance of analyzing play is highlighted in Figure 2.5.

The schema in Figure 2.5 outlines the coaching process in its observational, analytical and planning phases. The match is viewed (observational phase) and coach and trainers will form an idea of positive (strengths) and negative (weaknesses) aspects (analytical phase) of the performance during practice or matches. Often the results of previous matches and training are considered before planning and preparing (planning phase) for the next match. After the match has been played the process repeats itself. However, there are problems associated with a coaching process that relies heavily on the subjective assessments of match actions (Franks, 2004).

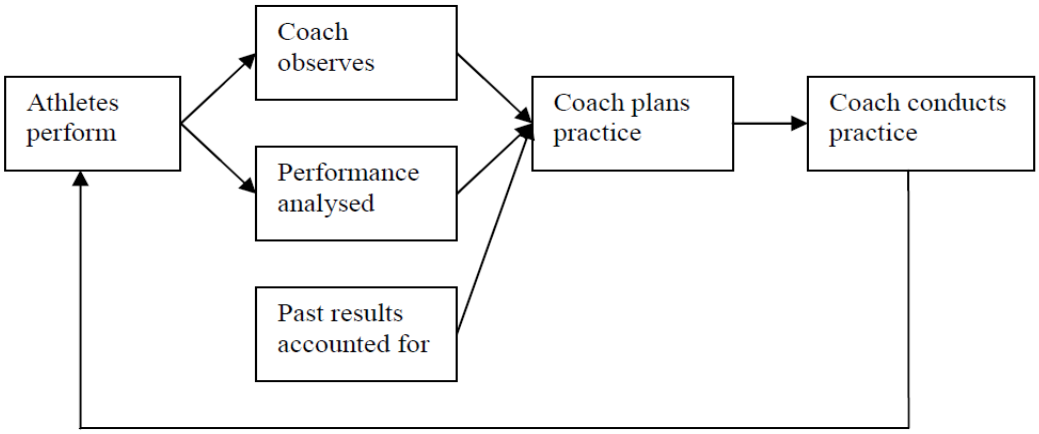


Figure 2.5: Coaching process adapted from Franks (2004)

The role of PA in the coaching process is to provide additional feedback based on a systematic and objective analysis. The information produced by PA includes quantitative information. According to O'Donoghue and Mayes (2013), Winkler's systematic PA process is only possible if: a) the aims of the observation are clearly defined; b) observation methods include technical aids; c) there is a viable means of analysis of observation; d) results are presented in the form of video sequences, figures, graphs and tables; and e) results are interpreted and stored for future reference.

The following section will seek to address different components in order to assist coaches and trainers with preparation for training and match play.

i. Periodization and strategic planning

Periodization involves the division of an entire rugby season into smaller phases of training in order to provide a framework for planned and systematic variation of training. A key role of periodization in rugby is to prevent stagnation, but it should also reduce the potential for overtraining, maintain performance throughout the competitive season, and ensure players peak at the appropriate time of the year (Bompa, 2009). Rugby requires the development and maintenance of multiple physical, technical and tactical qualities over an extended completive season. When planning the training programmes several factors need to be taken into consideration, such as the perceived importance of matches, difficulty of matches and the extent of disruption in case of travelling. The seasonal plan for international and national teams should include details of all training camps, along with international and national fixtures. Tours, tournaments and training camps can be very disruptive when travelling across several time zones. The seasonal plan should also take into account the technical and tactical proficiency and physical development of all the players in the squad or team.

ii. Technical and tactical coaching and preparation

For players and teams to excel in rugby they need a wide variety of skills–from technical to tactical to psychological aspects. In order to achieve their potential these skills need to be developed in a systematic and integrated way. The guidance and facilitation of a coach can be invaluable. The game of rugby is classified as an invasive ball sport based around principles of attack and defence (IRB, 2013c). The essential requirements of rugby performance comprise a combination of multifaceted physiological capacities, advanced technical abilities and complex tactical decision making.

Technique is the ability to use certain movements or actions. In rugby the term technique refers to the movements executed by players during practices or match play. The principles of attack and defence identify what has to be achieved, while the performance of individual skills is the route by which this can take place. There is therefore a link between each principle and the skills used to achieve these principles. A key factor analysis (KFA) breaks down each of the techniques of the game into its components, which, when executed in the correct sequence, will enable the player to

execute the technique correctly. Rugby requires players to be proficient in a number of skills in order to play the game. General play skills can consist of running, tackling, passing, catching, rucking and mauling, and set-piece skills consist of scrummaging, kick restarts, line-outs and kicking at goal (IRB, 2013c).

Tactics and strategies are important concepts of rugby coaching and can be used during training or match play. Strategy is the organization of training or match play that is based on a philosophy or way of approaching a certain game situation. Within the strategic framework are tactics, also referred to as game plans. Tactical training in rugby refers to training attacking and defending objectives. The main objective of rugby is to score points through tries, conversions, penalties and drop goals. A further objective is to restrict the number of points scored by the opposition. The basis of any successful game plan is a high level of technical proficiency, thus technique is a limiting factor for all game plans and game plans are a function of a player's technique. Physical training is the foundation of technical and tactical coaching. Securing possession of the ball is a fundamental element required to score points and win games in rugby. Vahed *et al*. (2016) state that the modern domestic rugby game has changed to one that is more physical and continuous, with an increased number of player actions (passes, tackles and rucks/mauls) and a reduced number of stoppages, predominantly in the second half. Thus training programmes should place an emphasis on teaching players the correct techniques at the contact situation while on attack or defence.

iii. Physical conditioning

Rugby has changed into a physical and continuous demanding game, therefore training programmes should put emphasis on developing players around the various contact situations while on attack or in defence in the game and not only on the running-based demands when looking at speed and agility or interval training. This is important for developing effective forwards, as they participate in the most contact situations during a match. Repeated sprint sessions should include short periods of resistance work between the sets and/or repetitions. The most recent development in training drill is the Rugby-Specific Repeated Sprint (RS2), which has been shown to simulate the repeated running and contact efforts of the game (Hendricks and Lambert, 2010). Adding intermittent wrestling to small-sided games has been shown to improve the repeated high-intensity effort ability specific to rugby, as well as introduce a level of pressure and fatigue. Importantly, it has been found that the addition of wrestling

does not compromise the volume or quality of skill involvement; instead, players adapt to the constraints by producing faster ball movements (Garraway *et al*., 2014).

Agility training involving contact could be incorporated into current speed and contact drills. Wheeler and Sayers (2011) examined the running technique of rugby players under various conditions and found that players changed their running technique in response to a defender. They highlighted the importance of body height and shortening strides to fend off defenders. Worsnop (2012) also mentioned key aspects of dominating contact for both attacking and defending players. High levels of leg strength are needed to drive forward in the contact and upper-body strength to twist and turn the ball carrier. Training these techniques of dominating contact could prevent excessive body impact and associated injuries (Smart and Gill, 2013; Smart *et al*., 2013). Training sessions that target specific energy systems should not only focus on repeated running movements (accelerating, decelerating), but also include falling down and getting back up, as these movements follow tackles and rucks/mauls.

The energy expenditure of falling and getting back up is demanding on players. Multi-direction movements should be implemented in speed training sessions and warm-up plans, as these movements are prominent when players are forming defensive patterns. When defending players normally run backward and side shuffle to get into a position to tackle, this is followed by a forward movement, running forward or jogging. When designing fitness sessions based around defensive patterns these movements should be used to fatigue players. Pre-season rugby training should place a priority on strength development and transferring strength to functional, rugby-specific movements. The use of plyometrics and strongman-based strength/power exercises is ideal for transferring strength gains attained into functional, more specific movements (Gabbett, 2012).

iv. Monitoring of players

Owing to the dynamic nature of the game and high frequency of events, nobody can adequately recall all aspects of the game; therefore performance analysts are playing an increasingly important role in rugby. The ability of analysts to meet this demand is being enhanced by technological advancements worldwide, including the integrated capabilities of digital video, computer systems and video analysis software. Most analyses are conducted post-match by reviewing video footage and coding events of interest. Sound methodological approaches exist to develop PIs, which, if appropriately

collated, can be used to create PPs indicative of player and/or team abilities. Sufficient data should be collected to ensure valid profiles, which can then be compared with population norms for more objective interpretation. PPs for tournaments and opponents should be developed to help understand what players go through physically and help understand and interpret tactical strengths and weaknesses. Research examining muscle damage and recovery among rugby players during matches has shown that the degree of muscle damage is related to the number of contacts sustained in a match (Austin *et al*., 2011; Smart and Gill, 2013; Smart *et al*., 2013). Performance analysts should identify the number of contact situations in which each player was involved, which coaches, specialist coaches, trainers and medical staff should use when monitoring players, implementing recovery strategies and planning different training loads. Quarrie *et al*. (2013) concluded that due to the large differences in movement patterns, contact loads and activities between positional groups imply a need for different conditioning and recovery programmes for different groups. Forwards may in general require greater time to recover after a match than backs given the greater contact loads they sustain.

Player fatigue is influenced by the number of matches played over a competitive season (Hartwig *et al*., 2009) and the number of days and training load imposed on players between matches (McLean *et al*., 2010). In most cases players recover from symptoms of fatigue after training or a match within 48 to 72 hours. However, excessive training and match loads and poor management of recovery afterwards are likely to result in players demonstrating more prolonged signs of fatigue. If left unattended, this underrecovery could affect a player or team's performance capability and health. Physical contact has been described as the main cause of injuries in rugby across different levels (Gabbett, 2008). Due to rugby leaning more towards a contact-oriented game, it is important for specialists to design and implement return-to-play protocols for teams. When standardizing and developing these protocols, coaches need to take into consideration the role and position these players fulfil during match play, and the type of exercise, volume and intensity.

v. Recovery of players

Training in its simplest form represents acute challenges to the body intended to optimize chronic improvements in physiological capabilities (Bishop *et al*., 2008). Speedy and complete recovery after training and matches is very important, given the often congested competitive playing and training schedules of modern rugby players.

It is often stated that optimal performance is only achievable if players balance training and competition stress with adequate time for recovery (Coutts and Sirotic, 2004; Fuller and Paccagnella, 2004; Kellmann, 2009). Lambert and Borresen (2006) suggest that inadequate recovery is a training error preventing players from producing peak performances. Players do not only have to deal with physical strain, but also have to cope with psychological, emotional, social and behavioural stressors. Training programmes and competition schedules are so demanding that "natural" means of recovery alone can no longer provide adequate outcomes (Rushall and Pyke, 1990). The player should implement a variety of recovery modalities as part of an effective regeneration strategy. According to Peterson (2005:64) "the concept of effective, regular, and varied recovery activities has become part of the language of today's smart, professional athlete".

vi. Injury management

Due to the change in game dynamics coaches need to understand the physical demands of attack and defence in rugby. Understanding these demands can assist coaches and trainers with information to design and develop proper training drills and equipment, plan and manage training and recovery between training sessions and matches, and minimize the risk of injury. The tackle area, breakdown and defence in rugby put players at the highest risk of injury compared to any other facet of play (Gabbett, 2008). National programmes such as RugbySmart in New Zealand and BokSmart in South Africa equip coaches and players with information to reduce the risk of injury by promoting safe techniques. The study by Hendricks and Lambert (2014) indicated that televised rugby matches and programmes have more influence on players' tackling technique than rugby training videos or books. Most of the players' knowledge of tackle techniques was obtained at under-19 level. During matches, bringing the opposing player down at all cost was more important than proper technique, staying on your feet and safety. Coaches seem to emphasize good techniques during tackle training. However, the importance of these techniques is not always carried over into matches. Hendricks *et al*., (2014) state that in order to develop safe tackling techniques coaches should do effective tackle skill training and proper physical conditioning. Strength, power, equipment and attitude/motivation can offset the upper limit.

vii. Analysis and feedback

Due to the change in match profile as a result of law changes, coaches and trainers could take the following suggestions into consideration when analyzing matches and constructing and implementing training programmes: The norm for technical staff is to record and analyze data of a match as a whole, but in order to be more specific the match could be broken down into two separate halves as some important information may be lost when reviewing the match as a whole. One half's PIs may be significantly higher than those of the other half (Vahed *et al*, 2014). A match could even be broken down into four quarters to provide better insight. Coaches, specialist coaches and trainers should develop PPs of their own team and the opponents to assist them with preparation and planning.

Coaches and trainers need to find a variety of delivery methods, which cater for each individual player's learning style, and make sure players stay motivated with regard to the use of PA to improve performance. Coaches should encourage the active involvement of players during feedback sessions and ensure each individual player takes responsibility for conducting his own analysis on his performance and the performance of his direct opponent to enhance his knowledge of the game (Francis and Jones, 2014).

2.6. Summary

Rugby is an extremely physically demanding game. With the implementation of ELVs and law changes and amendments after the 2007 RWC, ball-in-play time and the number of events players are involved in have increased dramatically. Modern coaching and training regimes are often restricted by outdated information. The aim of this review article was to provide greater insight into the demands of the modern game in order to provide coaches, trainers and performance analysts with better information from which they can make more informed decisions regarding coaching and training regimes.

Due to rugby's increasing level of professionalism, coaching and rugby performance analysis are evolving rapidly. Coaches are demanding greater access to more detailed analysis of team and player performance. The key element to achieve success in rugby is to be able to replicate and often exceed match-play demands in training. In order for

coaches to do so they require accurate, longitudinal and reliable information regarding all aspects of match-play performance. These aspects include technical and tactical proficiency and the effect of law changes on the demands of match play.

2.7. References

Austin, D., Gabbett, T. & Jenkins. D. (2011). The physical demands of Super 14 rugby union. **Journal of Science and Medicine in Sport**, 14: 259-263.

Bartlett, R. (2001). Performance analysis: can bringing together biomechanics and notational analysis benefit coaches? **International Journal of Performance Analysis in Sport**, 1(5): 122-126.

Bishop, P.A., Jones, E. & Woods, A.K. (2008). Recovery from training: a brief review. **Journal of Strength and Conditioning Research**, 22(3): 1015-24

Bompa, T.O. (2009). Periodization: Theory and methodology of training (5th ed). Champaign, IL: Human Kinetics.

Bracewell, P.J. (2003). Monitoring meaningful rugby ratings. **Journal of Sports Sciences**, 21: 611-620.

Butterworth, A., O'Donoghue, P.G. & Cropley, B. (2013). Performance profiling in sports coaching: a review. **International Journal of Performance Analysis in Sport**, 13: 572-593.

Carling, C., Reilly, T. & Williams, A.M. (2008). Performance Assessment for Field Sports. London: Routledge.

Coutts, A. and Sirotic, A. (2004). Post-match recovery practices. **Sports Coach**, 27(2): 20-23.

Cunniffe, B., Proctor, W., Baker, J.S. & Davies, D. (2009). An evaluation of the physiological demands of elite rugby union using global positioning system tracking software. **Journal of Strength and Conditioning Research**, 23(4): 1195-1203.

Duthie, G., Pyne, D. & Hooper, S. (2003), Applied physiology and game analysis of rugby union. **Journal of Sports Medicine**, 33(13): 973-991.

Eaves, S.J. and Hughes, M. (2003). Patterns of play of international rugby union teams before and after the introduction of professional status. I**nternational Journal of Performance Analysis in Sport,** 3(2): 103-111.

Eaves, S.J., Lamb, K. L. & Hughes, M.D. (2008a). The impact of rule and playing season changes on time variables in professional rugby league in the United Kingdom. **International Journal of Performance Analysis in Sport**, 8(2): 45-54.

Eaves, S.J. Hughes, M.D. & Lamb, K. (2008b). Assessing the impact of the season change and rule change on specific match and tactical variables in professional rugby league rugby league in the United Kingdom. **International Journal of Performance Analysis in Sport**, 8(2): 104-108.

Francis, J. and Jones, G. (2014). Elite Rugby Union Players' Perceptions of Performance Analysis. **International Journal of Performance Analysis in Sport**, 14: 188-207.

Franks, M.I. (2004). **Notational analysis of sport: Improving Coaching and Performance in Sport**, (2nd ed). London: E. and F.N. Spon.

Fuller, K. and Paccagnella, M. (2004). Revitalising body and soul - physiological and psychological strategies for recovery. **Sports Coach**, 27(3): 14-16.

Fuller, C.W., Raftery, M., Readhead, C., Stephen G.R., Targett, S.G.R. & Molloy, M.G. (2009). Impact of the International Rugby Board's experimental law variations on the incidence and nature of match injuries in southern hemisphere professional rugby union. **South African Medical Journal**, 99(4): 232-237.

Fuller, C.W., Taylor, A.E., Brooks, J.H.M. & Kemp, S.P.T. (2013). Changes in the stature, body mass and age of English professional rugby players: A 10-year review. **Journal of Sports Sciences**, 31(7): 795-802.

Gabbett T.J. (2008). Influence of fatigue on tackling technique in rugby league players. **Journal of Strength Conditioning Research**, 22(2): 625-32.

Gabbett, T.J., Jenkins, D.G. & Abernethy, B. (2012). Influence of wrestling on the physiological and skill demands of small-sided games. **National Strength and Conditioning Association**, 26(1): 113-120.

Gabbett, T.J. Kelly, J. N. & Sheppard, J.M. (2008), Speed, change of direction speed, and reactive agility of rugby league players. **Journal of Strength and Conditioning Research**, 22(1): 174-181.

Garraway, W.M., Lee, A.J., Hutton S.J., Russell, E.B.A.W. & Macleod, D.A.D. (2014). Impact of professionalism on injuries in rugby union, **Journal of Sports Medicine**, 34: 348-351.

Green, B.S., Blake, C. & Caulfield, B.M. 2011). A valid field test protocol of linear speed and agility in rugby union, **Journal of Strength and Conditioning Research**, 25(5): 1256-1262.

Hartwig, T.B., Naughton, G. & Searl, J. (2009). Load, stress and recovery in adolescent rugby union players during a competitive season. **Journal of Sports Sciences**, 27: 1087-1094.

Hendricks, S., Karpul, D. & Lambert, M. (2014). Momentum and kinetic energy before the tackle in rugby union. **Journal of Sports Science and Medicine**, 13(3): 557–563.

Hendricks, S., Roode B., Matthews, B. & Lambert, M. (2013). Defensive structures in rugby union. **Perceptual & Motor Skills: Exercise & Sport**, 11: 765-87.

Hendricks, S. & Lambert, M. (2010). Tackling in rugby: coaching strategies for effective technique and injury prevention. **Journal of Sports Science & Coaching**, 5(1): 117-136.

Hughes, M. and Bartlett, R.M. (2002). The use of performance indicators in performance analysis. **Journal of Sports Sciences**, 20: 739-754.

International Rugby Board (2007a). Statistics review and match analysis: six nations IRB game analysis 2007, Dublin, Huguenot House.

International Rugby Board (2007b). Statistics review and match analysis: tri nations IRB game analysis 2007, Dublin, Huguenot House.

International Rugby Board (2008a). Statistics review and match analysis: six nations IRB game analysis 2008, Dublin, Huguenot House.

International Rugby Board (2008b). Statistics review and match analysis: tri nations IRB game analysis 2008, Dublin, Huguenot House.

International Rugby Board (2008c). The IRB guide to experimental law variations. Dublin, Huguenot House.

International Rugby Board (2009a). Statistics review and match analysis: six nations IRB game analysis 2009, Dublin, Huguenot House.

International Rugby Board (2009b). Statistics review and match analysis: tri nations IRB game analysis 2009, Dublin, Huguenot House.

International Rugby Board (2010a). Statistics review and match analysis: six nations IRB game analysis 2010, Dublin, Huguenot House.

International Rugby Board (2010b). Statistics review and match analysis: tri nations IRB game analysis 2010, Dublin, Huguenot House.

International Rugby Board (2011a). Statistics review and match analysis: rugby world cup 2011, Dublin, Huguenot House.

International Rugby Board (2011b). Statistics review and match analysis: six nations IRB game analysis 2011, Dublin, Huguenot House.

International Rugby Board (2011c). Statistics review and match analysis: tri nations IRB game analysis 2011, Dublin, Huguenot House.

International Rugby Board (2012a). Statistics review and match analysis: six nations IRB game analysis 2012, Dublin, Huguenot House.

International Rugby Board (2012b). Statistics review and match analysis: tri nations IRB game analysis 2012, Dublin, Huguenot House.

International Rugby Board (2012c). Laws of the game, rugby union. Dublin, Huguenot House.

International Rugby Board (2013a). Statistics review and match analysis: six nations IRB game analysis 2013, Dublin, Huguenot House.

International Rugby Board (2013b). Statistics review and match analysis: the rugby championship IRB game analysis 2013, Dublin, Huguenot House.

International Rugby Board (2013c). International Rugby Board Level 3 Coaching Analysis and Preparation for coaches. Dublin: The Bridge.

International Rugby Board (2014a). Statistics review and match analysis: six nations IRB game analysis 2014, Dublin, Huguenot House.

International Rugby Board (2014b). Statistics review and match analysis: the rugby championship IRB game analysis 2014, Dublin, Huguenot House.

James, N., Mellalieu, S.D. & Jones, N.M.P. (2005). The development of position-specific performance indicators in professional rugby union. **Journal of Sports Sciences**, 23: 63-72.

Jones, R.L. (2006). The Sports Coach as Educator (1st ed.). London and New York: Routledge.

Kraak, W.J. and Welman, K.E. (2014). Ruck-play as performance indicator during the 2010 Six Nations Championship. **International Journal of Sport Science and Coaching**, 9(3): 525-537.

Kellmann, M. (2009). Is recovery important? [Abstract]. **Journal of Science and Medicine in Sport**, 12S: S21.

Lambert, M. and Borresen, J. (2006). A theoretical basis of monitoring fatigue: A practical approach for coaches. **International Journal of Sports Science and Coaching**, 1(4): 371-388.

Malcolm, D., Sheard, K. & Smith, S. (2004). Protected research: Sports medicine and rugby injuries. Sport in society: **Cultures, Commerce, Media, Politics**, (7)1: 95-108.

McLean, B.D., Coutts, A.J., Kelly, V., McGuigan, M.R. & Cormack, S.J. (2010). Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players. **International Journal of Sport Physiology and Performance**, 5: 367-383.

McLellan, C. P., Coad, S., Marsh, D. & Lieschke, M. (2013). Performance analysis of Super 15 rugby match-play using portablemicro-technology. **Journal of Athletic Enhancemen**t, 2(5). doi:10.4172/2324-9080.1000126.

Mellalieu, S., Trewartha, G. & Stokes, K. (2008). Science and rugby union. **Journal of Sports Sciences**, 26(8): 79–794.

Murray, A.D., Murray, I.R. & Robson, J. (2012). Rugby union: Faster, higher, stronger: Keeping an evolving sport Safe. **British Journal of Sports Medicine**, (In Print).

O'Donoghue, P. (2005). Normative profiles of sports performance. **International Journal of Performance Analysis in Sport**, 5(1): 104-119.

O'Donoghue, P. (2006). The use of feedback videos in sport. **International Journal of Performance Analysis in Sport**, 6(2): 1-14.

O'Donoghue, P.G. and Mayes, A. (2013), Coach behavior. In McGarry, T., O'Donoghue, P.G. and Sampaio, J. (Eds) Routledge Handbook of Sports performance Analysis, pp. 165 – 175. London: Routledge.

Ortega, E., Villarejo, D. & Palao, J.M. (2009). Differences in game statistics between winning and losing rugby teams in the Six Nations Tournament. **Journal of Sports Science and Medicine,** 8,523-527.

Owen, S.M., Venter, R.E., Du Toit, S. & Kraak, W.J. (2015). Acceleratory match-play demands of a Super Rugby team over a competitive season. **Journal of Sports Sciences**, doi: 10.1080/02640414.2015.1028086 (in print).

Peterson, K. (2005). Overtraining: balancing practice and performance. In S. Murphy (Ed.), The sport psych handbook (49-70). Champaign, IL: Human Kinetics.

Pool, G. (2008). Rugby: Understanding the game. A visual explanation (1st ed). Stellenbosch, South Africa: Rapid Access Publishers.

Prim, S., Van Rooyen, M.K. & Lambert, M. (2006). A comparison of performance indicators between the four South African teams and the winners of the 2005 Super 12 Rugby competition. What separates top from bottom? **International Journal of Performance Analysis in Sport**, 6(2): 126-133.

Quarrie, K.L. (2009). An evaluation of the Experimental Law Variations in Air New Zealand Cup Rugby. New Zealand Rugby Union.

Quarrie, K. L. and Hopkins, W.G. (2007). Changes in player characteristics and match activities in Bledisloe Cup rugby union from 1972 to 2004. **Journal of Sports Sciences**, 25: 895–903.

Quarrie, K.L., Hopkins, W.G., Anthony, M.J. & Gill, N. (2013). Positional demands of international rugby union: evaluation of player actions and movements. **Journal of Science and Medicine in Sport**, 16: 353-359.

Reid, L.C., Cowman, J.R., Green, B.S., Garrett, F. & Coughlan, G.F. (2013). Return to play in elite rugby union: Application of global positioning system technology in return-to-running programs. **Journal of Sport Rehabilitation**, 22: 122-129.

Roberts, S.P., Trewartha, G, Higgitt, R.J., El-Abd, J. & Stokes, K.A. (2008). The physical demands of elite English rugby union. **Journal Sports Science**, 26: 825-833.

Robertson, S.J. and Joyce, D.G. (2014). Informing in-season tactical periodization in team sport: development of a match difficulty index for Super Rugby. **Journal of Sports Sciences**, 30: 1-9.

Rushall, B.S. and Pyke, F.S. (1990). Training for sport and fitness. Melbourne, Australia: MacMillan.

Sasaki, K., Furukawa, T., Murakami,J., Shimozono, H., Nagamatsu, M., Miyao, M., Yamamoto, T., Watanabe, I., Yasugahira, H., Saito, T., Ueno, Y., Katsuta, T. & Kono, I. (2007). Scoring profiles and defense performance analysis in Rugby Union. **International Journal of Performance Analysis in Sport**, 7(3): 46-53.

Sinclair, J., Taylor, P.J., Atkins, S., Bullen, J., Smith, A. & Hobbs, S.J. (2014). The influence of lower extremity kinematics on ball release velocity during in-step place kicking in rugby union. **International Journal of Performance Analysis in Sport**, 14: 64-72.

Smart, D.J. and Gill, N.D. (2013). Effects of an off-season conditioning program on the physical characteristics of adolescent rugby union players. **Journal of Strength and Conditioning Research**, 27(3): 708-717.

Smart, D.J., Hopkins, W.G. & Gill N.D. (2013). Differences and changes in the physical characteristics of professional and amateur rugby union players. **Journal of Strength and Conditioning Research**, 27(11): 3033-3044.

Van den Berg, P. and Malan, D.D.J. (2012). The effect of experimental law variations on the super 14 rugby union tournament. **African Journal for Physical Health Education, Recreation and Dance**, 18(3): 476-486.

Vahed, Y., Kraak, W. & Venter, R. (2014). The effect of the law changes on time variables of the South African Currie Cup Tournament during 2007 and 2013. **International Journal of Performance Analysis of Sport**, 14(3): 868-885.

Vahed, Y., Kraak, W. & Venter, R. (2016). Changes on the match profile of the South African Currie Cup Tournament during 2007 and 2013. **International Journal of Sport Science and coaching**, (in print).

Van Rooyen M.K., Diedrick, E. & Noakes, T.D. (2010). Ruck frequency as a predictor of success in the 2007 rugby world cup tournament. **International Journal of Performance Analysis in Sport**, 10(1): 33-46.

Van Rooyen, M.K., Rock, K., Prim, S. & Lambert, M. (2008). The quantification of contacts with impact during professional rugby matches. **International Journal of Performance Analysis in Sport**, 8(1): 133-126.

Vaz, L., Carreras, D. & Kraak, W. (2012). Analysis of the effect of alternating home and away field advantage during the Six Nations Rugby Championship. **International Journal of Performance Analysis in Sport**, 12: 593-607.

Vaz, L., Van Rooyen, M. & Sampaio, J. (2010), Rugby game-related statistics that discriminate between winning and losing teams in IRB and Super twelve close games. **Journal of Sports Science and Medicine**, 9: 51-55.

Williams, J. Hughes, M.D. & O'Donoghue, P. (2005). The effect of rule changes on match and ball in play time in rugby union. **International Journal of Performance Analysis in Sport**, 5(3): 1-11.

Wheeler, K.W., Askew, C.D. & Sayers, M.G. (2010). Effective attacking strategies in rugby union. **European Journal of Sport Science**, 10(4): 237-242.

Wheeler, K.W. and Sayers, M.G.L. (2011). Rugby union contact skills alter evasive agility performance during attacking ball carries. **International Journal of Sport Science & Coaching**, 6(3): 419-432.

Wheeler, K.W., Mills, D., Lyons, K. & Harrinton W. (2013). Effective defensive strategies at the ruck contest in rugby union. **International Journal of Sport Science Coaching**, 8(3): 462-491.

Worsnop, S. (2012). Rugby games and drills / rugby football union. United States of America: Human Kinetics.

Wright, C., Atkins, S. & Jones, B. (2012). An analysis of elite coaches' engagement with performance analysis services (match, notational analysis and technique analysis). **International Journal of Performance Analysis in Sport**, 12: 436-451.

Wright, C., Atkins, S., Jones, B. & Todd, J. (2013). The role of performance analysts within the coaching process: Performance Analysts Survey 'The role of performance analysts in elite football club settings'. **International Journal of Performance Analysis in Sport,** 13(1): 240-261.

CHAPTER THREE
RESEARCH ARTICLE ONE

How did law changes affect the scoring profile of international rugby union between 2007 and 2013?

This article has been submitted for publication in the European Journal of Sport Science. The article is included herewith in accordance with the guidelines for authors of this esteemed journal (included as Appendix B). However, to provide a neat and well-rounded final product for this dissertation, the article has been edited to represent an actual published article as it would appear in this particular journal. This does not imply that the article has been accepted or will be accepted for publication. Consequently, the referencing style used in this chapter may differ from that used in the other chapters of this dissertation.

How did law changes effect the scoring profile of international rugby union between 2007 and 2013?

WILBUR KRAAK*, RANEL VENTER & FREDERIK COETZEE

Field of study: Sport Science (Performance analysis)

Running title: Scoring profile of rugby union

Wilbur Kraak* (Corresponding author)

Department of Sport Science

Stellenbosch University

Matieland

Republic of South Africa

7601

Tel: (+27) 21 808 4915

Email: kjw@sun.ac.za

Ranel Venter

Department of Sport Science

Stellenbosch University

Matieland

Republic of South Africa

7601

Email: rev@sun.ac.za

Frederik Coetzee

Department of Exercise and Sport Sciences

University of the Free State

Bloemfontein

Republic of South Africa

9300

Email: coetzeef@ufs.ac.za

How did law changes effect the scoring profile of international rugby union between 2007 and 2013?

WILBUR KRAAK*[a], RANEL VENTER[a] & FREDERIK COETZEE[b]

[a] *Department of Sport Science, Stellenbosch University, Republic of South Africa, 7601*

[b] *Department of Exercise and Sport Sciences, University of the Free State, Republic of South Africa, 9300*

Abstract

Scoring profiles in rugby are used to provide coaches with information on which source teams scored and conceded points from so that they can, amongst others, get an idea of a team's strengths and weaknesses. The purpose of this study was to investigate and compare the scoring profiles of international rugby between 2007 and 2013 in order to determine how law changes had influenced the game. A mixed-method design was used for data collection. A total of 248 matches were recorded and analyzed by means of the Fairplay video analysis software package (4.08.287). Semi-structured interviews were conducted with 16 expert coaches, specialist coaches and players. The scoring profile of international rugby revealed a decrease in the number of tries ($p=0.07$) and drop goals ($p=0.06$) and a significant increase in the number of penalty kicks ($p<0.01$). Although not statistically significant, a trend showed that more points and tries were scored during the 2nd halves and especially during the 4th quarters of the matches across most of the years. Information on scoring profiles can provide information to assist coaches and trainers in simulating specific match situations during training, as well as to create performance profiles of their own team and the opposition.

Keywords: *Scoring modes, law changes, scoring profile, performance indicators, source of tries*

Introduction

Scoring profiles in rugby union (rugby) are used to provide coaches, performance analysts, technical advisors and trainers with information on scoring modes, the source and field location of tries, and the time in the match when points are scored or conceded so they can create performance profiles (PPs) of their own teams and opposition teams. PPs are a description of a pattern of performance by an individual or team and are created from continual analysis. Such profiles can lead to a better understanding of match situations and tactics implemented by teams, which offers some prediction of future performances (Jones *et al*., 2004; Robertson & Joyce, 2014). During a match, teams can accumulate points through four scoring modes, namely tries (including penalty tries), conversion kicks, penalty kicks and drop goals. All of

these scoring modes can be decisive in determining the outcome of a match (Ortega *et al*., 2009; Stefani, 2009; Lim *et al*., 2011; Vaz *et al*., 2011). Since the onset of professionalism, rugby has evolved into a more structured sport, with teams demonstrating increasingly complex match strategies and tactics (Hendricks *et al*., 2013) in order to be successful.

Rugby is known for its complex laws and unique game structures, which render research from other sports as largely inapplicable (De Lacy & Fox, 2000). Law changes and amendments are fundamental to the development of the game and are introduced for a variety of reasons (Kraak & Welman, 2014). Some of these changes are in response to player performance, to ensure player safety, enhance participation and enjoyment, to promote continuity of the game, technological advancements and commercial pressures, all the while retaining the integrity of the game and its continued development (Eaves *et al*., 2008). World Rugby (WR), formerly known as the International Rugby Board (IRB), is responsible for delivering safe, enjoyable and entertaining rugby events. Laws therefore can provide a framework by which WR can evaluate whether these aspects are being delivered (Murray *et al*., 2012). Williams *et al.* (2005) stated that the effect of law changes in a sport cannot be objectively determined, unless there is some form of measure associated with it. The discipline of performance analysis (PA) can provide impartial records of performance through which the effectiveness of the laws can be assessed. The use of PA, specifically computerized analysis services, has become increasingly accessible across all levels of rugby worldwide (Wright *et al*., 2012), thus the scrutiny of the game has increased. However, it is not clear if or how rugby changed during the period between 2007 and 2013 and in particular if any of the law changes or/and amendments that were made during that time had any influence on the scoring profile of the game, specifically at the international level.

Pulling and Stenning (2015) examined the number of tries scored involving the use of an offload by international teams in the Southern Hemisphere (SH) and Northern Hemisphere (NH) teams. The study recorded a total of 491 offloads, 53% (263 offloads) of which were by the SH teams compared to the 46% (228 offloads) of the NH teams involved. Importantly, the SH teams scored tries from 11% (30) of their offload situations, whereas the NH teams could only manage to convert 4% (9) of their offloads into tries ($U=216.00$, $p=0.02$, $r=-0.31$; $U=206.50$, $p=0.01$, $r=0.36$). These findings suggest that SH international teams are using the offload as an attacking

strategy more effectively to score tries than NH international teams. This is further supported by Wheeler *et al*. (2010), who have found that offloading in the tackle enhances a team's try-scoring potential during matches.

Vaz et al. (2012) analyzed the effect of alternating home- and away-field advantage on selected performance indicators by looking at the scoring profile during the Six Nations Rugby Championship (2005-2009). The study concluded that: (i) generally teams that are playing at home are likely to win more matches, (ii) PIs of the game showed statistically significant differences when teams are playing at home and away; (iii) the results indicated that 50% or more of the total match points are scored when teams play at home. No distinctions were made between the data collected between 2005 and 2007 under a previous set of laws and post 2008 once the law changes and amendments were adopted. Sasaki *et al.* (2007) investigated the scoring profile of the Japanese Top League matches between 2003 and 2005. The study revealed that the number of points decreased from 2003 to 2005 and that scrums and line-outs were the common source of tries (55%). However, the study concluded that poor defence and the frequency of the turnover in ball possession contributed more to scoring tries than attacking play, but there were no references to whether any law changed during this period. The literature relating to scoring profiles of rugby matches, internationally, nationally and domestically, concludes that tries are scored according to the skill levels of the players, without any discussion relating to how changes in the laws governing the game are influencing playing styles.

Research conducted on whether law changes have influenced scoring profiles focused on a domestic competition. Vahed *et al*. (2014) revealed that the total points scored between the 2007 and 2013 seasons of the South African Currie Cup did not show any significant change (3.3±2.0 vs 2.7±1.5, p=0.81); however, the scoring mode had changed from tries to penalty kicks. The total number of tries scored showed a decreasing trend (p=0.07), particularly in the 2nd half of matches in 2013 (p=0.05). According to the authors the possible cause of the reduction in tries could be the introduction of Law 16.7 (c), which states that when the ball has been clearly won by a team at a ruck and is available to be played, the referee will call "use it", after which the ball must be played within five seconds. The study revealed no significance differences between the source of the tries (scrum p=0.13, line-out p=0.25, general play p=0.26). The decrease in the number of tries has consequently led to a decrease in the number of conversion kicks (p=0.07) (Vahed *et al*., 2014).

The focus of this study is to perform a longitudinal analysis of the scoring profiles of international rugby matches incorporating years when there were amendments to the laws, to determine if and/or how the game has been influenced by the law amendments. These findings can assist coaches and trainers with information to re-create match situations during training in order to improve performance on match day. Having a scoring profile will inform coaches of the source from which their team score or concede points so that they can create PPs. Timing profiles can also give an idea of when in the game points are scored or conceded, and whether a team's performance decreases or improves at certain stages of a match. The field location from where the phases of play originate can give an idea of whether the team can score from within their own half or only within the opposition's half – this can show the style of game that should be played to increase the likelihood of creating scoring opportunities or to decrease the probability of conceding points. A team's performance during training and matches is based upon a multitude of focus areas – from individual player's technical and tactical skills to overall team tactics and strategies. When coaching teams, these strengths and weaknesses need to be prioritized into areas of concerns that can be worked upon with a view to improving performance (Laird & Lorimer, 2004). Based on this background the purpose of this study was therefore to investigate and compare the scoring profiles of international rugby between 2007 and 2013.

Methods

Study design

A mixed-method design was used during the research process (De Vos *et al*., 2005). Mixed-method research combines elements of qualitative and quantitative research approaches (e.g. the use of qualitative and quantitative viewpoints, data collection, and analysis and inference techniques) to gain in-depth understanding and corroboration. Coding and quantitative analyses (PA) (N = 248 matches) were done by an accredited performance analyst (Level 6 International Society of Performance Analysis (ISPAS)), who is also an accredited WR coach educator and Level 3 coach.

For qualitative data collection, semi-structured interviews were conducted with expert rugby coaches (n=5), specialist coaches (n=7) and players (n=4). With the use of the mixed-method approach, the possible effect of law changes on specific PIs pertaining to the scoring profile of international rugby union was comprehensively resourced and tested, enhancing the interpretability and application of the research findings.

Sample

Video recordings of international (N = 248) matches played between 2007 and 2013 were analyzed. Semi-structured interviews were conducted with 16 international-level expert rugby coaches, specialist coaches and players. Ethical approval of the research was obtained from Stellenbosch University (REC-050411-032).

Data collection procedures

Television video recordings of international rugby matches were supplied by the company Fika (Cape Town, South Africa). The PIs (Table 3.1) were analyzed by the coding function of the Fairplay (Canberra, Australia) (4.08.287) software package. The video files were viewed and coded in the tagging panel. The same researcher analyzed all the games to prevent inter-rater variability in the different observations and interpretations of activities.

Table 3.1: Performance indicators used in the analyses

Performance indicator	Description
Points per match	Teams are awarded 5 points for scoring a try or being awarded a penalty try, 2 points for successfully converting a try and 3 points for a successful penalty or a drop goal.
Scoring modes	Try (including penalty tries), conversion kick, penalty kicks and drop goals
Breakdown of tries	
Source of tries	*Structured*: Line-out; scrum; kick restart receipt. *Unstructured:* Quick line-out throw-in; kick receipt in general play; quick tap from penalty and free kicks; turnovers at line-out, scrum, tackle/ruck/maul. *Turnover*: General play, ruck and maul, kick in general play, line-out, scrum, kick restart receipt. *Other*: All those not listed above.
Positional groups	1 - 5 (T5), 6 - 8 (LF), 9, 10 & 12 (IB), 11, 14 & 15 (OB) or penalty try
Number of phases	The number of phases needed to score a try.
Location	Zone D – defence area between try line and 22m area. Zone C – defence area between 22m and halfway line. Zone B – attacking area between halfway line and 22m area. Zone A – attacking area between 22m and try line.
Halves and quarters	Matches divided into 2 x 40 minutes and 4 x 20 minutes

Note: T5 – tight forwards, LF – loose forwards, IB – inside backs and OB – outside backs

Reliability

The reliability of the coding was determined by the re-analysis method (test-retest reliability) for inter-rater reliability (Hughes *et al*., 2001; James *et al*., 2005). This method entails a different analyst doing a re-analysis of the video material one month after the original analysis. For the purpose of this study 25% of the matches were re-analyzed by a different experienced performance analyst. Inter-rater agreement was interpreted as follows: poor (0–0.20), fair (0.30–0.40), moderate (0.50–0.60), strong (0.70–0.80) and almost perfect (>0.80) (Liporace *et al*., 2012). Analysis showed that the strength of the agreement between all variables was perfect (1.00).

Statistical analysis

The Centre for Statistical Consultation Services of Stellenbosch University analyzed the research data. The Statistica Data Processing package (Statsoft Inc., 2011) was used to process the data. Descriptive data was reported as frequencies (number of observations), percentages and averages with 95% confidence intervals (CI). A one-way Anova was conducted for PIs that had 1 measurement. A mixed-model repeated Anova was calculated for PIs that had more than 1 measurement. Differences between categorical frequencies were determined by Chi-Square. The year 2007 was used as baseline to compare and track the changes over time between different years. Some PIs are expressed as percentages which, according to Hughes and Bartlett (2002), provide a more accurate analysis of team performance. An alpha level of 0.05 was set for statistical significance. Prior to the start of the semi-structured interviews a majority opinion was referenced as 80% agreement between the experts.

Results

A total of 3162 scoring modes were used that contributed to a total of 10 869 points (Tables 3.2 & 3.3) between the period 2007 to 2013. In total 1 081 tries were scored at an average of 4.35 per match. The average points per match were 22. Tries contributed to 34% of the scoring modes and 50% of the total points. A total of 779 conversion kicks were successful at an average of 3 per match and added to 1 558 points at an average of 14 points per match. Conversion kicks contributed to 25% of the scoring modes and 14% of the total points. A total of 1 216 penalty kicks were kicked at an average of 5 per match and contributed to 3 648 points at an average of

15 points per match. Thirty-nine per cent (39%) of the scoring modes and 34% of the total points were due to penalty kicks. A total of 86 drop goals were kicked successfully at an average of 0.34 per match and contributed to 258 points at an average of 1 point per match. Three per cent (3%) of the scoring modes and 1% of the total points came from drop goals respectively.

Table 3.2: The total number of scoring modes between 2007 and 2013 presented as the number of observations, average scoring mode per match and percentage of total scoring modes and overall scoring mode

f	2007	2008	2009	2010	2011	2012	2013
	n = 54	n = 24	n = 24	n = 23	n = 69	n = 27	n = 27
				Tries			
f	278	93	79**	99	339	90#	103#
95% CI	251 – 307	76 - 113	64 - 97	82 - 119	310 - 370	74 - 109	86 - 123
Average *f*	5	4	3	4	5	3	4
% *f*	37	32	28	29	39	30	30
				Conversion kicks			
f	203	72	52**	73	237	64	78
95% CI	180 - 228	58 – 89	40 - 67	59 - 91	213 - 263	51 - 81	63 - 96
Average *f*	4	3	2.16	3	3	2	3
% *f*	27	25	18	23	27	21	23
				Penalty kicks			
f	255	117	138*	129	275	142*	160*
95% CI	228 - 284	98 - 139	118 - 161	109 - 152	247 - 305	122 - 165	138 - 185
Average *f*	5	5	6	6	4	5	6
% *f*	34	40	49	41	32	47	47
				Drop goals			
f	20	8	14#	10	27	4	3#
95% CI	13 - 29	4 - 15	9 - 22	6 - 17	19 - 36	2 - 10	1 - 8
Average *f*	0.37	0.33	0.58	0.43	0.39	0.14	0.11
% *f*	3	3	5	3	3	1	0.87
				Overall frequency of scoring mode			
f	756	290	283	311	878	300	344
95% CI	170 - 804	24 - 323	23 - 316	28 - 345	230 -928	26 - 334	34 - 380
Average *f*	14	12	12	14	13	11	13

*Note: *Statistically significantly different from 2007 = (p ≤ 0.01), ** statistically significantly different from 2007 = (p ≤ 0.05) and #tendency when p is between 0.06 - 0.09*

Table 3.3: The total number of points scored between 2007 and 2013 presented as points per scoring mode, average points per match, percentage contribution of total points and overall total points

Points	2007	2008	2009	2010	2011	2012	2013
	n = 54	n = 24	n = 24	n = 23	n = 69	n = 27	n = 27
				Tries			
Points	1390	465**	395	495	1965**	450*	515*
95% CI	711 - 1440	205 - 496	151 - 425	217 - 527	1222 – 2017	186 - 481	214 - 548
Average points	26	19.37	17	22	25	17	19
% points	53	47.25	42	47	64	44	44
				Conversion kicks			
Points	406	144	104*	146	474	128**	156
95% CI	57 - 444	18 - 167	9 - 124	17 - 169	67 - 515	14 - 150	18 - 180
Average points	8	6	4	6	7	5	6
% points	15	14.63	11	14	15	13	13
				Penalty kicks			
Points	765	351	414	387*	825 #	426	480
95% CI	210 - 811	115 - 381	167 - 444	131 - 418	209 - 874	166 - 457	185 - 513
Average points	14	14.62	17	17	12	16	18
% points	29	35.67	43	37	27	42	41
				Drop goals			
Points	60	24	42*	30**	81	12**	9*
95% CI	1 - 77	0 - 35	1 - 56	1 - 43	2 - 100	0 - 21	0 - 17
Average points	1	1	0.19	1	1	0.44	0.33
% points	2	2	4	3	3	1	1
				Overall points			
Points	2621	984	955	1058	3075	1016	1160
95% CI	611 - 2709	84 - 1044	79 - 1014	95 - 1120	844 - 3168	90 - 1077	117 - 1225
Average points	49	41	40	46	45	38	43

Note: *Statistically significantly different from 2007 = ($p \leq 0.01$), ** statistically significantly different from 2007 = ($p \leq 0.05$) and #tendency when p is between 0.06 - 0.09

The results showed no statistically significant differences between any of the scoring modes when comparing 2007 with 2008, 2010 and 2011 (Table 3.2). However, when comparing 2007 with 2009, a significant difference in the number of tries scored ($p<0.05$), conversion kicks ($p=0.01$) and penalty kicks ($p=0.00$) was found. Comparing 2007 with 2012, the results showed a significant increase in penalty kicks ($p=0.00$). Comparisons between 2007 and 2013 revealed significant differences for penalty kicks ($p<0.00$).

Table 3.3 presents the total points for each scoring mode, average total points per match and percentage contribution of each scoring mode's points to the total points. Comparing 2007 with 2008 a significant difference was found in points scored from tries ($p=0.03$). When comparing 2007 with 2009, significant differences were observed in points from conversions and penalty kicks ($p<0.001$). When comparing 2007 with 2010 the data revealed significant differences in points from tries ($p=0.01$) and conversion kicks ($p<0.01$). No differences were revealed for any of the scoring modes when comparing 2007 with 2011 ($p>0.05$). The data revealed a significant decrease in tries ($p<0.01$), conversion kicks ($p=0.04$) and drop goals ($p=0.03$) when comparing 2007 with 2012. When 2007 was compared with 2013 a significant difference in tries and drop goals ($p<0.001$) was revealed.

The frequency of scoring mode and total points per half and quarter and specific mode will be presented next. The results are also shown in Table 3.4. When comparing 2007 with 2008, 2009, 2011 and 2013 no significant differences in terms of percentage tries scored per half and quarter were found. However, comparing 2007 with 2009, significant differences were revealed for the 1st quarter with regard to the number of tries ($p=0.01$). The year 2010 showed significant differences in tries in the 1st quarter ($p=0.05$). When comparing 2007 with 2008, 2009, 2011, 2012 and 2013 no significant differences in terms of percentage conversion kicks scored per half and quarter were found. Conversion kicks showed significant differences for the 1st half ($p<0.01$) and 2nd half ($p<0.01$), 1st quarter ($p<0.01$), 2nd quarter ($p<0.01$), 3rd quarter ($p<0.01$) and 4th quarter for 2012.

Table 3.4: Percentage frequency and points for each scoring modes per half and quarter

Timing	2007	2008	2009	2010	2011	2012	2013
	n = 54	*n = 24*	*n = 24*	*n = 23*	*n = 69*	*n = 27*	*n = 27*
				Tries			
1st half	41%	43%	44%	51%	44%	43%	41%
2nd half	59%	57%	56%	49%	56%	57%	59%
1st quarter	14%	17%	11%	27%*	21%**	18%	16%
2nd quarter	27%	26%	33%	23%	22%	26%	25%
3rd quarter	24%	23%	25%	16%	22%	24%	23%
4th quarter	35%	34%	30%	33%	35%	32%	36%
				Conversion kicks			
1st half	39%	42%	48%	48%*	40%	44%	42%
2nd half	61%	58%	52%	52%*	60%	56%	58%
1st quarter	13%	18%	13%	25%*	19%	17%	18%
2nd quarter	26%	24%	35%	23%*	21%	27%	24%
3rd quarter	24%	21%	25%	16%*	22%	25%	21%
4th quarter	36%	38%	27%	36%*	38%	31%	37%
				Penalty kicks			
1st half	54%	58%*	55%*	58%	65%	56%	61%*
2nd half	46%	42%*	45%*	42%	35%**	44%	39%
1st quarter	13%	30%*	28%*	25%*	29%*	21%#	30%
2nd quarter	41%	28%*	28%*	33%	36%	35%	31%
3rd quarter	27%	21%*	28%*	22%	15%*	24%	21%
4th quarter	19%	21%*	17%*	20%	20%	20%	18%
				Drop goals			
1st half	50%	38%	64%	40%	44%	25%	33%
2nd half	50%	63%	36%	60%	56%	75%	67%
1st quarter	10%	25%	14%	20%	22%	25%	33%
2nd quarter	40%	13%	50%	20%	22%	0%	0%
3rd quarter	15%	0%	14%	10%	22%	0%	0%
4th quarter	35%	63%	21%	50%	33%	75%	67%

Note: *Statistically significantly different from 2007 = ($p \leq 0.01$), ** statistically significantly different from 2007 = ($p \leq 0.05$) and #tendency when p is between 0.06 - 0.09

Table 3.5: Percentage of tries per positional group, location, source and number of phases

PIs	2007	2008	2009	2010	2011	2012	2013
	n = 54	*n = 24*	*n = 24*	*n = 23*	*n = 69*	*n = 27*	*n = 27*
				Positional groups			
Tight forwards	14%	14%	9%	14%	16%	11%	15%
Loose forwards	22%	9% *	13%	19%	13% *	7% *	17%
Inside backs	18%	17%	23%	13%	18%	21%	13%
Outside backs	45%	58%	56%	53%	52%	60% #	54%
Penalty tries	0%	2%	0%	0%	1%	1%	1%
				Location			
Zone A	31%	9%*	42%	39%	37%	39%	43% #
Zone B	35%	47%	43%	30%	33%	32% *	31%
Zone C	30%	41%	15% **	28%	25%	29%	20%
Zone D	4%	3%*	0% #	2%	5%	0% **	6%
				Source			
Structured	47%	43%	46%	42%	50%	47%	43%
Unstructured	24%	25%	23%	26%	19%	23%	23%
Turnover	27%	23%	20%	26%	30%	26%	32%
Other	2%	10%*	11%*	5%	1%	4%	2%
				Number of phases			
1 phase	46%	46%	53%	31%#	33%*	37%	29%**
2 phases	23%	15%	15%	18%	18%	13%#	20%
3 phases	12%	3%**	5%	11%	12%	10%	20%#
4 phases	5%	11%#	6%	11%#	11%**	4%	7%
5 phases	5%	3%	6%	10%	6%	7%	10%
6 phases	1%	5%**	1%	7%*	7%*	2%	4%
6> phases	6%	16%*	13%#	11%	12%**	27%*	10%

Note: *Statistically significantly different from 2007 = ($p \leq 0.01$), ** statistically significantly different from 2007 = ($p \leq 0.05$) and #tendency when p is between 0.06 - 0.09

For penalty kicks a significant difference was revealed for the 1st half ($p<0.01$), 2nd half ($p=0.01$), 1st quarter ($p<0.01$), 2nd quarter ($p<0.01$), 3rd quarter ($p<0.01$) and 4th quarter ($p=0.04$) in 2008. The results showed a significant difference for the 1st half, 2nd half, 1st quarter, 2nd quarter 3rd quarter and 4th quarter ($p<0.01$) in 2009. In 2011 significant differences were observed for the 2nd half ($p=0.05$), 1st quarter ($p<0.01$) and 2nd quarter ($p<0.01$). The year 2012 revealed significant differences in the tendency for penalty kicks for the 1st quarter ($p=0.07$) and in 2013 a significant difference for the 1st half ($p<0.01$). When comparing 2007 with all the other years no significant differences in terms of percentage drop goals scored per half and quarter were found.

The percentage of tries per positional group, location, source and number of phases is presented in Table 5. The tries of the different positional groups did not show any significant differences when comparing 2007 with 2009, 2010 and 2013. Significant differences were revealed for the LF in 2008 ($p=0.01$), 2011 ($p=0.01$) and 2012 ($p=0.00$) and a tendency for OB during 2012 ($p=0.07$). The location of the tries revealed a significance difference between 2007 and 2008 for Zone A ($p=0.01$) and Zone B ($p=0.01$). Source of tries did not reveal any significant differences in structured and unstructured play, and turnovers; however, tries from structured play did show a decrease and for tries from turnovers a trend when comparing 2007 with the other years.

With regard to the number of phases needed to score a try, 2008 showed a significant difference for three phases ($p=0.02$), six phases ($p=0.03$) and >6 ($p=0.01$), and a tendency for four phases ($p=0.08$). During 2009 a tendency was revealed for >6 phases ($p=0.08$). A significant difference was observed for six phases ($p<0.01$) and a tendency for one phase ($p=0.06$) and four phases ($p=0.06$) when comparing 2007 with 2010. The study revealed a significant difference for one phase ($p=0.01$), four phases ($p=0.02$), six phases ($p=0.00$) and >6 phases ($p=0.02$) when comparing 2007 with 2011. During 2012 a significant difference for >6 phases ($p=0.00$) and a tendency for two phases ($p=0.07$) were revealed. When 2007 was compared with 2013 the study revealed a significant difference for one phase ($p=0.02$) and a tendency for three phases ($p=0.08$).

Discussion

This is the first quantitative and qualitative study to investigate the effect of law changes on the scoring profile of international rugby. The possible differences due to law changes will first be discussed, and then other possible reasons extracted from the interviews with the panel of experts as mentioned earlier.

The results of the scoring profile show that the total points scored and the frequency between the seasons had changed significantly for selected scoring modes: the source of points had changed from tries to successful penalty kicks. The decreasing tendency to score tries and increasing tendency to kick penalty goals were also seen in the South African Currie Cup tournament (Vahed *et al*., 2014) and Japanese top league (Sasaki *et al*., 2007).

The possible cause of the reduction in tries could be the introduction of **Law 16.7. This law states that when the ball has been clearly won by a team at a ruck and is available to be played, the referee will call "use it", after which the ball must be played within five seconds** (WR, 2015).

According to the experts the law change may have led to teams adopting a better defensive strategy and structure at the breakdown. Thereby they may be sacrificing the possibility of winning turnovers at the breakdown by committing more players to a defensive breakdown to favour more numbers on defence (Wheeler *et al*., 2013), thus allowing the defensive team more numbers and leaving the attacking team less space on the field. This is supported by previous research that indicated that teams retain possession of the ball at the ruck over 90% of the time (Van Rooyen *et al*., 2010; Wheeler *et al*., 2013; Kraak & Welman, 2014). Hendricks *et al*. (2013) stated that the success of the defending team at the breakdown is thanks to the line speed of the defenders and that success in rugby is dependent partly on the defensive strategies utilized by a team.

The experts stated that with the continuous development of rugby and the increasing competitiveness of the game, there has been an increased emphasis on analyzing and training specific areas of the game, which has led to the appointment of specialists such as defence, breakdown and kicking coaches and performance analysts as part of coaching staff. These specialists are tasked to focus on interpreting and developing

a specific area of the game. The role of the performance analysts in conjunction with the coaches and trainers is to use PIs to analyze performance in order to create PPs. The in-depth analysis and preparation of teams, due to the specific information and improved defensive structures used, have led to attacking teams struggling to penetrate the defence line and finding themselves passing and being tackled more frequently, thereby increasing the difficulty to score points. Whether players and spectators will find physical, closely contested battles with fewer tries enjoyable or entertaining is debatable. Lastly, the progressive increase in the physical size and improved conditioning of international players has reduced the opportunities of physical mismatches during matches. The reduction in mismatches can be seen in the smaller score margins between the Tier 1 and Tier 2 nations during the 2011 RWC (IRB, 2011).

The decrease in the number of tries has consequently led to a decrease in the number of conversion kicks. However, additional analysis revealed that there was an increase in the success rate of conversion kicks. The study further revealed a significant increase in the number of and points resulting from penalty kicks. The emphasis on the importance of kicking at goal in modern rugby has led to the appointment of specialist kicking coaches as part of coaching staff. A decrease in the number of drop goals was observed and the experts indicated that it could be due to, firstly, better defensive structures adopted by the teams and, secondly, by the attacking structures and patterns used. Teams might still have a main goal to score tries or they can try to force the defending team to infringe in order to receive a penalty to set up a scoring opportunity at goal without defenders close by. According to Quarrie and Hopkins (2015) goal kicking is an important element in rugby as the performance of goal kickers can have a major bearing on the success of a team.

The results of the study indicated that more tries were scored during the 2nd half of the matches. According to the coaches and players the reason for this is that the teams see the 1st half of a match as more of an opportunity game in which they try to score as many points as possible from a variety of scoring modes, compared to the strategic 2nd half in which teams know exactly the number of points they need in order to win the match or achieve a bonus point for scoring four tries or lose within 7 points. Similar trends were revealed in soccer by Mitrotasios and Armatas (2014) who found that during the European Soccer Championship in 2012, 58% of the goals were scored in

the 2nd half and 21% of them in the last 15-minute period. A second explanation could be fatigue and loss of concentration by the defending team players. There is a trend that coaches make use of tactical substitutions during the 4th quarter of the match, thus the fresh legs can make a difference to the attacking and defending team.

Law 3.4 – players nominated as substitutes. For international matches a union may nominate up to eight replacements/substitutes (WR, 2015). The challenge for coaching staff is to get their timing right with regard to when to make a substitution. Gabbett (2008) stated that one of the reasons for getting tackles wrong is the increasing levels of fatigue and the loss of the effectiveness of the tackle technique during the last part of the match, thereby increasing the risk of injury.

The current study shows a decrease in tries from structured sources of play and an increase in tries from unstructured play and as a result of more frequent turnovers in possession. The coaches and players stated that this could be due to **Law 19.1. The law states that if a team puts the ball back into its own 22 and the ball is subsequently kicked directly into touch, there is no gain in ground (WR, 2015).** Thus teams are forced to have a tactical kicking plan in order to play rugby in the opposition's half of the field. A further explanation could be players' size, conditioning, technical proficiency at the contest during the different phases of play, and pressure from defenders on the attacking team. Hendricks *et al*. (2013) stated that the ability to win the breakdown is not only dependent on tactical proficiency but also on technical proficiency. Integral to defending is the ability of the players to repeatedly execute tackles throughout the 80 minutes of the game (Van Rooyen, 2012). The attacking team might also move the ball wide without having enough support players in order to retain possession of the ball, thus the ball carrier will become isolated and will be outnumbered by the defending team. International rugby has shifted to a territorial game. Due to law 19.1, teams are following a specific kicking strategy to play the game in the opposition's half of the field. Teams are forcing the attacking teams to launch an attack from deep within their own half of the field and, thanks to the improved defensive strategies, the defending team can force the attacking team to make a mistake in their own half of the field and the turnover possession can lead to tries. The coaches also indicated specific strategies followed by teams where their aim is to kick in order to create unstructured play to suit their style of play. The differences in the number of

phases needed to score tries are due to different strategies and tactics used by the teams during this time.

Practical application

Based on the effect of the law changes on the scoring profile of international rugby, this section will recommend practical applications to coaches and trainers to assist with the development of rugby-specific technical, tactical and physical training programmes. With the appointment of performance analysts and the advancement of sophisticated software to conduct detailed PA, the performance analyst in conjunction with the coaches and trainers should analyze matches to determine a performance profile of their own team and of the opposition. This could be broken down into halves and even quarters to provide a more specific analysis as some significant information may be lost when analyzing the game as a whole. The opposition's PPs could be used by the coaches to develop strategies to counter their strengths and exploit their weaknesses and could provide coaches and trainers with information to recreate match situations during training in order to improve performance on match day.

Conclusion

The study revealed that international rugby has moved to a game with fewer points being scored from tries and an increase in the number of points from penalty kicks. The decrease in tries has consequently led to a decrease in the number of conversion kicks. Most of the points and tries were accumulated during the 2nd half, especially during the 4th quarter of the match. A decrease in the number of tries from structured sources and an increase from turnovers and unstructured sources were found. Results from this study emphasize the importance of continual research into the scoring profile in order to identify technical and tactical trends. Future studies should focus on identifying the match profile of all international rugby matches across the different levels of play. This could lead to improvements in training regimes and programmes by preparing players and teams better for competition. Studies should also focus on analyzing the changes in the scoring profile of national and domestic rugby in different countries.

Acknowledgements

The authors wish to thank the MSc students for assisting with capturing the data from the software, as well as the expert coaches and players for their time to assist with the discussion of the findings.

References

De Lacy, H. & Fox, G. (2000). Think and Play Winning Rugby. Harper Sports: Auckland.

De Vos, A.S., Strydom, H., Fouche, C.B., & Delport, C.S.L. (2005). Research at grass roots the social science and human service professions (2nd Eds). Pretoria: Van Schaik Publishers.

Eaves, S.J., Hughes, M.D., & Lamb, K.L. (2008). Assessing the impact of the season and rule changes on specific match and tactical variables in professional Rugby League Football in the United Kingdom. *International Journal of Performance Analysis in Sport*, 8(3), 104-118.

Gabbett T.J. (2008). Influence of fatigue on tackling technique in rugby league players. *Journal of Strength Conditioning Research*, 22(2): 625-32.

Hendricks, S., Roode, B., Matthews, B., & Lambert, M. (2013). Defensive strategies in rugby union. *Perceptual and Motor Skills*, 117(1), 65-87.

Hughes, M.D. & Bartlett, R.M. (2002). The use of performance indicators in performance analysis. *Journal of Sports Sciences*, 20(10), 739-754.

Hughes, M., Evans, S., & Wells, J. (2001). Establishing normative profiles in performance analysis. *International Journal of Performance Analysis in Sport*, 1(1), 1-26.

James, N., Mellalieu, S.D., & Jones, N.M.P. (2005). The development of position-specific performance indicators in professional rugby union. *Journal of Sports Sciences*, 23, 63-72.

Jones, N.M.P., Mellalieu, S.D., & James, N. (2004). Team performance indicators as a function of winning and losing in rugby union. *International Journal of Performance Analysis in Sport*, 4(1), 61-71.

Kraak, W.J. & Welman, K.E. (2014). Ruck-play as performance indicator during the 2010 Six Nations Championship, *International Journal of Sport Science and Coaching*, 9(3), 525-537.

Laird, P. & Lorimer, R. (2004). An examination of try scoring in rugby union: A review of international rugby statistics. *International Journal of Performance Analysis in Sport*, 4(1), 72-80.

Lim, E., Lay, B., Dawson, B., Wallman, K., & Anderson, S. (2011). Predicting try scoring in super 14 rugby union – the development of a superior attacking team scoring system. *International Journal of Performance Analysis in Sport*, 11(3), 464-475.

Liporace, F.A., Yoon, R.S., Kubiak, E.N., Parisi, D.M., Koval, K.J., Feldman, D., & Egol, K.A. (2012). Does adding computed tomography change diagnosis and treatment of tillaux and triplane pediatric ankle fractures? *Orthopedics*, 35(2), 105.Mitrotasios, M. & Armatas, V. (2014). Analysis of goal scoring patterns in the 2012 European Football Championship. *The Sport Journal*, 1, 1–11.

Murray, A.D., Murray, I.R., & Robson, J. (2012). Rugby union: Faster, higher, stronger: Keeping an evolving sport Safe. *British Journal of Sports Medicine*, (In Print).

Ortega, E., Villarejo, D., & Palao, J. M. (2009). Differences in game statistics between winning and losing rugby teams in the Six Nations Tournament. *Journal of Sports Science and Medicine*, 8(4), 523-527.

Quarrie, K.L. & Hopkins, W.G. (2015). Evaluation of goal kicking performance in International rugby union matches. *Journal of Science and Medicine in Sport*. 18, 195-198.

Robertson, S.J. & Joyce, D.G. (2014). Informing in-season tactical periodization in team sport: development of a match difficulty index for Super Rugby. *Journal of Sports Sciences*, 30, 1-9.

Pulling, C. & Stenning, M. (2015). Offloads in Rugby Union: Northern and Southern Hemisphere International teams. *International Journal of Performance Analysis in Sport*, 15, 217-228.

Sasaki, K., Furukawa, T., Murakami, J., Shimozono, H., Nagamatsu, M., Miyao, M., Yamamoto, T., Watanabe, I., Yasugahira, H., Saito, T., Ueno, Y., Katsuta, T., & Kono, I. (2007). Scoring profiles and defense performance analysis in Rugby Union. *International Journal of Performance Analysis in Sport,* 7(3), 46-53.

Stefani, R.T. (2009). Predicting score difference versus score total in rugby and soccer. *IMA Journal of Management Mathematics*, 20(2), 147-158.

Vahed, Y, Kraak, W., & Venter, R. (2014). The effect of the law changes on time variables of the South African Currie Cup Tournament during 2007 and 2013. *International Journal of Performance Analysis of Sport*, 14(3), 868-885.

Van Rooyen, M. (2012). A statistical analysis of tackling performance during International rugby union matches from 2011. *International Journal of Performance Analysis of Sport*, 12, 517-530.

Vaz, L, Mouchet, A., Carreras, D., & Morente, H. (2011). The importance of rugby game-related statistics to discriminate winners and losers at the elite level competitions in close and balanced games. *International Journal of Performance Analysis in Sport*, 11(1), 130-141.

Vaz, L, Carreras, D., & Kraak, W. (2012). Analysis of the effect of alternating home and away field advantage during the Six Nations Rugby Championship. *International Journal Performance Analysis in Sport*, 12(3): 594-608.

Wheeler, K.W., Askew, C.D., & Sayers, M.G. (2010), Effective attacking strategies in rugby union. *European Journal of Sport Science*, 10(4), 237-242.

Wheeler, K.W., Mills, D., Lyons, K., & Harrinton, W. (2013). Effective defensive strategies at the ruck contest in rugby union. *International Journal of Sports Science and Coaching,* 8(3), 462-491.

Wheeler, K.W. & Sayers, M. (2009). Contact skills predicting tackle-breaks in rugby union. *International Journal of Sports Science and Coaching*, 4(4), 535-544.

Williams, J. Hughes, M.D., & O'Donoghue, P. (2005). The effect of rule changes on match and ball in play time in rugby union. *International Journal of Performance Analysis in Sport*, 5(3), 1-11.

World Rugby (WR). (2015). Laws of the game. Rugby Union incorporating the Playing Charter. Dublin, Ireland. 212 pages.

Wright, C., Atkins, S., & Jones, B. (2012). An analysis of elite coaches' engagement with performance analysis services (match, notational analysis and technique analysis). *International Journal of Performance Analysis in Sport*, 12(2), 436-451.

CHAPTER FOUR
RESEARCH ARTICLE TWO

Game analysis of the general match profile of international rugby union between 2007 and 2013

This article has been submitted for publication in the Journal of Sports Sciences. The article is herewith included according to the guidelines for authors of this journal (included as Appendix C). However, to provide a neat and well-rounded final product for this dissertation, the article has been edited to represent an actual published article as it would appear in this particular journal. This does not imply that the article has been accepted or will be accepted for publication. Consequently the referencing style used in this chapter may differ from that used in the rest of the chapters of this dissertation.

Game analysis of the general match profile of international rugby union between 2007 and 2013

Wilbur Kraak, Ranel Venter & Frederick Coetzee

Field of study: Sport Science (Performance analysis)

Running title: Analysis of international rugby

Wilbur Kraak (Corresponding author)

Department of Sport Science

Private Bag X1

Matieland

Republic of South Africa

7602

Tel: (+27) 21 808 4915

Email: kjw@sun.ac.za

Ranel Venter

Department of Sport Science

Private Bag X1

Matieland

Republic of South Africa

7602

Email: rev@sun.ac.za

Frederik Coetzee

Department of Exercise and Sport Science

University of the Free State

Republic of South Africa

Bloemfontein

9300

Email: coetzeef@ufs.ac.za

Game analysis of the general match profile of international rugby union between 2007 and 2013

Wilbur Kraak[a], Ranel Venter[a] & Frederik Coetzee[b]

[a]Department of Sport Science, Stellenbosch University, South Africa

[b]Department of Exercise and Sport Sciences, University of the Free State, South Africa

Abstract

Game analysis within rugby union organizations is growing due to the increasing professionalism of the game, rugby coaches' and conditioning coaches' needs for analytical assistance, and advancements in performance analysis technology. Law amendments are fundamental to the development of sports and are introduced for a variety of reasons. The purpose of this study was to investigate and compare the scoring and general match profile of international rugby between 2007 and 2013 in order to determine the effect of law changes. For the purpose of this study the researchers made use of mixed-method methodology. A total of 248 matches were recorded and analyzed by means of the Fairplay video analysis software package. Further semi-structured interviews were conducted with expert coaches, specialist coaches, players and referees and referee coaches. The results revealed significant decrease in the number of scrums (d=1.03) line-outs (d=0.86), rucks (d=0.86), mauls (d=0.62) and kicks (d=0.46). An increase in the number of passes (d=0.43), ball carries (d=1.22) tackles attempted (d=0.65) and penalty kicks (d=0.98) from between 2007 and 2013. The general match profile of international rugby have move to game with a decrease in the number of set pieces and kicks to an increase in the number of ball carries and tackles. From the interviews with the expert coaches, players and referees the game have in imbalance between attack and defence under the current laws.

Keywords: *Law changes; performance profiles; technical coaching; tactical periodization*

Introduction

Rugby union (rugby) is a sport that involves physical contact. Any sport involving physical contact has inherent risks. Players should play the game in accordance with the laws of the game and be mindful of their own safety and that of others. It is the responsibility of those who coach or teach the game to ensure players are prepared in a manner that ensures compliance with the laws of the game and in accordance with safe practices. Rugby consistently changes over time due to either technological advances and/or law changes (Sheridan, 2007). The profile of rugby rarely remains the same, as it is frequently pushed to the limit by coaches, referees and players (Eaves *et al*., 2008). Law amendments are fundamental to the development of sports and are introduced for a variety of reasons (Kraak & Welman, 2014). Some of the reasons why law changes are implemented in rugby are in response to player

performance, to ensure safety, enhance participation and enjoyment, promote game continuity, technological advancement and commercial pressures, as well as to retain game integrity and development (Eaves *et al*., 2008). World Rugby (WR) formerly known as the international Rugby Board (IRB) is responsible for delivering safe, enjoyable and entertaining rugby events. Therefore laws provide a framework by which the WR ensures these aspects (Murray *et al*., 2012).

From the onset of professionalism, rugby has evolved into a more structured sport, with teams demonstrating increasingly complex match strategies and tactics (Hendricks *et al*., 2013) to be successful. Following the 2011 Rugby World Cup (RWC), the Games Analysis unit of WR published a comprehensive report on the shape of the RWC (WR, 2011). The report indicated that the ball-in-play time increased from 1991 from 24min 48sec (31% in play) to 35min 25 sec (44% in play) in 2011. The data indicated that the ball is in play longer in the modern rugby game. Williams *et al*. (2005) investigated the changes to match and ball-in-play time in the Six Nations, Tri-Nations, European Cup and Super Rugby competitions over a five-year period (1999-2003) and found that both time variables had increased significantly over the period. It was speculated that the increase in ball-in-play time could have increased the continuity of the game, which may have led to increased player actions. The authors stated that the findings were largely due to the law changes implemented during the period of the research.

Vaz *et al*. (2010) analyzed 18 performance indicators (PIs) in order to determine which game-related statistics could discriminate between winning and losing teams in IRB games (120) played between 2003 and 2006. The researchers conducted a cluster analysis to establish, according to game final score differences, three different match groups. Only close games were selected for further analysis (IRB n = 64, fewer than 15 points difference; Super Twelve n = 95, fewer than 11 points difference). The discriminant functions were statistically significant for Super Twelve games (Chi-square = 33.8, $p < 0.01$), but not for IRB games (Chi-square = 9.4, p = n.s.)., In the Super Twelve competition, possession kicked (SC = 0.48), tackles made (SC = 0.45), rucks and pass (SC = -0.40), passes completed (SC = 0.39), mauls won (SC = -0.36), turnovers won (SC = -0.33), kicks to touch (SC = 0.32) and errors made (SC = -0.32) discriminated between winners and losers. The study concluded that rugby game-related statistics were able to discriminate between winners and losers in Super 12

close games. It was also suggested that a kicking-based game, supported by an effective defensive structure, is more likely to win matches than a possession-based game.

In another study that set out to determine the differences in game statistics between winning and losing rugby teams, Ortega *et al*. (2009) analyzed 58 games from the Six Nations tournament between the 2003 and 2006 seasons. The study showed that: a) in the phases of obtaining the ball and more specifically in scrummage and line-out, winning teams lost fewer balls than losing teams (winning teams had an efficacy of 90% in both actions); b) the winning team tended to play more with their feet when they obtained the ball, to utilize the maul as a way of attacking, and to break the defensive line more often than the losing team did; and c) on defence, winning teams recovered more balls and completed more tackles than losing teams (tackles completed by winning teams were 94%).

In professional team sport, the aim of peaking for matches or competitions of perceived greatest priority or difficulty is facilitated through a process known as “tactical periodization” (Robertson & Joyce, 2014). For example, coaches may seek to vary the volume and intensity of training on a week-to-week basis in order to optimize athlete preparedness for the upcoming match. This form of periodization is particularly useful because it also considers elements of preparation such as skill, strategy and tactical training in addition to the physical loading imparted by fitness work, travel effects and cumulative fatigue throughout the season (Robertson & Joyce, 2014). Despite the range of detailed analysis in the literature, there is a need for a structured account of the effect of law changes on the scoring and general match profile of international rugby union in recent years. Based on the background, the purpose of this study was therefore to compare the changes of the general match profile of international rugby between the 2007 and 2013 seasons.

Methodology

Study design

A mixed-method design was used during the research process. Coding and quantitative performance analyses (PA) (N = 248 matches) were done by an accredited performance analyst (Level 6 International Society of Performance analysis (ISPAS)), who is also an accredited WR coach educator and Level 3 coach. For

qualitative data collection and analyses, semi-structured interviews were conducted with expert international rugby coaches (n=5), international specialist coaches (n=7), international coaches (n=2), international referee coaches and advisors (n=2) and international players (n=4). Following a mixed-method approach the effect of law changes on specific performance indicators pertaining to the scoring profile for international rugby union was comprehensively resourced and tested, enhancing the interpretability and application of the research findings.

Materials

Sample

Video recordings of international (N = 248) matches played between 2007 and 2013 were used for the purpose of this study. Semi-structured interviews were conducted with 20 international-level expert rugby coaches, specialist coaches and players. Ethical approval for the research was obtained from the institution (REC-050411-032).

Data collection procedures

Video footage

Television video recordings of the international rugby matches were supplied by the company Fika (Cape Town, South Africa).

Performance indicators and description

Table 4.1. Performance indicators and description used in the analyses

Performance indicators	Description
Scoring profile	Points per match, tries scored, successful conversion kicks, successful penalty kicks and successful drop goals
Ball-in-play and match time	Ball-in-play time and total match duration
Set pieces profile	Scrums (win or loss by attacking team & resets), line-outs (win or loss by attacking team); 50m kick restarts and 22m kick restarts (contestable and uncontestable)
General play profile	Passes, offloads, kicks in play, ball carries, tackle breaks, line breaks, tackles attempted, tackles successful, tackles missed, rucks, mauls
Infringement profile	Penalties (against attacking or defending team) and free kicks (against attacking or defending team)

Coding

The PIs (Table 4.1) were analyzed by means of the coding function of the Fairplay software package (V4.08.287, Australia). The video files were viewed and coded in the software's tagging panel. The same analyst analyzed all the games to prevent inter-rater variability in the different observations and interpretations of activities.

Reliability

The reliability of the coding was tested by using a re-analysis method (test-retest reliability) for inter-rater reliability (Hughes *et al*., 2001; James *et al*., 2005). This method entails a different analyzer doing a re-analysis of the video material one month after the original analysis. For the purpose of this study 25% of the matches were re-analyzed by a qualified analyzer. The researchers made use of the intraclass correlation coefficient (ICC) to determine the reliability of the two trials with parametric data of the interval or ratio variables (Gratton & Jones, 2004). Inter-rater agreement was interpreted as follows: poor (0–0.20), fair (0.30–0.40), moderate (0.50–0.60), strong (0.70–0.80), and almost perfect (>0.80) (Liporace *et al*., 2012). Analysis showed that the strength of the agreement between all variables was almost perfect, and thus very agreeable (Table 4.2).

Table 4.2. Intra-rater reliability correlations coefficient (ICC) of the coding test-retest

Ball-in-play time	Set pieces profile	General play profile	Infringement profile
0.96	0.98	0.98	1.00

Statistical analysis

The Centre for Statistical Consultation Services of Stellenbosch University analyzed the research data. The Statsoft Data Processing package (Statsoft Inc., 2011) was used to process the data. Descriptive statistics (means and standard deviations) were reported and a significance level of 5% ($p<0.05$) was used as guideline for determining significant differences. The year 2007 was used as baseline to compare and track the changes between different years. Outcome measures were presented as the mean ± s. Cohen's d effect sizes (Thomas *et al*., 1997) were calculated, using the difference in means over the pooled standard deviation, to characterize the differences between 2007 and 2013. A one-way Anova was conducted for PIs that had one measurement.

A mixed-method repeated Anova was calculated for PIs that had more than one measurement. The magnitude of Cohen's d effect sizes was evaluated according to the following criteria (Hopkins, 2011) as trivial (<0.2), small (≥0.2 and <0.6), moderate (≥0.6 and <1.2), large (≥1.2 and <2.0) and very large (≥2.0). Some PIs are expressed as percentages, which according to Hughes and Bartlett (2002) provide a more accurate analysis of team performance. Prior to the start of the semi-structured interviews a majority opinion was referenced as 80% agreement between the experts.

Results

The total match time displayed in Table 4.3 showed a significant decrease in total match time in 2008 (d=0.20), 2010 (d=0.35) and 2012 (d=0.33) and a significant increase for 2013 (d=0.34). Significant differences were found with regard to the total match time of the two halves of the matches. For the 1st half of the total match time the study revealed a small significant decrease for 2011 (d=0.25) and 2012 (d=0.36), and a small significant increase for 2009 (d=0.28) and 2013 (d=0.31) was found. The 2nd half showed a small significant decrease for 2008 (d=0.40) and 2010 (0.29) and an increase for 2013 (d=0.22).

The total ball-in-play time (Table 4.3) showed no significant change for 2011 and 2012. However, it revealed a large significant increase for 2008 (d=1.06) and a small significant increase for 2009 (d=0.29) and 2010 (d=0.44). For 2013 (d=0.87) a moderate significant decrease in the total ball-in-play time was found. The 1st half showed a large significant increase for 2008 (d=1.16) and a small significant increase for 2009 (d=0.34) and 2010 (d=0.38). A moderate significant decrease in ball-in-play time was revealed for 2013 (d=0.71). The 2nd half of the match showed a moderate increase in 2008 (d=0.62) and a small significant increase in 2010 (d=0.30). A small and moderate decrease was observed for the 2nd half during 2012 (d=0.32) and 2013 (d=0.70) respectively.

Results for the general match profile indicated a moderate significant decrease in the number of scrums from 2007 - 2010 (d=0.79), 2007 - 2011 (d=1.07), 2007 - 2012 (d=1.13) and 2007 - 2013 (d=1.03). Scrum resets showed a large significant decrease in 2011 (d=1.59) and a moderate significant difference in 2012 (d=0.84) and 2013 (d=0.74). The number of line-outs showed a moderate significant decrease for all the seasons from 2007 to 2013. There were trivial to small differences for 50m and 22m

kick restarts across the seven years. The number of rucks showed a large and moderate significant increase during 2008 (d=1.33) and 2010 (d=0.46) respectively. A moderate decrease was revealed for the number of rucks in 2013 (d=0.86). Mauls showed a decreasing trend in all of the years, with a moderate significant decrease in 2011 (d=0.90). A large increase was revealed for the number of passes during 2010 (d=1.30) and 2011 (d=1.16) and a moderate difference in 2008 (d=0.56) and 2012 (d=0.73). Offloads showed a large decrease in 2009 (d=1.32), 2010 (d=1.22), 2011 (d=1.30), 2012 (d=1.90) and 2013 (d=1.80). The results revealed a moderate increase in 2009 (d=0.84) and a large increase in 2010 (d=2.25), 2011 (d=3.27), 2012 (d=3.97) and 2013 (d=3.00) for the number of line breaks. The results showed a decreasing trend in all the years, but revealed a moderate significant decrease in kicks in 2011 (d=1.05).

Ball carries showed a significant increase in all the years, with large significant increases in 2010 (d=1.86), 2011 (d=1.85), 2012 (d=1.22) and 2013 (d=1.22). Due to the increase in ball carries the number of tackles also revealed a large increase in 2011 (d=1.35) and a moderate significant increase in 2008 (d=1.03), 2010 (d=1.04), 2012 (d=0.72) and 2013 (d=0.65). The number of tackle breaks revealed a very large significant increase in 2010 (d=2.08) and 2013 (d=2.03) and a large significant increase for 2011 (d=1.81) and 2012 (d=1.92). The study showed a moderate decrease in penalty kicks in 2008 and a moderate significant increase in 2009 (d=0.67), 2011 (d=0.68), 2012 (d=0.88) and 2013 (d=0.98). A moderate significant increase in free kicks was observed during 2008 (d=1.22).

Table 4.4 presents the percentage success at scrums and line-outs, contestable and uncontestable kick restarts and the tackle outcome. Results revealed a large significant decrease in the number of scrums won by the attacking team (d=1.18) in 2013. In 2010 a small significant decrease was revealed for the percentage line-outs won by the attacking team (d=0.21). Results showed a small significant increase in the number of contestable 50m kick restarts in 2009 (d=0.33) and a moderate significant decrease in 2013 (d=0.96). A small significant decrease in 22m kick restarts was found in 2008 (d=0.33) and a small increase in 2010 (d=0.34), 2012 (d=0.46) and 2013 (d=0.62). The results revealed a moderate significant decrease in the number of successful tackles made in 2009 (d=0.66) and a large significant decrease in 2010 (d=1.73), 2011 (d=1.61), 2012 (d=1.73) and 2013 (d=1.91).

Table 4.3. Average match time and ball-in-play time per half and match between 2007 and 2013 presented as average time in minutes and seconds

PIs	2007	2008	2009	2010	2011	2012	2013
	n = 54	*n = 24*	*n = 24*	*n = 23*	*n = 69*	*n = 27*	*n = 27*
				Match time			
1st Half	44min35s	44min53s	45min04s[a]	44min18s	44min10sa	43min54sa	45min12s[a]
2nd Half	47min11s	46min23s[a]	46min58s	46min26s[a]	47min08s	46min45s	47min44s[a]
Total	91min45s	91min16s[a]	92min32s	90min44s[a]	91min19s	90min39sa	92min56s[a]
				Ball in play time			
1st Half	16min44s	18min28s[d]	17min18s[a]	17min22sa	16min53s	17min16s[a]	15min41s[c]
2nd Half	18min45s	20min15s[d]	19min08s	19min26sa	18min33s	17min56s[a]	17min00s[c]
Total	35min28s	38min43s[d]	36min36s[a]	36min48sa	35min26s	35min13s	32min41s[d]

Note: Practical significance (Hopkins, 2011): [a] small = practical significant difference from 2007 (≥0.2 and <0.6), [b] moderate = practical significant difference from 2007 (≥0.6 and <1.2), [c] large = practical significant difference from 2007 (≥1.2 and <2.0) and [d] very large = practical significant difference from 2007 (≥2.0).

Table 4.4. General match profile descriptive statistics between 2007 and 2013

PIs	2007	2008	2009	2010	2011	2012	2013
	n = 54	*n = 24*	*n = 24*	*n = 23*	*n = 69*	*n = 27*	*n = 27*
Scrums	24.6±5.7	23.3±4.7[a]	21.8±5.2[a]	20.4±4.1[b]	19.0±4.9 [b]	18.3±5.5 [b]	19.3±3.8[b]
Scrum resets	6.9±2.7	6.5±2.6	6.1±2.8a	5.7±2.2[a]	3.3 ± 1.9[c]	4.7 ± 2.[b]	5.0 ± 2.2[b]
Line-outs	29.8±5.5	25.9±5.4[b]	23.8±5.9[b]	23.0±4.4[c]	24.1 ± 4.5[b]	25.4 ± 5.4[b]	26.3 ± 4.9[b]
Kick restarts	11.6±2.5	10.6±2.3a	11.1±2.7[a]	11.8±2.2	10.8 ± 2.7[a]	10.4 ± 1.9[a]	11.2 ± 2.4
22m restarts	3.3±2.5	2.9±2.3	3.4±1.7	3.0 ± 1.8	2.9 ± 1.9	3.0 ± 1.6	2.4 ± 1.9a
Rucks	118.1±23.4	147.7±20.7[d]	116.7±25.5	129.1 ± 24.9[c]	119.4 ± 22.1[a]	106.6 ± 26.5[a]	98.8 ± 21.4[b]
Mauls	13.2±4.7	11.8±4.9[a]	10.8±6.4[a]	11.2 ± 5.1[a]	9.4 ± 4.1[b]	11.4 ± 4.6[a]	10.5 ± 4.3[b]
Passes	209.3±32.8	239.5±26.0[b]	232.1±6[a]	253.1 ± 37.7[c]	250.7 ± 38.2[c]	235.1 ± 42.0[c]	225.4 ± 46.8[a]
Offloads	30.4±8.1	26.5±6.8[a]	20.2±7.4[c]	21.1 ± 6.9[c]	20.4 ± 7.4c	15.4 ± 7.8[c]	15.7 ± 8.8[c]
Line breaks	3.1±2.9	2.9±2.0	6.2±5.1b	16.3 ± 10.0[d]	21.7 ± 7.2[d]	20.4 ± 6.5[d]	25.9 ± 12.8[d]
Tackle breaks	28.9±9.1	33.0±10.2[a]	36.1±13.7[b]	50.8 ± 13.7[d]	56.1 ± 18.6[c]	48.1 ± 11.9[c]	52.1±15.5[d]
Ball carries	166.6±29.8	193.7±24.5[d]	189.6±43.5[b]	224.5 ± 35.5[c]	223.9 ± 32.3[c]	208.1 ± 42.3[c]	206.9 ± 39.7[c]
Kicks	55.2±15.6	60.8±10.9[a]	59.4±15.3[a]	50.3 ± 16.4[a]	41.2 ± 11.5[b]	47.3 ± 10.6[a]	48.9 ± 9.8[a]
Tackles	196.0±32.0	226.0±22.8[b]	203.1±42.5	230.7 ± 38.0[b]	240.4 ± 34.0[c]	221.5 ± 42.0[b]	217.5±35.7[c]
Penalty kicks	16.7±4.0	14.1±4.6[b]	19.5±4.9[b]	18.9±3.1[a]	19.5±4.1[b]	20.2±4.1[b]	20.6±4.1[b]
Free kicks	1.9±1.4	7.4±8.1[c]	2.6±1.9[a]	2.4±1.8[a]	1.5±1.2[a]	1.8±1.3	2.5±1.1[a]

Note: Practical significance (Hopkins, 2011): [a] small = practical significant difference from 2007 (≥0.2 and <0.6), [b] moderate = practical significant difference from 2007 (≥0.6 and <1.2), [c] large = practical significant difference from 2007 (≥1.2 and <2.0) and [d] very large = practical significant difference from 2007 (≥2.0).

Table 4.5. Percentage success at scrums and line-outs, contestable and uncontestable kick restarts and tackle outcomes between 2007 and 2013

Outcome	2007	2008	2009	2010	2011	2012	2013
	n = 54	*n = 24*	*n = 24*	*n = 23*	*n = 69*	*n = 27*	*n = 27*
				Scrums			
Won	91	94[a]	91	88[a]	88[a]	88[a]	80[c]
Lost	9	6	9	12	12	12	20
				Line-outs			
Won	85	84	83	82[a]	83	86	85
Lost	15	16	17	18	17	14	15
				50m kick restarts			
Contestable	45	40	48[a]	46	47	44	34[b]
Uncontestable	55	60	52	54	53	56	66
				22m kick restarts			
Contestable	33	23a	30	44[a]	37	48[a]	47[a]
Uncontestable	67	77	70	56	63	52	53
				Tackles			
Made	85	85	82[b]	78[c]	77[c]	78[c]	76[c]
Missed	15	15	18	22	23	22	24

Note: Practical significance (Hopkins, 2011): [a] small = practical significant difference from 2007 (≥0.2 and <0.6), [b] moderate = practical significant difference from 2007 (≥0.6 and <1.2), [c] large = practical significant difference from 2007 (≥1.2 and <2.0) and [d] very large = practical significant difference from 2007 (≥2.0).

Table 4.6. Ratio (%) penalty and free kicks against attacking and defending teams between 2007 and 2013

PIs	2007		2008		2009		2010		2011		2012		2013	
	n = 54		n = 24		n = 24		n = 23		n = 69		n = 27		n = 27	
	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence
PK	32	68	27	73	40	60	33	67	31	69	29	71	32	68
FK	37	63	37	63	38	62	39	61	44	56	42	58	53	47

Note: PK – penalty kick; FK – free kick

The percentage ratio for and free kicks against the attacking teams is presented in Table 4.5. A trend is evident that more penalties and free kicks were given against the defending team for all the years when compared to 2007. The average ratio percentages for penalty kicks were similar for all the years except for 2009 (30:70). Free kicks revealed a similar trend for 2008 (37:63), 2009 (38:62), and 2010 (39:61). The ratio was different during 2011 (44:56), 2012 (42:58) and 2013 (53:47).

Discussion

The aim of the study was to compare the general match profile of international rugby between 2007 and 2013. Although the current study analyzed the possible effect of law changes on the general profile of international rugby, it is acknowledged that the changes are not the only contributors to the changes in the general match profile. Possible changes due to law changes will be discussed first, followed by a discussion of other possible reasons extracted from the interviews with the panel of experts mentioned earlier.

The study revealed an increase in the total match time when comparing 2007 with 2013. This could be due to **Law 6 – referee consulting with others; extension of the jurisdiction of the television match official (TMO)** (WR, 2015), as there was an increase in the number of referrals for awarding tries and assistance with foul-play incidents. Due to this law change, decisions on tries scored are regularly directed to the TMO. Some of these can take up to three minutes. Secondly**, the Pitch Side Concussion Assessment (PSCA)** (Fuller *et al*., 2014) could also affect total match time. If a referee or medical staff member suspects a possible head injury or concussion, the player is removed from the field for the concussion test and replaced, and after completion of test the player may return to the playing field.

Thirdly, **Law 3 – for international matches teams may nominate up to eight replacements/substitutes,** could influence match time. Teams are using the substitute bench more frequently and the number of players allowed in international rugby has changed from seven to eight. Furthermore, **Law 9 – the kicker must take the kick within one minute and thirty seconds (ninety seconds) from the time a try has been awarded**, may not have led to any significant change in the total match time. The study revealed no significant change in the total match time from 2008 – 2012. According to the experts, the reason for no significant change in the total match

time could be the improved conditioning and skill level of the players since rugby became professional. Fewer mistakes are made, with the decrease in the number of scrums as a possible indication.

The large significant increase in ball-in-play time, especially during 2008, could be due to the ELVs used during the Tri-Nations tournament. According to the experts, this could be due to the tactical kicking game that teams are adopting. The kicking game is especially a style of play in the Northern Hemisphere competitions where weather and field conditions are not always suitable for an expansive game approach. Additionally, the experts agreed that the decrease in the number of set pieces and increase in the number of passes, ball carries and tackle breaks have led to the ball being in play longer. The experts believe the decrease in the ball-in-play time from 2010 to 2013 could be due to the decrease in the number of kicks observed by the current study. Due to improvements and technological advancements with regard to the playing surfaces, the game in the Northern Hemisphere has also developed into a more ball-in-hand approach over the past few years. It has been established that the total match time increased in several tournaments (Six Nations, Tri-Nations, Super Rugby and European Cup) (Williams *et al*., 2005); however, the significant decrease in ball-in-play time differs from previous studies (Eaves & Hughes 2003, William *et al*., 2005).

The decrease in the number of line-outs could be due to **Law 19 – if a team puts the ball back into its own 22m area and the ball is subsequently kicked directly into touch, there is no gain in ground.** This law change has led to teams establishing better-organized kicking patterns. Specific kicking plans will allow teams to kick the ball down the field and try to force the opposition to play within their own half through good chasing lines. Furthermore, the experts mentioned that, based on the strengths and weaknesses of a team, they do not opt to kick out because they might run the risk of losing the ball in the line-out. The current study has found that there has been an increase in the number of line-outs won by the non-feeding team since 2010. This could be due to **Law 19 – pre-gripping, which allows players who are lifting to pre-grip on the shorts.** The experts believe this is due to PPs created by performance analysts in conjunction with the specialist coaches, by which teams can be better prepared and know what to expect from the opposition.

The occurrence of fewer scrums and scrum resets could be due to **Law 20 – where the scrum cadence sequence changed from crouch, touch, pause and engage to crouch, bind and set**. According to the experts this is, firstly, due to the appointment of specialist scrum coaches who specifically focus on this facet of the game. Players are coached to improve their techniques and conditioning to overcome possible mismatches in the scrums during match play. Secondly, the players interviewed also added that the advantage law and the management thereof by the referee play a role in the decrease in the number of scrums. Thirdly, thanks to the improved skill set of the players, fewer mistakes are being made. Fourthly, the experts believe technological advancements could also play a role, such as better grip of the ball (fewer mistakes when carrying the ball), as well as the improvement of the jerseys that assist with the props binding together. The decrease in the number of scrums won by the defending team is due to the scrums that allow a clear contest at the scrum. According to the referee and referee advisors, the change in scrum cadence (from four words to three words, and “engage” to “set”) has assisted with the engagement process. The referees added that, due to referees policing the feed from the scrum-half more strictly, the balls are fed straight, which allows for a contest between the two forward packs. A further reason, as explained by the referees and referee advisors, is that if there is a collapse in the front row but the ball is available at the feet of the eighth man, the referees will allow play to continue. The findings of the current study correspond with those of Vahed *et al*. (2014) who also reported a decrease in the number of line-outs and scrums in the South African Currie Cup Competition.

The number of 50m kick restarts showed no change. This is due to no change in the number of scoring modes utilized during the matches. Interestingly, the number of contestable restarts has increased, but is still less than the uncontestable kicks. The experts believe the reasons for teams kicking uncontestable kick restarts are a) to put the receiving team under pressure in their own half of the field and a) to try to force them to kick the ball out in order to set up an attacking line-out by forcing the opposition team to make a mistake within their own half of the field and b) also to try to regain the ball in the attacking half of the field and start an attack. The experts are of the opinion that teams are taking fewer risks in international rugby when compared to national tournaments such as the European Cup and Super Rugby, due to the importance of winning test matches and the limited number of matches per season. The decrease in

the number of 22m kick restarts, especially during 2013, might be due to the accuracy of the goal kickers and also to the decrease in the number of drop goals attempted by teams.

The introduction of **Law 16 – unsuccessful end to a ruck**, could have led to a decreasing trend in the number of rucks. In modern rugby, teams are applying a certain philosophy with regard to the breakdown area. This has led to teams adopting a better defensive strategy and structure at the breakdown whereby they may be sacrificing the possibility of contesting at the breakdown by committing more players to a defensive breakdown to favour more numbers on defence. The defending team need to bind with the attacking team's players in order to form a ruck, but by not contesting the breakdown and not binding no ruck is formed, thus allowing the attacking team to retain possession of the ball without a clear contest. This is supported by a number of researchers (Kraak & Welman, 2014, Wheeler *et al*., 2013; van Rooyen *et al*., 2010) indicating that the ball is successfully retained by the attacking team in more than 90% of the rucks. According to Wheeler *et al*. (2013) it has been acknowledged that it is difficult for referees to officiate the ruck area accurately due to the number of players involved. As mentioned earlier, the defending team are responsible for forming a ruck. As was reported, more penalties are awarded against the defending team. Defending teams are opting not to form a ruck, but would rather fan out and join the defending line than running the risk of conceding a penalty. The decrease in the number of mauls follows on the decrease in the number of line-outs, as line-outs are considered the main source of mauls. The coaches and players believe that, thanks to detailed analysis, teams can identify which teams use the maul as an attacking tool and can work out strategies to counter the maul. This has led to opposing teams becoming more clinical when countering these mauls by not contesting and thus giving the referees no choice but to penalise the attacking teams either for obstruction or joining the maul from the side. This statement is supported by the additional analysis by the current project (not used in the article), which has shown an increase in maul penalties against the attacking team. As a result of this trend attacking teams are now using other facets of play from which to score points.

The study revealed an increase in ball carries, passes, line breaks and tackle breaks. In modern rugby, teams will use their effective ball carries to carry the ball across the advantage line through tackles and line breaks (Hendricks *et al*. 2014). This forces the

defending team to play “catch-up rugby” while the attacking team play with momentum. Evasive attacking strategies are associated with tackle breaks. The sidestepping strategy represents the most effective method of evasive agility skill execution during ball carries in rugby (Wheeler *et al*., 2010). Also, the conditioning and skills of players have improved, thus they are making fewer mistakes. The reason for the decrease in the number of offloads could be better-structured defensive systems and tackling techniques, which leave teams in doubt as to whether to throw a 50/50 offload. The interviewed coaches mentioned that, because defending teams are not contesting at ruck play, attacking teams are allowed to go to ground and secure possession without risking loss of the ball. Wheeler (2013) suggest that the defensive structures of high-level rugby teams restrict the space needed for ball carriers to avoid any contact with the defence, as characteristic of line breaks. Similarly, committing more than one defender at the tackle means that it is difficult for ball carriers to successfully offload the ball.

The increase in the number of ball carries, tackle breaks, line breaks and passes has led to an increase in the number of tackles. Due to the teams in international rugby who prefer to keep the ball in hand, coaches and trainers should condition teams to be able to tackle for the duration of the match. The increased size and speed of players, favouring defence; increased defensive organization; introduction of ideas from rugby league; and increased athleticism of players are all factors that enable the defending teams to compete for and slow the ball down at breakdowns, reorganize better and render the opposition’s possession less effective. Due to a competition structure where teams can obtain a further bonus point for scoring four tries or losing within seven points, attacking teams need to obtain possession of the ball in the last part of matches to score points and force defending teams to make more tackles. The increase in missed tackles is due to the improved skill set of the attacking players. Due to the increase in the number of tackles in modern rugby Hendricks *et al*. (2014) recommended that the technical characteristics be emphasized and incorporated into training to effectively prepare tacklers for match play.

Another finding from the study is the decrease in the number of kicks. This could be due to the ball-in-hand approach that teams are adopting in the latter part of the matches. Knowing when to kick, and doing so effectively, has become a key aspect. Teams whose defence is poorly organized will lose if they adopt this kicking strategy.

However, if a team's kicking is effective and their defence well organized, they are more likely to win than a team who control possession, take the ball through more phases and pass more. The current study also showed that there was an increase in the number of kicks during the 1st half of the match. According to the experts, it is typical for teams to "feel each other out" at the beginning of the match by kicking back and forth, hoping that the opposing team will make a mistake on which to capitalize.

As reported in the results, there was an increase in the number of penalty kicks from 2007 to 2013. However, a decrease was observed for 2008. The reason for the decrease was ELVs used during the international tournaments, where all infringements excluding offside, not entering the breakdown through the gate and foul play were sanctioned with a free kick. What is interesting is the fact that the number of penalty kicks against the attacking team increased, while the number of penalty kicks against the defending team decreased, although there were still more penalties against the defending team. The experts gave a possible explanation for this, namely that the increase in the number of breakdown situations could be responsible for this finding, as 70% of the penalties still occur at the breakdown and ruck. It was mentioned previously that more penalties are awarded against the defending team because referees favour the attacking team in order to improve the continuity of the game. It could also be suggested that players may not be accustomed to the new law changes, therefore they repeatedly infringe the laws of the game.

The study showed a decrease in the number of free kicks. From the interviews, the experts suggested that teams and players are understanding the laws better, thus resulting in fewer free kicks. The study revealed an increase in the number of free kicks against the attacking team and a decrease in the number of free kicks against the defending team. From the interviews it was deduced that referees have become stricter at the scrum and line-out feed. The increase in 2008 could be due to the ELVs used in the Tri-Nations competition. Referee sanctions: "With the exception of offside, not entering the breakdown through the gate, and foul play, the punishment will be a free kick."

Practical application

Based on the effect of the law changes on the scoring and general match profile, the next section will recommend practical applications to coaches to assist with the development of rugby programmes that are specific to the demands of the game.

Review and preview of match footage

The norm for technical staff and performance analysts when analyzing a matches is to analyze the PIs as a whole, but in order to be more specific one could break the match down into two separate halves or even quarters. Significant information might get lost when analyzing the games as a whole. For example, one half's PIs may be significantly higher than those of the other half. PPs should be compiled for tournaments and opponents to assist with a review of the opposition's and own team's performance. Players should also be allowed to self-analyze their own performance and that of their opposition. The role of the specialist coach and performance analyst is crucial in this regard.

Technique and skills coaching

With the increase in the number of ball carries, breakdown situations and tackles, contact sessions should focus on executing effective tackling techniques (Wheeler *et al*., 2013; Worsnop, 2012; Hendricks & Lambert, 2010), contact technique when going into contact, and effective means of contesting at breakdown points and improving defence speed (speed of defence in response to the attacking line) (Hendricks *et al*., 2013). Teaching players to use these effective techniques when fatigued might minimize the risk of injury during the latter part of matches. Research has shown that fatigue is one of the biggest contributors to injuries at the tackle in the latter part of the match (Gabbett, 2008). The coaches should develop game-specific drills that allow players to make decisions under pressure in attack and defence, and during practice place them in situations where they must read and determine the best plan of action (Kraak & Welman, 2014).

Conclusion

The study firstly revealed an increase in the total match time. This is due to the increase in the number of stoppages for TMO referrals, stoppages for substitutions and the on-field concussion assessment. Secondly, an increase in ball-in-play time

was found to be due to the ball-in-hand approach by certain teams. Thirdly, the profile of international rugby has changed to a more continuous game dynamic with an increase in the number of ball carries, passes, tackle breaks and line breaks. This has led to an increase in the number of tackles and missed tackles. Lastly, a decrease in the number of rucks, mauls and set pieces (scrums, line-outs, kick restarts and 22m restarts) was shown. An implication of these findings is that coaches, referees and players are responsible for changes in the profile of international rugby, showing that these components cannot work on their own to create changes in the profile. Finally the study also revealed that there is an imbalance between attack and defence as defence is still dominating international rugby. The results from this study emphasize the importance of further research on match and tournament profiles. Future studies should focus on the scoring and general match profile of national rugby in other hemispheres. Which could lead to improvements in training regimes and programmes by preparing players for the specific demands of a tournament and determining whether there are differences between the hemispheres' national competitions.

Acknowledgements

We would like to thank Mr Carel du Plessis and Johan van der Westhuizen of Fika for providing us with the match videos. Prof. Martin Kidd of the Centre for Statistical Consultation, Stellenbosch University, for assisting with the statistical analysis and the MSc students who assisted with the data capturing from the software.

References

Eaves, S.J., Lamb, K. L., & Hughes, M.D. (2008). The impact of rule and playing season changes on time variables in professional rugby league in the United Kingdom. *International Journal of Performance Analysis in Sport*, 8(2), 45-54.

Eaves, S.J. & Hughes, M. (2003). Patterns of play of international rugby union teams before and after the introduction of professional status. *International Journal of Performance Analysis in Sport*, 3(2), 103-111.

Fuller, G.W., Kemp, S.P.T., & Decq, F. (2014). The International Rugby Board (IRB) Pitch Side Concussion Assessment trial: a pilot test accuracy study. *British Journal of Sports Medicine,*

Gabbett T.J. (2008). Influence of fatigue on tackling technique in rugby league players. *Journal of Strength Conditioning Research*, 22(2), 625-32.

Gratton, C. & Jones, I. (2004). Research Methods for Sport Studies. London: Routledge.

Hendricks, S., Karpul, D., & Lambert, M. (2014). Momentum and kinetic energy before the tackle in rugby union. *Journal of Sports Science and Medicine*, 13(3), 557–563.

Hendricks, S., Roode, B., Matthews, B., & Lambert, M. (2013). Defensive strategies in Rugby Union. *Perceptual and Motor Skills*, 117(1), 65-87.

Hendricks, S. & Lambert, M. (2010). Tackling in rugby: coaching strategies for effective technique and injury prevention. *Journal of Sports Science & Coaching*, 5(1).117-136.

Hopkins, W.G. (2011). A new view of statistics. Retrieved from http://www.sportsci.org/resource/stats

Hughes, M. & Bartlett, R.M. (2002). The use of performance indicators in performance analysis. *Journal of Sports Sciences*, 20, 739-754.

Hughes, M., Evans, S., & Wells, J. (2001). Establishing normative profiles in performance analysis. *International Journal of Performance Analysis in Sport*, 1(1), 1-26.

International Rugby Board. (2011). Statistics review and match analysis: Rugby World Cup 2011, Dublin: Huguenot House.

James, N., Mellalieu, S.D., & Jones, N.M.P. (2005). The development of position-specific performance indicators in professional rugby union. *Journal of Sports Sciences*, 23:63-72.

Kraak, W.J. & Welman, K.E. (2014). Ruck-play as performance indicator during the 2010 Six Nations Championship, *International Journal of Sport Science and Coaching*, 9(3), 525-537.

Liporace, F.A., Yoon, R.S., Kubiak, E.N., Parisi, D.M., Koval, K.J., Feldman, D., & Egol, K.A. (2012). Does adding computed tomography change diagnosis and treatment of tillaux and triplane pediatric ankle fractures? *Orthopedics*, 35(2):208-211.

Murray, A.D., Murray, I.R., & Robson, J. (2012). Rugby union: Faster, higher, stronger: Keeping an evolving sport Safe. *British Journal of Sports Medicine*, (In Print).

Ortega, E., Villarejo, D., & Palao, J.M. (2009). Differences in game statistics between winning and losing rugby teams in the Six Nations Tournament. *Journal of Sports Science and Medicine*, 8, 523-527.

Robertson, S.J. & Joyce, D.G. (2014), Informing in-season tactical periodization in team sport: development of a match difficulty index for Super Rugby. *Journal of Sports Sciences*, 30, 1-9.

Sheridan, H. (2007). Evaluating technical and technological innovations in sport: Why fair play isn't enough. *Journal of Sport and Social Issues*, 31(2), 179-194.

Thomas, J.R., Lochbaum, M.R., Landers, D.M., & He, C. (1997). Planning significant and meaningful research in exercise science: Estimating sample size. *Research Quarterly for Exercise and Sport*, 68(1), 33–43.

Vahed, Y., Kraak, W., & Venter, R. (2014). The effect of law changes on time variables of the South African Currie Cup Tournament during 2007 and 2013. *International Journal of Performance Analysis in Sport*, 14(3), 866–883.

Van Rooyen M.K., Diedrick, E., & Noakes, T.D. (2010). Ruck frequency as a predictor of success in the 2007 rugby world cup tournament. *International Journal of Performance Analysis in Sport*, 10(1):33-46.

Vaz, L., Van Rooyen, M., & Sampaio, J. (2010), Rugby game-related statistics that discriminate between winning and losing teams in IRB and Super twelve close games. *Journal of Sports Science and Medicine*, 9, 51-55.

Wheeler, K.W., Mills D., Lyons, K., & Harrinton W. (2013). Effective defensive strategies at the ruck contest in rugby union. *International Journal of Sport Science Coaching*, 8(3), 237-242.

Wheeler, K.W., Askew, C.D., & Sayers, M.G. (2010). Effective attacking strategies in rugby union. *European Journal of Sport Science*, 10(4), 237-242.

Williams, J. Hughes, M.D., & O'Donoghue, P. (2005). The effect of rule changes on match and ball in play time in rugby union. *International Journal of Performance Analysis in Sport*, 5(3), 1-11.

World Rugby. (2015). Laws of the game. Rugby Union incorporating the Playing Charter. Dublin: Ireland.

Worsnop, S. (2012), Rugby games and drills / rugby football union. United States of America: Human Kinetics.

CHAPTER FIVE
RESEARCH ARTICLE THREE

Scoring and general match profile of Super Rugby between 2008 and 2013

This article has been submitted for publication in the International Journal of Performance Analysis in Sport. The article is herewith included according to the guidelines for authors of this journal (included as Appendix A). However, to provide a neat and well-rounded final product for this dissertation, the article has been edited to represent an actual published article as it would appear in this particular journal. This does not imply that the article has been accepted or will be accepted for publication. Subsequently, the referencing style used in this chapter may differ from that used in the other chapters of this dissertation.

Scoring and general match profile of Super Rugby between 2008 and 2013

Wilbur Kraak, Ranel Venter & Frederik Coetzee

Field of study: Sport Science (Performance analysis)

Running title: Super Rugby match profile

Wilbur Kraak (Corresponding author)

Department of Sport Science

Private Bag X1

Matieland

Republic of South Africa

7602

Email: kjw@sun.ac.za

Ranel Venter

Department of Sport Science

Private Bag X1

Matieland

Republic of South Africa

7602

Email: rev@sun.ac.za

Frederik Coetzee

Department of Exercise and Sport Sciences

University of the Free State

Republic of South Africa

Bloemfontein

9300

Email: coetzeef@ufs.ac.za

Scoring and general match profile of Super Rugby between 2008 and 2013

Wilbur Kraak[1], Ranel Venter[1] & Frederik Coetzee[2]

[1] Department of Sport Science, Stellenbosch University, South Africa

[2] Department of Exercise and Sport Sciences, University of the Free State, South Africa

Abstract

Rugby research has focused on a range of performance indicators related to game structures and tactical aspects. The purpose of this study was to investigate and compare the effect of law changes on the match profile of Super Rugby between the 2008 and 2013 seasons. For the purpose of this study the researchers made use of mixed-method methodology. A total of 646 national matches were recorded and analyzed by means of the Fairplay video analysis software package. Further semi-structured interviews were conducted with expert coaches, specialist coaches, players and referees and referee coaches. Results revealed a significant increase in the number of points scored (p<0.01) and a decrease in the number of tries scored (p<0.01). Results of the study show that the profile of national rugby has changed to a more continuous game dynamic with the increase in the number of ball carries (d=1.34), passes (d=0.43), tackle breaks (d=1.59) and line breaks (d=2.40), and has led to an increase in the number of tackles (d=0.63). A decrease in the number of rucks (d=1.73), mauls (d=0.63), scrums (d=0.27) and scrum resets (d=1.36) was found. An increase in penalty kicks (d=2.04) and a decrease in free kicks (d=0.4.53) between 2008 and 2013 were observed. The general match profile of international rugby has moved to a game with fewer scrums and kicks and more ball carries and tackles. According to the interviewed expert coaches, players and referees, good playing surfaces in the Southern Hemisphere allow for an open-game approach by the teams.

Keywords: *Law changes, principles of play, Super Rugby, performance profiles*

5.1. Introduction

Rugby union (rugby) was officially awarded professional status in August 1995, after which the Super 10 rugby competition was introduced in 1996 (Owen *et al*., 2015). This competition has grown and is known as the Super Rugby tournament. Currently, 15 franchise teams participate but this number will be increased to 18 in 2016 and include teams from Argentina and Japan. The tournament is governed by the South African,

New Zealand and Australian Rugby Unions (SANZAR) (Meiklejohn, 2010). Since the introduction of professionalism, the sport has undergone a number of law changes and amendments in an attempt to enhance its attractiveness for spectators as well as to remain competitive with other football codes (Duthie *et al*., 2003).

With professional status, rugby has evolved into a faster, more dynamic sport with greater emphasis on the physical elements of matches, which means players are involved in more frequent and powerful contact situations (Eaves & Hughes, 2003, Van Rooyen *et al*., 2008). Along with the changes to the game, the use and development of science and technology in the sport have also increased, allowing for more practical and accurate methods of describing the loads and demands of the sport (Liebermann *et al*., 2002). These changes are thought to be primarily due to law changes and amendments, improved match analysis, technology and better player conditioning (Quarrie *et al*., 2007). As a result, professional players are being exposed to greater training loads and, owing to commercial pressure, participate in more competitions with less recovery time between games and competitions, along with a shorter pre-season (Van Rooyen *et al*., 2008).

Vahed *et al*. (2014 & 2016) investigated the effect of law changes on the scoring, time interval, general skills and contact profiles of the South African Currie Cup during the 2007 and 2013 seasons. The scoring profile revealed that fewer tries were scored ($p=0.07$), while the number of successful penalty kicks increased significantly ($p<0.01$). The time interval profiles showed that the total match time and total stoppage time were significantly ($p<0.01$) more, while the total ball-in-play time ($p<0.01$) and the number of stoppages were significantly ($p<0.01$) less. The skills profile indicated a significant increase in the number of passes ($p<0.01$) and a decrease in the number of handling errors, offloads and kicks ($p<0.01$). The contact profile showed more rucks/mauls and tackles completed ($p<0.01$) and fewer scrums and line-outs ($p<0.01$). The study firstly showed that the profile of the game has changed to one that is more physical and continuous, with more player actions (passing, tackling and rucks/mauls) and fewer stoppages, predominantly in the second half. Secondly, a trend was found for teams to adopt a more defensive playing style, whereby they sacrifice committing numbers to the breakdowns and rather commit players on defence. This has created a more physically intense game with fewer tries being scored.

Quarrie (2009) analyzed the impact of ELVs on match activities during 2000 and 2008 for the Air New Zealand Cup in New Zealand. The report indicated that the total match time increased from 2000 to 2008 (88.5±3.0), the ball-in-play time showed a decrease before the introduction of the ELVs and was reversed after the introduction (38.9±2.8). The scoring profile showed that there was an insignificant decrease (-6%; 905 CI±8%) in the total points scored and did not reveal differences between the number of tries scored. The set piece profile revealed a decrease in the number of line-outs (26.9±5.5), scrums (27±6.4) and scrum resets (5.2±2.5). The report showed more passes (257±39), rucks (160±24) and kicks (64±17) and fewer mauls (10±3.6), with no change in the number of tackles (4.3±7.0). The infringement profile revealed an increase in the number of penalties and free kicks (26±4.8) and yellow cards (4.3±7.0).

Van den Berg and Malan (2012) investigated whether the experimental law variations (ELVs), introduced in 2008, were effective in making rugby more appealing to spectators by improving the continuity of the game. The results of the study revealed that the number of scrums and line-outs decreased but that the number of tackles made, metres gained and penalties conceded increased significantly. The authors concluded that the more player activities (passing, tackling, rucking) showed more continuity, suggesting that the ELVs implemented have succeeded in enhancing the appeal of the game. These studies have clearly established that the game has changed over time and that the sport has become more physically demanding.

According to Williams *et al*. (2005) the effect of law changes on a sport cannot be determined objectively, unless there is some form of measure associated with it. By undertaking systematic and objective analysis of key match variables the impact of changes to the game can be examined. This will facilitate the creation of performance databases and enable participants to compare and contrast performance of individuals and teams at international and national level. Moreover, the evolution of the body of knowledge pertaining to how law changes impact the game will enable coaches and specialist coaches to develop more specific and possibly holistic training programmes (Eaves, 2008). Given the above-mentioned background, the purpose of this study was to investigate and compare the effect of law changes on the match profile of Super Rugby between the 2008 and 2013 seasons.

5.2. Methodology

5.2.1. Research design

The study included qualitative and quantitative elements. Semi-structured interviews were conducted with expert n coaches (n = 6), referees and referee coaches (n = 5), specialist coaches (n = 8) and players (n = 7). The main process in the study was quantitative analyses (PA) and coding and analyses were done by an accredited performance analyst (Level 6 International Society of Performance Analysis (ISPAS)), who is also an accredited WR coach educator and Level 3 coach.

At a conceptual level, the predominantly qualitative nature of the semi-structured interviews created an additional level of understanding of the possible effect of law changes on specific performance indicators pertaining to the match profile of Super Rugby between 2008 and 2013. The findings of the semi-structured interviews were contextualized in the law changes. The PA provided an ideal vehicle to test possible effects of law changes on the match profile of Super Rugby among a panel of rugby experts in a predominantly quantitative fashion, but allowing space for qualitative freedom of expression. By combining the two types of data collection, the effects of law changes on specific performance indicators pertaining to the match profile of Super Rugby were comprehensively resourced and tested, enhancing the interpretability and application of the research findings.

5.2.2. Materials

Sample

Video recordings of the Super Rugby (N = 646) matches played between 2008 and 2013 were used for the purpose of this study. Ethical approval was obtained from the Research Ethics Committee: Human Research, Stellenbosch University (REC-050411-032).

5.2.3. Data collection procedures

Video footage

Video recordings of the Super Rugby matches were supplied by Fika, the official analyst company of the South African Rugby Union. The (N = 646) matches that were recorded were analyzed using the Fairplay (Canberra, Australia, (4.08.287) video analysis software package.

Coding

The performance indicators (Table 5.1) were analyzed by the coding function of the Fairplay software. The video files were viewed and coded in the software's tagging panel. The same analyst analyzed all the games so as to prevent inter-rater variability in the different observations and interpretations of activities.

Performance indicators and description

Table 5.1: Performance indicators and description used in the scoring and general match profile

Performance indicators	Description
Scoring profile	Points per match, tries scored, successful conversion kicks, successful penalty kicks and successful drop goals
Ball-in-play and match time	Ball-in-play time and total match duration
Set pieces profile	Scrums (win or loss by attacking team & resets), line-outs (win or loss by attacking team); 50m kick restart and 22m kick restarts (contestable and uncontestable)
General play profile	Passes, offloads, kicks in play, ball carries, tackle breaks, line breaks, tackles attempted, tackles successful, tackles missed, rucks and mauls
Infringement profile	Penalty kicks (against attacking and defending team) Free kicks (against attacking and defending team)

Reliability

The reliability of the coding was determined by using a re-analysis method (test-retest reliability) for inter-rater reliability (Hughes *et al*., 2001; James *et al*., 2005). This method entails a different analyzer doing a re-analysis of the video material one month after the original analysis. For the purpose of this study 25% of the matches were re-analyzed by a qualified analyst. Inter-rater agreement was interpreted as follows: poor (0–0.20), fair (0.30–0.40), moderate (0.50–0.60), strong (0.70–0.80) and almost perfect (>0.80) (Liporace *et al*., 2012). Analysis showed that the strength of the agreement between all variables was almost perfect (Table 5.2).

Table 5.2: Intra-rater reliability correlations coefficient (ICC) of the coding test-retest

Time interval profile	Set pieces profile	General play profile	Infringement profile
0.98	1.00	0.98	1.00

5.2.4. Statistical analysis

The Statistical Consultation Services of Stellenbosch University analyzed the research data. The Statsoft Data Processing package (Statsoft Inc., 2011) was used to process the data. The year 2008 was used as baseline to compare and track the changes over time between different years. A one-way Anova was conducted for PIs that had one measurement. A mixed-model repeated Anova was calculated for PIs that had more than one measurement. Descriptive data was reported as means, standard deviations, frequencies (number of observations), percentages and averages with 95% confidence intervals (CI), and a significance level of 5% ($p<0.05$) was used as guideline for determining significant differences. Differences between categorical frequencies (scoring profile) were determined by Chi-Square. Outcome measures were presented as the mean ± s. Cohen's d effect sizes (Thomas et al., 1997) were calculated, using the difference in means over the pooled standard deviation, to characterize the differences per year. The magnitude of Cohen's d effect sizes evaluated according to the following criteria (Hopkins, 2011) as trivial (<0.2), small (≥0.2 and <0.6), moderate (≥0.6 and <1.2), large (≥1.2 and <2.0) and very large (≥2.0). Some PI's are expressed as percentages, which according to Hughes and Bartlett (2002) provide a more accurate analysis of team performance. An alpha level of 0.05 was set for statistical significance. Prior to start of the semi-structured interviews a majority opinion was referenced as 80% agreement between the experts.

5.3. Results

Table 5.3 presents the total amount scoring modes between 2008 and 2013 Super Rugby presented as number of observations, average scoring mode per match and percentage of total scoring modes and overall scoring mode. Results showed no statistical significant differences between 2008 and 2009 for any of the scoring modes. When comparing 2008 with 2010 a significant difference for the number of tries scored ($p=0.03$) and penalty kicks ($p<0.01$) was found. A comparison between 2008 and 2012 revealed significant differences for tries ($p<0.01$), conversion kicks ($p=0.04$), penalty kicks ($p<0.01$) and drop goals ($p<0.01$). Comparisons between 2008 and 2013 showed significant differences for number of tries ($p=0.00$), conversion kicks ($p<0.01$), penalty kicks ($p=0.01$) and drop goals ($p<0.01$).

The total number of points scored between 2008 and 2013 Super Rugby (presented as points per scoring mode), average points per match, percentage contribution of total

points and overall total points are shown in Table 5.4. Comparing 2008 with 2009, significant differences for points scored from penalty kicks ($p<0.01$) and drop goals ($p=0.01$) were found. Comparisons between 2008 and 2010 show a significant difference for points scored from tries ($p<0.01$), penalty kicks ($p=0.01$) and drop goals ($p=0.07$). Significant differences were observed when comparing 2008 with 2011 for points from scored tries ($p<0.01$), penalty kicks ($p<0.01$) and a tendency for drop goals ($p<0.05$). Comparing 2008 with 2012, significant differences for points scored from tries ($p<0.01$), penalty kicks ($p<0.01$), conversion kicks ($p<0.01$) and drop goals ($p=0.05$) are revealed. Results showed significant differences when comparing 2008 with 2013 for points scored from tries ($p<0.01$), conversion kicks ($p<0.01$), penalty kicks ($p<0.01$) and drop goals ($p<0.01$).

Table 5.5 presents the total match time and ball in play time. The results indicated that there were no significant differences for the 1st, 2nd half and the total match for 2010 and 2013 when compared to 2007 with regard to total match time. However, a small practical significant increase for the 2nd half ($d=0.21$) and total match time ($d=0.23$) for 2009 was revealed. In 2011 and 2012, the opposite trend was evident with a small practical significant decrease for the 1st ($d=0.53$; $d=0.25$) and 2nd ($d=0.25$; $d=0.33$) half, as well as the total match time ($d=0.50$; $d=0.41$) in 2011 and 2013. The ball in play time showed a general decreasing trend between 2008 and 2013. The results indicated a small practical significant decrease for the 1st, 2nd half and a moderate practical significant decrease for the total ball in play time ($d=0.91$) in 2009. A moderate practical significant decrease was observed for the 1st ($d=0.76$), 2nd ($d=0.65$) and total ball in play time ($d=0.91$) in 2010. A small practical significant difference for the 1st half, 2nd half and total match time in 2011 was found. During 2012, results revealed a small practical significant decrease for the 1st half ($d=0.48$) and a moderate practical significant decrease for the 2nd half ($d=0.62$) and total ball in play time ($d=0.72$). In 2013, a moderate practical significant decrease for the 1st half ($d=0.65$), 2nd half ($d=0.94$) and the total ball in play time ($d=1.08$) was determined.

The results for the general match profile, displayed in Table 5.5, indicated that there was a small practical significant decrease between 2008 and 2009 in the number of scrums ($d=0.27$). When comparing 2008 with 2010, a moderate practical significant decrease ($d=0.97$) was found. Results indicated a large practical significant decrease when comparing 2008 with 2011 ($d=1.68$), 2008 with 2012 ($d=1.96$) and 2008 with 2013 ($d=1.83$) was shown. Scrums resets showed a large practical significant

decrease in 2011 (d=1.90), 2012 (d=1.45), 2013 (d=1.36) and a moderate significant difference for 2009 (d=0.73) and 2010 (d=0.84). The number of line-outs showed a small practical significance decrease for 2009 (d=0.29), 2010 (d=0.39) and 2012 (d=0.34), with no practical significant difference for 2011 and 2013.

Table 5.3: The total amount scoring modes between 2008 and 2013 Super Rugby presented as number of observations, average scoring mode per match and percentage of total scoring modes and overall scoring mode.

Scoring mode	2008	2009	2010	2011	2012	2013
	n = 83	n = 94	n = 94	n = 125	n = 125	n = 125
			Tries			
Scoring mode	448	516	530**	578*	609*	595*
95% CI	417 - 480	483 – 550	495 - 566	541 – 617	570 – 649	557 – 634
Average	5	5	6	5	5	5
%	43	44	37	35	34	35
			Conversion kicks			
Scoring mode	314	375	396	403*	463**	428**
95% CI	286 – 344	344 – 407	364 – 430	370 – 438	428 – 500	394 – 464
Average	4	4	4	3	4	3
%	30	32	28	24	26	25
			Penalty kicks			
Scoring mode	262	257*	469*	665*	691*	679*
95% CI	236 – 290	230 – 286	435 – 504	626 – 705	651 – 732	640 – 719
Average	3	3	5	5	6	5
%	25	22	33	40	39	40
			Drop goals			
Scoring mode	20	34	19	22	16**	8*
95% CI	13 - 31	24 - 47	12 - 30	15 - 33	10 - 26	4 - 16
Average	0	0	0	0	0	0
%	2	3	1	1	1	0
			Overall			
Scoring mode	1044	1182	1414	1668	1779	1710
95% CI	986 - 1105	1121 – 1246	1348 - 1483	1597 - 1741	1706 - 1854	1638 - 1784
f	13	13	15	13	14	14

*Note: *statistically significant different from 2008 = ($p \leq 0.01$), ** statistically significant different from 2008 = ($p \leq 0.05$) and #tendency when p is between 0.06 - 0.09*

Table 5.4: The total amount of points scored between 2008 and 2013 Super Rugby presented as points per scoring mode, average points per match, percentage contribution of total points and overall total points.

Points	2008	2009	2010	2011	2012	2013
	n = 83	n = 94	n = 94	n = 125	n = 125	n = 125
			Tries			
Points	2240	2580	2650*	2890*	3045*	2975*
95% CI	2181 – 2298	2581 - 2641	2581 – 2718	2816 – 2964	2969 - 3121	2900 - 3050
Average	27	27	28	23	24	24
%	60	61	54	50	50	50
			Conversion kicks			
Points	628	750	792	806	926*	856*
95% CI	585 – 674	703 – 800	743 – 844	756 – 859	872 – 982	804 – 910
Average	8	8	8	6	7	7
%	17	18	16	14	15	15
			Penalty kicks			
Points	786	771*	1407*	1995*	2073*	2037*
95% CI	738 – 836	723 – 821	1346 – 1470	1925 – 2066	2001 – 2146	1966 - 2109
Average	9	8	15	16	17	16
%	21	18	29	35	34	35
			Drop goals			
Points	60	102**	57#	66*	48**	24*
95% CI	47 - 77	84 – 123	44 - 74	52 – 84	36 – 64	16 - 36
Average	1	1	1	1	0	0
%	2	2	1	1	1	0
			Overall			
Points	3714	4203	4906	5757	6092	5892
95% CI	3606 - 3827	4086 - 4322	4782 - 5033	5624 - 5892	5956 - 6230	5758 – 6028
Average	45	45	52	46	49	47

*Note: *statistically significant different from 2008 = ($p \leq 0.01$), ** statistically significant different from 2008 = ($p \leq 0.05$) and #tendency when p is between 0.06 - 0.09*

Table 5.5: Average match time and ball in play time per half and match between 2008 and 2013 Super Rugby presented as average time in minutes and seconds.

Timing	2008 *n = 83*	2009 *n = 94*	2010 *n = 94*	2011 *n = 125*	2012 *n = 125*	2013 *n = 125*
			Match time			
1st Half	44min28s	44min47s	44min23s	43min20s[a]	43min56s[a]	44min30s
2nd Half	46min59s	47min34s[a]	46min57s	46min26s[a]	46min12s[a]	47min17s
Total	91min27s	92min21s[a]	91min20s	89min46s[a]	90min09s[a]	91min47s
			Ball in play time			
1st Half	17min05s	16min10s[a]	15min48s[b]	16min24s[a]	16min15s[a]	15min53s[b]
2nd Half	19min2s	17min59s[a]	17min42s[b]	18min02s[a]	17min42s[b]	17min05s[b]
Total	36min06s	34min10s[b]	33min30s[b]	34min26s[a]	33min57s[b]	32min58s[b]

Note: practical significance (Hopkins, 2011): [a] small = practical significant different from 2008 (≥0.2 and <0.6), [b] moderate = practical significant different from 2008 (≥0.6 and <1.2), [c] large = practical significant different from 2008 (≥1.2 and <2.0) and [d] very large = practical significant different from 2008 (≥2.0).

Table 5.6. General match profile descriptive statistics between 2008 and 2013 Super Rugby.

PI's	2008	2009	2010	2011	2012	2013
	n = 83	n = 94	n = 94	n = 125	n = 125	n = 125
Scrums	26.4±4.7	25.0±5.4[a]	21.9±4.8[b]	18.7±4.6[c]	17.9±4.1[c]	18.4±4.2[c]
Scrum resets	6.3±2.1	4.5±2.8[b]	4.4±2.3[b]	2.8±1.7[c]	3.4±2.1[c]	3.7±1.9[c]
Line-outs	25.3±5.4	23.6±6.5[a]	23.2±5.6[a]	24.4±5.1	23.7±4.5[a]	25.2±4.6
50m kick restarts	10.3±2.2	10.0±2.7	12.2±2.7[b]	11.7±2.6[b]	11.9±2.3[b]	11.7±2.3[b]
22m kick restarts	2.8±1.7	2.8±1.7	2.7±1.6	2.5±1.6[a]	2.1±1.5[a]	2.2±1.7[a]
Rucks	128.1±20.9	115.9±18.1[b]	113.6±21.3[b]	111.6±21.3[b]	104.0±18.1[c]	92.9±20.1[c]
Mauls	12.2±4.6	12.4±5.2	9.9±3.7a	7.7±3.3[b]	9.5±3.8[b]	9.7±4.5[a]
Passes	243.9±34.7	251.4±35.8[a]	246.2±35.7	257.0±41.4[a]	241.6±35.5	258.1±46.6[a]
Offloads	27.8±8.4	26.8±7.7	22.8±8.7[a]	21.7±.2[b]	19.4±7.2[b]	18.4±6.8[c]
Line breaks	2.9±2.0	4.0±2.6[a]	7.1±3.6[c]	14.2±4.5[d]	11.9±4.3[d]	13.3±5.4[d]
Tackle breaks	37.5±8.7	38.1±12.7	56.4±11.8[c]	52.8±13.0[c]	56.4±15.1[c]	56.4±13.7[c]
Ball carries	184.2±25.0	200.4±25.7[b]	219.8±34.3[b]	228.5±31.6[c]	223.2±31.8[c]	219.2±34.6[b]
Kicks	55.1±11.6^^	61.2±13.2[b]	45.2±11.9[b]	42.3±11.6[b]	42.1±11.6[b]	43.2±11.3[b]
Tackles	221.2±28.0	208.2±25.8[a]	230.1±33.3[a]	241.2±35.7[b]	236.6±33.9[a]	232.5±33.6[a]
Penalty kicks	11.7±3.4	10.5±2.9[a]	20.6±4.6	19.3±3.9[d]	19.4±3.8[d]	18.6±3.4[d]
Free kicks	16.3±5.2	16.3±4.1[a]	1.9±1.6[d]	1.8±1.5[d]	1.4±1.2[d]	1.1±1.0[d]

Note: practical significance (Hopkins, 2011): [a] small = practical significant different from 2008 (≥0.2 and <0.6), [b] moderate = practical significant different from 2008 (≥0.6 and <1.2), [c] large = practical significant different from 2008 (≥1.2 and <2.0) and [d] very large = practical significant different from 2008 (≥2.0).

The number of rucks showed a large practical significant decrease during 2012 (d=1.26) and 2013 (d=1.73). A moderate practical significant decrease during 2009 (d=0.63), 2010 (d=0.69) and 2011 (d=1.26). Mauls have shown a decreasing trend for all of the years with a moderate practical significant decrease for 2011 (d=1.16) and 2012 (d=0.63). A small practical significant increase was found for the number of passes during 2009 (243.9±34.7 vs 251.4±35.8; d=0.22), 2011 (d=0.34) and 2013 (d=0.34). Offloads have shown a large practical significant decrease for 2013 (27.8±8.4 vs 18.4±6.8; d=1.25). The results revealed a large practical significant increase in 2010 (d=0.1.43) and a very large practical significant increase for 2011 (d=3.10), 2012 (d=2.53) and 2013 (d=2.40) for number of line breaks.

Ball carries have shown a significant increase in all the years, with large practical significant increases in 2011 (d=1.53) and 2012 (d=1.34). Due to the increase in ball carries, the number of tackles also revealed a moderate practical significant increase for 2011 (d=0.63). The number of tackle breaks revealed a large practical significant increase in 2010 (d=1.81), 2011 (d=1.33), 2012 (d=1.46) and 2013 (d=1.59). A very large practical significant increase in penalty kicks was found for 2011 (d=1.67), 2012 (d=2.12) and 2013 (d=2.04). A very large practical significant decrease in free kicks was observed during 2010 (d=3.87) 2011 (d=4.15), 2012 (d=4.38) and 2013 (d=4.53).

Table 5.7: Percentage success at scrums and line-outs, contestable and uncontestable kick restarts and the tackle outcomes of Super Rugby between 2008 and 2013

Outcome/ contest	2008	2009	2010	2011	2012	2013
	n = 83	n = 94	n = 94	n = 125	n = 125	n = 125
			Scrums			
Won	73	77[a]	73	76[a]	73	72
Lost	27	23	29	24	27	28
			Line-outs			
Won	83	80[a]	84	82	84	85[a]
Lost	17	20	16	18	16	15
			Kick restarts			
Contestable	46	46	45	45	46	35[a]
Uncontestable	54	54	55	55	54	65
			22m kick restarts			
Contestable	10	17[a]	24[a]	23[a]	26[a]	23[a]
Uncontestable	90	83	76	77	74	77
			Tackles			
Made successfully	83	82	76	78	76	76
Missed	17	18	24	22	24	24

Note: practical significance (Hopkins, 2011): [a] small = practical significant difference from 2008 (≥0.2 and <0.6), [b] moderate = practical significant difference from 2008 (≥0.6 and <1.2), [c] large = practical significant difference from 2008 (≥1.2 and <2.0) and [d] very large = practical significant difference from 2008 (≥2.0).

Table 5.8: Ratio (%) of penalty and free kicks against attacking and defending teams in Super Rugby between 2008 and 2013

PIs	2008		2009		2010		2011		2012		2013	
	n = 24		n = 24		n = 23		n = 69		n = 27		n = 27	
	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence	Attack	Defence
PK	19	81	25	75	29	71	28	72	29	71	27	73
FK	43	57	43	57	50	50	46	54	38	62	46	54

Note: PK – penalty kick; FK – free kick

Table 5.7 presents the percentage success at scrums and line-outs, contestable and uncontestable kick restarts and tackle outcomes. Results revealed a small significant practical increase in the number of scrums won by the attacking team in 2009 (d=0.23) and 2013 (d=0.22). In 2009 a small practical significant decrease was revealed for the percentage line-outs won by the attacking team (d=0.21) and a small practical significant decrease in 2013 (d=34). Results showed a small practical significant increase in the number of contestable 50m kick restarts in 2009 (d=0.33) and a moderate practical significant decrease in 2013 (d=0.96). A small practical significant decrease in 22m kick restarts was revealed in 2008 (d=0.34), 2010 (d=0.34), 2012 (d=0.46) and 2013 (d=0.62). The results revealed no practical significant differences in the number of successful tackles made for all the years.

The percentage ratio for penalties and free kicks against the attacking and defending teams is presented in Table 5.8. A trend is evident that more penalties and free kicks were awarded against the defending team for all of the years. The average percentage ratio revealed a similar trend (increase against the attacking team and a decrease against the defending team) for all the years when compared to 2009 (25:75), 2010 (29:71) 2011 (28:72), 2012 (29:71) and 2013 (27:73). Free kicks revealed a similar trend (increase against the attacking team and a decrease against the defending team) for 2011 (46:54) and 2013 (46:54). In 2010 free kicks were evenly spread (50:50) and 2012 (38:62) showed a decrease against the attacking team and an increase against the defending team.

5.4. Discussion

The aim of the study was to investigate and compare the effect of law changes on the match profile of Super Rugby between the 2008 and 2013seasons. Although the current study analyzed the changes in the profile of Super Rugby as a result of law changes, it is acknowledged that profile changes cannot only be due to law changes as addressed by the study. The discussion will firstly focus on the possible changes due to law changes and then other possible reasons as collected from the experts during the semi-structured interviews.

Results showed an increase in the number points scored during the period of the research, but the scoring mode shifted from tries to penalty kicks. The tendency of

scoring fewer tries and more kicking of penalty goals was also seen in the South African Currie Cup tournament (Vahed et al., 2014) and Japanese top league (Sasaki et al., 2007). A possible cause of fewer tries could be the introduction of **Law 16.7. This law states that when the ball has been clearly won by a team at a ruck and is available to be played the referee will call "use it", after which the ball must be played within five seconds (WR, 2015).** The law change may have led to teams adopting a better defensive strategy and structure at the breakdown, whereby they may be sacrificing the possibility of winning turnovers at the breakdown by committing more players to a defensive breakdown to favour more numbers on defence. According to Hendricks *et al*. (2013) success in rugby is dependent partly on the defensive strategies of a team. The ability to score tries comes directly from the ability to create a line break. The current study revealed more line-breaks but fewer tries. The interviewed coaches and players suggested that a possible reason could be improved defensive structures, some of which have been taken from rugby league.

The study showed a decrease in total match time. This change could be due to **Law 9 – the conversion kick must be taken within one minute and 30 seconds (90 seconds) after the try has been scored**. From the interviews and discussions with the expert coaches and players, two possible reasons became clear. Firstly, the conditioning of players has improved thanks to better periodized planning, new training techniques and technological advancements. Secondly, with the appointment of specialist coaches to improve individual techniques and tactics, players are making fewer mistakes during match play. This is supported by the fact that the study showed fewer scrums and scrum resets. The decrease in ball in play time could be due to **Law 6 – referee consulting with others. Extension of the jurisdiction of the television match official (TMO)**. Due to this law change tries are sometimes referred to the TMO for a decision. Some of these decisions might take up to three minutes. This could lead to teams losing momentum and the break in play might lead to loss of concentration. The coaches and players were of the opinion that the decrease in the number of kicks has also led to a decrease in the ball-in-play time. The current findings suggest that, from a tactical perspective, defensive pressure and not possession might be the most important in modern rugby.

The line-outs did not show any change. **Law 19 – if a team puts the ball back into its own 22 and the ball is subsequently kicked directly into touch, there is no gain in ground**, could have forced teams to adopt better-organized kicking patterns. Teams might kick the ball down the field and force the opposition to play within their own half through good chasing lines. The coaches and players felt that this could be due to a specific strategy that teams follow and which is based on their strengths and weakness, as they do not want to kick out to set up a line-out as they do not believe in this set piece. The current finding of fewer scrums and scrum resets could be a result of **Law 20, where the scrum has changed from crouch, touch, pause and engage to crouch, bind and set**. A few factors could play a role in the effect this law change has had on the number of scrums and scrum resets that occur. According to the coaches and players, the appointment of specialist scrum coaches can assist players to improve their techniques and conditioning to overcome the mismatches in the scrums. The players also suggested that the advantage law and the management thereof by the referee play a role in the decrease in the number of scrums. Furthermore, the improved skill set of the players and the fact that they consequently make fewer mistakes, could have an effect. The decrease in the number of scrums won by the defending team is due to scrums allowing a clear contest at the scrum. The referees added that due to referees policing the feed from the scrum-half more strictly, the balls are fed straight and this allows for a contest between the two forward packs. A further reason as provided by the referees and referee advisors is that if the front row collapses but the ball is available at the feet of the eighth man, the referees will allow play to continue. The findings of the current study corresponds with those of Vahed *et al*. (2014), who also observed a decrease in the number of line-outs and scrums.

The increase in the number of 50m kick restarts is due to the increase in the number of points scored from the scoring modes, leading to fewer restarts. Interestingly, the number of contestable restarts increased. The coaches and players felt the reason for this is to put the receiving team under pressure in their own half of the field and also to try to regain the ball in the attacking half of the field and to start an attack. From the interviews it was deduced that teams are taking more risks in Super Rugby when compared to international rugby, where teams might play a territorial game by kicking the ball deep into the opposition's half and forcing them to kick back or to make a

mistake in their 22m area. The decrease in the number of 22m kick restarts could be attributed to the accuracy of the goal kickers and also the decrease in the number of drop goals. This is an area that is considered very important to the success of teams and has led to the appointment of specialist kicking coaches to address this aspect of the game. The study also revealed an increase in the number of kicks, showing that the contest has become more important and that teams want possession of the ball.

The interviewed experts argued that the good weather conditions and dry playing surfaces in the Southern Hemisphere allow for an open-game approach by the teams. This approach has led to an increase in ball carries, passes, line breaks and tackle breaks. Teams will use their effective ball carries to take the ball across the advantage line through tackles and line breaks (Hendricks *et al*. 2014), forcing the defensive team to play catch-up rugby. Following this tactic gives the attacking team momentum. Also, the players' conditioning and skills have improved, thus they are making fewer mistakes. The reason for the decrease in the number of offloads could be better-structured defensive systems and tackling techniques, thus teams are in doubt whether to throw a 50/50 offload. The coaches felt that, due to the defending team adopting a game plan at ruck-play by not contesting, the attacking team are allowed to go to ground and secure possession without risking a loss.

Fewer rucks could be due to the law with regard to the ruck area, also referred to as the "chicken wings" law by the interviewers in December 2009. According to WR, the amendment was necessitated by delays in the release of the ball owing to the contest for possession, which resulted in adverse effects (Erugbynews, 2009). Hence the domination of defence over attack was slowing the continuity of play. The defending team are responsible for forming a ruck. Many defensive teams concentrate on scanning (making a decision to either join the ruck or join the defensive line), then spoiling (counter-ruck) the tackle area, before the attacking scrumhalf or player in the receiver position gets his hands on the ball or joins the defensive line (Prim *et al*, 2006; Kraak & Welman, 2014). This suggests that teams may be attempting to dominate the tackle situation and then forming a tackle situation (breakdown) rather than committing numbers to the rucks and delaying the release of the ball (Vahed *et al*., 2014).

The increase in the number of ball carries, line breaks and passes has led to an increase in the number of tackles, because teams in Super Rugby prefer to keep the

ball in hand. Coaches and trainers should condition teams to be able to tackle for 80 minutes. The increased size and speed of players, which favour defence; increased defensive organization courtesy game analysis and the introduction of ideas from rugby league; and increased athleticism of players, allow the defending team to compete and slow the ball down at breakdowns. Due to the competition structure where teams can obtain a further bonus point for scoring 4 tries or losing within 7 points, attacking teams need to obtain possession of the ball in the last part of matches to score points and are forcing the defending teams to make more tackles. The increase in missed tackles could be due to the improved skill set of the attacking players, which can be seen in the increase in the number of line breaks and tackle breaks. Due to the increase in the number of tackles in modern Super Rugby, Hendricks *et al*. (2014) recommended that the technical characteristics be emphasized and incorporated in training to effectively prepare tacklers for match play.

Results showing that there are fewer kicks could be due to the ball-in-hand approach adopted by teams in the latter part of a match. Knowing when to kick, and doing so effectively, is key. Similarly, a team whose defence is poorly organized will concede points if they adopt this strategy. However, if these aspects are superior, this team are more likely to win than the team who control possession, take the ball through more phases and pass more. The current study has shown an increase in the number of kicks during the 1st half of matches. Coaches and players stated that it is typical for teams to “feel each other out” at the beginning of the match by kicking back and forth, hoping that the opposition will make a mistake.

The number of penalty kicks increased from 2008 to 2013. It should be taken into account that in 2008 the ELVs were used where different sanctioning was used for infringements by the referees. The study revealed an increase in the number of penalty kicks against the attacking team and a decrease in the number of such kicks against the defending team, but still more penalties against the defending team. The referees and referee advisors were of the opinion that the reason for the increase in the number of penalties was the increase in the number of breakdown situations, as 65% of the penalties still occurred at the breakdown and ruck. The reason for more penalties against the defending teams could be referees favouring the attacking team to improve the continuity of the game. The study showed a decrease in the number of free kicks

from 2008 to 2013. During the interviews, the coaches and players suggested that players understand the laws better and are playing within the laws, thus resulting in a decrease in the number of free kicks. The study revealed more free kicks against the attacking team and fewer against the defending team. This could be due to referees being stricter at the scrum and line-out feed.

Practical application

Based on the suggested effect of the law changes on the scoring and general match profile, the next section will recommend practical applications to coaches to assist with the development of rugby-specific training programmes.

Monitoring of matches

The norm for technical staff and performance analysts is to analyze a match as a whole. More specifically, a match could be broken down into two separate halves, as some significant information may be lost when adding the two halves together. For example, one half's PIs may be significantly higher than those of the other half. Performance profiles for tournaments and opponents should be developed to help understand what players go through technically, tactically and physically and help understand and interpret tactical strengths and weaknesses.

Skills coaching

The study revealed an increase in the number of ball carries and tackles, thus contact sessions should primarily focus on executing effective tackling techniques by which players enter the contact with a relatively low body position to remain stable, and once contact is made players must drive powerfully with the legs to drive the ball carrier backwards, dominating the contact situation (Wheeler *et al*., 2013; Worsnop, 2012; Hendricks & Lambert, 2010). Additionally, contact sessions should also focus on executing fast and effective means of contesting at breakdown points and improving defensive line speed (Hendricks *et al*., 2013). Game-specific drills should aim to teach players decision-making skills by placing them in situations they must read and in which they must determine the best plan of action (Kraak & Welman, 2014) in a given situation, especially during the ruck as most of the penalties are awarded against defending teams.

5.5. Conclusion

The study firstly showed an increase in the total number of points scored and a decrease in the number of points scored from tries. The mode of scoring shifted from tries to penalty kicks. Secondly, the profile of the game has changed to a more continuous game dynamic with the increase in the number of ball carries, passes, tackle breaks and line breaks, and has led to more tackles and missed tackles. Fewer rucks, mauls and scrums occurred but no change was observed in the number of line-outs, while there were more contestable 50m kick restarts and 22m restarts. Lastly, the match duration revealed no change, possibly due to the improved skill level of the players resulting in fewer mistakes. The results of this study emphasize the importance of further research on match and tournament profiles and identifying specific time variable trends. Future studies should focus on the scoring and general match profile of national rugby competitions in the Northern Hemisphere (European Cup), which could lead to improvements in training regimes and programmes by preparing players for the specific demands of the tournament and determining whether there are differences between the hemispheres' national competitions. The importance of today's coach is to not only review the games and analyze the results, but to identify the coaching implications to better train and prepare players.

5.6. Acknowledgements

We would like to thank Mr Carel du Plessis and Johan van der Westhuizen of Fika for providing us with the match videos. Prof. Martin Kidd of the Centre for Statistical Consultation, Stellenbosch University, for assisting with the statistical analysis and the MSc students who assisted with the data capturing from the software.

5.7. References

Duthie, G., Pyne, D., & Hooper, S. (2003). Applied physiology and game analysis of rugby union. **Sports Medicine**, 33: 973–991.

Eaves, S.J. & Hughes, M. (2003). Patterns of play of international rugby union teams before and after the introduction of professional status. **International Journal of Performance Analysis in Sport**, 3(2): 103-111.

Eaves, S.J., Lamb, K. L., & Hughes, M.D. (2008). The impact of rule and playing season changes on time variables in professional rugby league in the United Kingdom. **International Journal of Performance Analysis in Sport**, 8(2): 45-54.

Erugbynews. (2009). Ask the Ref: Hands at the Ruck - IRB Law Ruling 4, http://erugbynews.com/article.php?sec=3170&a=4824 (Used: May 2013).

Hendricks, S. & Lambert, M. (2010). Tackling in rugby: coaching strategies for effective technique and injury prevention. **International Journal of Sports Science & Coaching**, 5(1): 117-136.

Hendricks, S., Roode, B., Matthews, B., & Lambert, M. (2013). Defensive strategies in Rugby Union. **Perceptual and Motor Skills,** 117(1): 65-87.

Hendricks, S., Karpul, D., & Lambert, M. (2014). Momentum and kinetic energy before the tackle in rugby union. **Journal of Sports Science and Medicine**, 13(3): 557–563.

Hopkins, W.G. (2011). A new view of statistics. Retrieved from http://www.sportsci.org/resource/stats.

Hughes, M.D. & Bartlett, R.M. (2002). The use of performance indicators in performance analysis. **Journal of Sports Sciences**, 20(10):739-754.

Hughes, M., Evans, S., & Wells, J. (2001). Establishing normative profiles in performance analysis. **International Journal of Performance Analysis in Sport**, 1(1): 1-26.

James, N., Mellalieu, S.D., & Jones, N.M.P. (2005). The development of position-specific performance indicators in professional rugby union. **Journal of Sports Sciences**, 23: 63-72.

Kraak, W.J. & Welman, K.E. (2014). Ruck-play as performance indicator during the 2010 Six Nations Championship, **International Journal of Sport Science and Coaching**, 9(3): 525-537.

Liporace, F.A., Yoon, R.S., Kubiak, E.N., Parisi, D.M., Koval, K.J., Feldman, D., & Egol, K.A. (2012). Does adding computed tomography change diagnosis and treatment of tillaux and triplane pediatric ankle fractures? **Orthopedics**, 35(2): 208-211.

Liebermann, D.G., Katz, L., Hughes, M.D., Bartlett, R.M., McClements, J., & Frank, I.M. (2002). Advances in the application of information technology to sport performance. **Journal of Sports Sciences**, 20: 755-769.

Meiklejohn, T. W. (2010). The formation, processes and impacts of interorganisational cliques: A study of New Zealand provincial rugby. New Zealand: Auckland University of Technology.

Owen, S.M., Venter, R.E., Du Toit, S. & Kraak, W.J. (2015). Acceleratory match-play demands of a Super Rugby team over a competitive season. **Journal of Sports Sciences**, doi: 10.1080/02640414.2015.1028086 (in print).

Prim, S., Van Rooyen, M.K. & Lambert, M. (2006). A comparison of performance indicators between the four South African teams and the winners of the 2005 Super 12 Rugby competition. What separates top from bottom? **International Journal of Performance Analysis in Sport**, 6(2): 126-133.

Quarrie, K.L. (2009). An evaluation of the Experimental Law Variations in Air New Zealand Cup Rugby. New Zealand Rugby Union.

Quarrie, K. L. and Hopkins, W.G. (2007). Changes in player characteristics and match activities in Bledisloe Cup rugby union from 1972 to 2004. **Journal of Sports Sciences**, 25: 895–903.

Sasaki, K., Furukawa, T., Murakami,J., Shimozono, H., Nagamatsu, M., Miyao, M., Yamamoto, T.,Watanabe, I., Yasugahira, H., Saito, T., Ueno, Y., Katsuta, T., & Kono, I. (2007). Scoring profiles and defense performance analysis in Rugby Union. **International Journal of Performance Analysis in Sport**, 7(3): 46-53.

Thomas, J.R., Lochbaum, M.R., Landers, D.M., & He, C. (1997). Planning significant and meaningful research in exercise science: Estimating sample size. **Research Quarterly for Exercise and Sport,** 68(1): 33–43.

Vahed, Y., Kraak, W., & Venter, R. (2014). The effect of the law changes on time variables of the South African Currie Cup Tournament during 2007 and 2013. **International Journal of Performance Analysis of Sport**, 14(3): 868-885.

Vahed, Y., Kraak, W., & Venter, R. (2016). Changes on the match profile of the South African Currie Cup Tournament during 2007 and 2013. **International Journal of Sport Science and coaching**, (in print).

Van den Berg, P. & Malan, D.D.J. (2012). The effect of experimental law variations on the super 14 rugby union tournament. **African Journal for Physical Health Education, Recreation and Dance**, 18(3): 476-486.

Van Rooyen, M.K., Rock, K., Prim, S., & Lambert, M. (2008). The quantification of contacts with impact during professional rugby matches. **International Journal of Performance Analysis in Sport**, 8(1): 133-126.

Wheeler, K.W., Mills D., Lyons, K., & Harrinton W. (2013). Effective defensive strategies at the ruck contest in rugby union. **International Journal of Sport Science Coaching,** 8(3): 237-242.

Williams, J. Hughes, M.D., & O'Donoghue, P. (2005). The effect of rule changes on match and ball in play time in rugby union. **International Journal of Performance Analysis in Sport**, 5(3): 1-11.

World Rugby. (2015). Laws of the game Rugby Union Incorporating the playing charter. Dublin: Ireland.

Worsnop, S. (2012), Rugby games and drills / rugby football union. United States of America: Human Kinetics.

CHAPTER SIX
SUMMARY AND CONCLUSIONS

6.1. Summary and conclusions

A relatively small amount of published literature exists on the effects of the law changes in rugby. This dissertation sought to provide a detailed analysis, with the use of computerized notational analysis (CNA), to compare and investigate the scoring and general match profile of international and national rugby between 2007 and 2013. The first objective of this study was to investigate and compare the scoring profile of international rugby between 2007 and 2013. The second objective was to investigate and compare the changes on the general match profile of international rugby between 2007 and 2013, and lastly to investigate and compare the scoring and general match profile of Super Rugby between 2008 and 2013.

This dissertation was presented in seven main parts, namely an introduction and problem statement (Chapter One), the theoretical background (Chapter Two) and three research articles (Chapters Three, Four and Five). The article format of the dissertation was approved by the Senate of Stellenbosch University and the three research articles were presented in accordance with the guidelines of the specific journals. Chapter One introduced the problem and stated the objectives of this study.

The theoretical background (Chapter Two) aimed to provide greater insight into the profile of the modern rugby game in order to provide coaches and trainers with

information from which they can make more informed decisions regarding training regimes to improve performance. The chapter firstly looked at the current state of the use of performance analysis in rugby. Secondly, the changes in the match profile due to law changes, changes in player attributes and changes in match demands of international and national rugby were reviewed. Thirdly, the chapter aimed to provide coaches and specialists coaches with information on how to possibly approach the modern profile of the game.

The summary and conclusions drawn from this research study are presented in accordance with the set objectives in Chapter One.

Chapter Three is in a research article format and addressed the first objective of the study: How did law changes affect the scoring profile of international rugby union between 2007 and 2013? Results indicated that law changes over the years have had a significant effect on the profile of international rugby. The scoring profile of international rugby revealed a decrease in the number of tries ($p=0.07$) and drop goals ($p =0.06$) and a significant increase in the number of penalty kicks ($p<0.01$). Most of the points and tries were accumulated during the 2nd half, especially during the 4th quarter of the match for most of the years. The origin of tries revealed that there was a decrease in tries from structured play (47% to 43%) and an increase from turnover possession (27% to 43%).

Chapter Four is in a research article format and addressed the second objective of the study: Game analysis of the general match profile of international rugby union between 2007 and 2013. The duration of the international matches has increased owing to the increase in the number of stoppages, mainly as a result of greater use being made of the TMO, substitutions and on-field concussion tests. This is evident in the significant increase in total match time ($d=0.34$) and ball-in-play time ($d=0.87$). Results of the study show that the profile of international rugby has changed to a more continuous game dynamic with the increase in the number of ball carries ($d=1.22$), passes ($d=0.73$), tackle breaks ($d=2.03$) and line breaks ($d=3.00$), and has led to an increase in the number of tackles ($d=0.65$). A decrease in the number of rucks ($d=0.86$), mauls ($d=0.90$), scrums ($d=1.03$), scrum resets ($d=0.74$) and line-outs ($d=0.61$) was found. A decrease in both penalty ($d=0.98$) and free kicks ($d=1.22$) between 2007 and 2013 was observed.

Chapter Five is in a research article format and addressed the third objective of the study: Scoring and general match profile of Super Rugby between 2008 and 2013. The scoring profile of national rugby indicated fewer tries ($p<0.01$) and conversion kicks ($p<0.01$) and significantly more penalty kicks ($p<0.01$). The duration of the national matches has decreased due to fewer stoppages, mainly as a result of the improved skill level of the players. This is evident in the significant decrease in total match time ($d=0.41$). The ball-in-play time ($d=0.91$) has decreased. Results of the study show that the profile of national rugby has changed to a more continuous game dynamic with the increase in the number of ball carries ($d=1.34$), passes ($d=0.43$), tackle breaks ($d=1.59$) and line breaks ($d=2.40$) and has led to an increase in the number of tackles ($d=0.63$). A decrease in the number of rucks ($d=1.73$), mauls ($d=0.63$), scrums ($d=0.27$) and scrum resets ($d=1.36$) was found. An increase in penalty kicks ($d=2.04$) and a decrease in free kicks ($d=0.4.53$) between 2008 and 2013 were observed.

In summary, the game of rugby at international and national level has evolved into a game that involves more contact, dominated by ball carriers and tackles. By analyzing the scoring and general match profile, coaches and specialist coaches should be able to adapt their training programmes to meet the specific technical, tactical and physical demands of match play.

6.2. Limitations

- ✓ The study did not take the quality of opposition, the match outcome (winning, drawing or losing) and the match location (home or away) into consideration as part of the analysis process.
- ✓ This study identified the scoring and general match profile of the selected matches from selected international and national competitions. The findings may therefore not reflect the profile of other international and national matches. It would thus be ideal to analyze all the international and national competitions and investigate their match profiles as they would provide a better understanding of domestic rugby in several countries, in both the Northern and Southern Hemispheres.
- ✓ This study analyzed only the international matches between the 2007 and 2013 seasons and the national matches between 2008 and 2013. There may have been format changes to the tournaments that could have affected the match profile of

the international and national games. It would therefore be ideal to analyze all the international and national matches.

- ✓ This study did not compare international and national match profiles to draw a comparison between the different levels.
- ✓ This study investigated only the scoring and general match profile of selected senior-level international and national matches. The findings may not reflect the junior international and national profile. It would therefore be ideal to investigate each participation level to determine the possible differences in the profiles.
- ✓ The sample size for the semi-structured interviews was too small.
- ✓ Semi-structured interviews were used due to the location of the experts.
- ✓ The researcher realizes that there are other factors, apart from law changes, which can also influence the profile of a game.

6.3. Future research

The results from this study emphasize the importance of further research on scoring and general match profiles of international and national rugby. Future studies should focus on identifying the profile of the junior and women's levels and comparing the differences between the different levels, which could lead to improvements in training regimes and programmes by preparing players for the specific demands of match play at a specific level. Studies should also focus on analyzing the changes in the profile of other matches of the lower-tier nations.

6.4. Practical applications

Based on the effect of the law changes on the scoring profile and general match profile of international and national rugby, practical applications are recommended to coaches and trainers to possibly assist with the development of rugby-specific technical, tactical and physical training programmes. With the appointment of performance analysts and the advancement of sophisticated software to conduct detailed PA, the performance analyst, in conjunction with the coaches and trainers, should analyze matches to determine a performance profile of their own team and of the opposition. Matches could be broken down into halves and even quarters to

provide a more specific analysis as some significant information may be lost when analyzing the game as a whole. The opposition's PPs could be used by coaches to develop strategies to counter their strengths and exploit their weaknesses and could assist coaches and trainers with information to recreate match situations during training to improve performance on match day.

Monitoring of matches

The norm for technical staff and performance analysts is to analyze a match as a whole, but in order to be more specific one could break the match down into two separate halves, as some significant information may be lost when adding the two halves together. For example, one half's PIs may be significantly higher than those of the other half. Performance profiles for tournaments and opponents should be developed to help understand what players go through technically, tactically and physically and help understand and interpret tactical strengths and weaknesses.

Skills coaching

The study revealed an increase in the number of ball carries and tackles, thus contact sessions should focus primarily on executing effective tackling techniques, by which players enter the contact situation with a relatively low body position to remain stable, and once contact is made players must drive powerfully with the legs to drive the ball carrier backwards, dominating the contact situation. Additionally, contact sessions should also look at executing fast and effective means of contesting at breakdown points and improving defensive line speed. Game-specific drills should aim to teach players decision-making skills by placing them in situations they must read and where they must determine the best plan of action, especially during the ruck as most of the penalties are awarded against defending teams.

Conditioning and recovery

Coaches and trainers need to individualize the conditioning and recovery that will allow players to be better prepared for their position-specific roles. After matches and training, forwards may require more time for physical recovery because they have greater aggregated body demands than backs. Tailoring recovery strategies and adjusting training demands to meet individual needs reduce the likelihood of

insufficient recovery, and therefore allow players to train optimally and reduce the risk of injury.

6.5. Important observations

The following important observations were made during the project:

- ✓ That the experimental law variations proposed are taking too long to be implemented as laws at international and national level, due to the processes currently followed for law changes. The game has changed to such an extent that the “new law” does not have the intended impact.
- ✓ Coaches, referees and players play an integral part in the change in the profile of the modern game. These role players separately cannot be responsible for the change in the profile of the game.
- ✓ The role of specialist coaches is developing continuously and is becoming more important as teams are looking for the smallest margin to get the edge over the opposition. The challenge for the head coach is to manage the process in order for teams to be successful.
- ✓ Defence in international and national rugby has evolved much faster compared to attack, resulting in an imbalance between attack and defence. The rugby bodies need to find a means to evolve attacking play in order to find a balance between attack and defence. The current approach of referees to penalize the defending team more in order to improve the continuity of the game needs to change. This would contribute to improving the current imbalance between attack and defence.

APPENDIX A

INTERNATIONAL JOURNAL OF PERFORMANCE ANALYSIS IN SPORT

1. Scope

The International Journal of Performance Analysis in Sport is published on behalf of the Centre for Performance Analysis, Cardiff School of Sport at Cardiff Metropolitan University and in association with the International Society of Performance Analysis in Sport. The emphasis is on the analysis of actual performance in sport and exercise. Studies using observational methods, biomechanical analysis, self-report emanating from actual sports performance, qualitative observation and measurements such as heart rate response during actual sports performance are all within the scope of the journal. Laboratory studies of key techniques within sports are also of interest where such techniques are clearly important and cannot be analysed in detail during actual competition. Such techniques include tennis serves and golf swings. There may be other contributions that do not analyse sports performance at all that are within the scope of the journal. For example, interview studies or meta analyses may lead to theoretical contributions explaining the nature of sports performance, tactics used and factors influencing performance. Review articles relevant to sports performance are also welcome. Other topics covered include technologies such as design of analysis systems, sports equipment, research into training, and modelling and predicting performance. Contributors wishing to clarify whether papers they are writing are within the scope of the journal are welcome to contact the general editor.

2. Submission

Authors must submit an original article in electronic form, (preferably by e-mail) in Microsoft Word, to the General Editor (podonoghue@cardiffmet.ac.uk). Papers submitted to the Journal will be refereed blind by acknowledged experts in the subject. Occasionally, where papers are submitted in highly specialist areas outside the expertise of the Editorial Board members, the General Editor may ask authors to provide contact details for potential reviewers who are experts in the area. The General Editor has the final decision on publication. No word limits are specified for papers, but discursive treatments of the subject matter are discouraged. The Journal does not normally publish letters to the editor.

3. Originality

All material submitted for publication in the journal must be accompanied by a statement by the lead author, with the authority of all of the authors, that: the material submitted is original and unpublished, and is not under consideration for publication elsewhere and that the material will not be submitted for publication elsewhere while it is under consideration by the journal.

4. Format

Papers consist of a title page, blind title page and the main text of the paper. Figures and tables should be included in the text rather than following the text. Typical sections of the text are Introduction, Methods, Results, Discussion, Conclusions, any acknowledgements, References and author correspondence details. However, it is acceptable to have a conclusions paragraph at the end of the discussion. Further variation is possible for review articles or where papers report on a series of studies which are best reported in a study by study order.

Page Layout

Pages must be A4 using margins of 3cm at the top, bottom, left and right. Portrait orientation is used except where landscaped orientation clearly assists the presentation of tables and / or figures. Paragraph text should be single spaced.

Title Page

The title page should contain the title (Times Roman, size 18, bold), author names using first names, other initials and surnames and affiliations of authors, the abstract and key words. All text other than the abstract should use Times Roman size 12 font. The abstract should be bold and in italics not exceeding 200 words. It should be inserted in the article after the authors' affiliations and indented by 1 cm at the left and right. The abstract should not contain figures or tables.

Blind Title Page

This should include all of the information on the title page except the author names and affiliations. Where acknowledgements or information in the methods about ethical clearance may compromise the blind reviewing process, the General Editor will temporarily remove this information while the paper is being reviewed.

Headings

Headings and subheadings should all be in Times Roman font, bold and size 12. Headings should be numbered 1., 2., 3., etc with any subheadings being 1.1., 1.2., for example.

Tables

Tables should normally only include horizontal lines to mark the top and bottom and separate column headings from the main body of tables. Tables must be created in word to facilitate any necessary editing by the journal. There are occasions, where correlation tables, for example, require vertical lines and this is acceptable. Table captions should appear above the table.

Figures

Illustrations, photographs, screen dumps, charts, plates and any other artwork should be included in the electronic submission. Authors must have permission to use any photographs within the paper and copyrighted material from published sources must not be included as Figures in the paper. Figure headings should be placed below figures.

Symbols, units and abbreviations

Symbols, units and abbreviations in papers must conform to the Système International d'Unités (SI Units). Authors are advised to consult the National Physical Laboratory publication (R.J. Bell (ed.), 1993, SI: The International System of Units. London: HMSO). For all abbreviations other than units, write the word or words to be abbreviated in full on the first mention followed by the abbreviation in parentheses. If at all possible, group these definitions together near the beginning of the article. As indicated earlier, avoid use of nonstandard abbreviations, especially fabricated ones, within the text; words are much easier to read and follow than abbreviations.

References

References in the text are cited as follows: Smith (1985) ... or (Brown and Green, 1996) ... or, if there are more than two authors, as Jones et al. (1993) ... or (Jones et al., 1993). Citations of different publications by the same author(s) in the same year are differentiated as Green (1993a) ... (Brown et al., 1995b); the a, b, c, etc. , are normally in order of citation in the text. Multiple citations are listed in ascending chronological order. Multiple publications by the same authors are treated in lists: Smith (1991, 1995), Brown and Green (1992, 1993), Jones et al. (1993, 1996a,b); or (Smith, 1991, 1995; Brown and Green, 1992, 1993; Jones et al., 1993, 1996a,b). A list of all cited references should be collected at the end of the paper in alphabetical order by, in the first instant, the first author's surname. Where the name of the first author appears more than once, the order is determined by: first, the number of co-authors (zero, one, or more than one); secondly, for one co-author, the first co-author's surname then the year; for two or more co-authors, year then order as dictated by the use of 1990a,b,c (for example) in the citations. The following is an example of how references would be ordered in the reference list: Brown (1980), Brown (1990), Brown and Jones (1977), Brown and Smith (1973), Brown and Smith (1975), Brown et al. (1990a), Brown et al. (1990b), Brown et al. (1990c). Note that the last three examples would all have been cited as Brown et al. in the text, with the a, b and c relating to the order of citation. The names and initials of all authors should be given in the list of references. The style should follow the examples below:

Journal Papers

Newton, P.K. and Keller, J.B. (2005), The probability of winning at tennis, Theory and Data,Studies in Applied Mathematics, 114, 214-269.

Books

Ashe, A. (1981), Arthur Ashe's Tennis Clinic. London: Heinemann.

Chapters of Edited Books (including conference proceedings published as books) Hughes, M. and Clarke, S. (1995), Surface effect on elite tennis strategy. In Reilly, T., Hughes, M. and Lees, A. (Eds.) Science and Racket Sports (pp. 272-277). London: E & FN Spon.

Conference abstracts published in journals

O'Donoghue, P.G. (2003), The effect of scoreline on elite tennis strategy: a cluster analysis. Journal of Sports Sciences, 21, 284-285.

5. Proofs

Once accepted papers have been edited, the PDF versions will be sent to the authors for final checking and final editing.

6. Copyright

Submission of a paper to the International Journal of Performance Analysis in Sport is taken to imply that it represents original, unpublished research and that authors agree that the International Journal of Performance Analysis will have copyright to the material.

APPENDIX B

EUROPEAN JOURNAL OF SPORT SCIENCES

This journal uses ScholarOne Manuscripts (previously Manuscript Central) to peer review manuscript submissions. Please read the guide for ScholarOne authors before making a submission. Complete guidelines for preparing and submitting your manuscript to this journal are provided below.

Use these instructions if you are preparing a manuscript to submit to *European Journal of Sport Science*. To explore our journals portfolio, visit http://www.tandfonline.com/, and for more author resources, visit our Author Services website.

European Journal of Sport Science considers all manuscripts on the strict condition that

- the manuscript is your own original work, and does not duplicate any other previously published work, including your own previously published work.
- the manuscript has been submitted only to *European Journal of Sport Science*; it is not under consideration or peer review or accepted for publication or in press or published elsewhere.
- the manuscript contains nothing that is abusive, defamatory, libellous, obscene, fraudulent, or illegal.

Please note that *European Journal of Sport Science* uses CrossCheck™ software to screen manuscripts for unoriginal material. By submitting your manuscript to *European Journal of Sport Science* you are agreeing to any necessary originality checks your manuscript may have to undergo during the peer-review and production processes.

Any author who fails to adhere to the above conditions will be charged with costs which *European Journal of Sport Science* incurs for their manuscript at the discretion of *European Journal of Sport Science*'s Editors and Taylor & Francis, and their manuscript will be rejected.

This journal is compliant with the Research Councils UK OA policy. Please see the licence options and embargo periods here.

Contents List

Manuscript preparation

1. General guidelines
2. Style guidelines
3. Figures

4. Publication charges
    - Submission fee
    - Page charges
    - Colour charges
5. Reproduction of copyright material
6. Supplemental online material

Manuscript submission

Copyright and authors' rights

Free article access

Reprints and journal copies

Open access

Manuscript preparation

1. General guidelines

- Manuscripts are accepted in English. British English spelling and punctuation are preferred. Please use double quotation marks, except where "a quotation is 'within' a quotation". Long quotations of 40 words or more should be indented with quotation marks.
- A typical manuscript will not exceed 4000 words including tables, references, captions and endnotes. Manuscripts that greatly exceed this will be critically reviewed with respect to length. Authors should include a word count with their manuscript.
- Manuscripts should be compiled in the following order: title page; abstract; keywords; main text; acknowledgements; references; appendices (as appropriate); table(s) with caption(s) (on individual pages); figure caption(s) (as a list).
- Abstracts of 250 words are required for all manuscripts submitted.
- Each manuscript should have 3 to 6 keywords.
- Search engine optimization (SEO) is a means of making your article more visible to anyone who might be looking for it. Please consult our guidance here.
- Section headings should be concise.
- All authors of a manuscript should include their full names, affiliations, postal addresses, telephone numbers and email addresses on the cover page of the manuscript. One author should be identified as the corresponding author. Please give the affiliation where the research was conducted. If any of the named co-authors moves affiliation during the peer review process, the new affiliation can be given as a footnote. Please note that no changes to affiliation

can be made after the manuscript is accepted. Please note that the email address of the corresponding author will normally be displayed in the article PDF (depending on the journal style) and the online article.

- All persons who have a reasonable claim to authorship must be named in the manuscript as co-authors; the corresponding author must be authorized by all co-authors to act as an agent on their behalf in all matters pertaining to publication of the manuscript, and the order of names should be agreed by all authors.
- Biographical notes on contributors are not required for this journal.
- Please supply all details required by any funding and grant-awarding bodies as an Acknowledgement on the title page of the manuscript, in a separate paragraph, as follows:
    - *For single agency grants:* "This work was supported by the [Funding Agency] under Grant [number xxxx]."
    - *For multiple agency grants:* "This work was supported by the [Funding Agency 1] under Grant [number xxxx]; [Funding Agency 2] under Grant [number xxxx]; and [Funding Agency 3] under Grant [number xxxx]."
- Authors must also incorporate a Disclosure Statement which will acknowledge any financial interest or benefit they have arising from the direct applications of their research.
- For all manuscripts non-discriminatory language is mandatory. Sexist or racist terms must not be used.
- Symbols, units and abbreviations in papers must confirm to the Système International d'Unités (SI Units). Authors are advised to consult the National Physical Laboratory publication (R.J.Bell (ed) 1993, SI: The International System of Units. London. HMSO). For all abbreviations other than units, write the word or words to be abbreviated in full on the first mention, followed by the abbreviation in parentheses.
- When numeric values are given, a space must appear between the number and unit, as in 95.6 W and 25.0 N (exceptions are angles in degrees, e.g. 23.5º, and percentages, e.g. 15%). Separate compound units by a raised dot (N·m) and not by a space (N m); a compound unit formed from others by division should be indicated, for example, as ml·min-1 not as ml/min. Angular velocities should be expressed in rad·s-1 not degrees s-1 or º s-1. Some exceptions to the use of the SI are allowed, for example for heart rate (beats·min-1) and blood or gas pressure (mmHg). Other units and abbreviations should conform to Bell (1993) or Council of Biology Editors (1994).
- Scalar variables or constants that are represented by a single letter should appear in italics (e.g. *v, k, x*). Where the abbreviation is of more than one letter (excluding suffices or superfices), it should be set in Roman typeface, as should abbreviations of mathematical functions (thus a = dv /dt). Vectors should be indicated in bold and italics (e.g. ***F, v***). For further and more detailed examples,

authors should consult Council of Biology Editors (1994). Equations and formulae should, wherever possible, be presented on one line.

- Statistical definitions and symbols should conform to ISO3534- 1977, summarized briefly in Council of Biology Editors (1994). Some examples should make matters clear: $F_{2,12}$, H_0 , t , n =10, P <0.05, r =0.71 (or for population correlation coefficient), SD, (for standard deviation of sample and population), s_x - (standard error of the mean), $\bar{x}$ (upper case for population mean). Mean values with standard deviations or standard errors of the mean should be reported as, for example: mean value 13.7, s = 2.5 m, or mean 15.7, s_x - =3.6 kg (no need for ±). In tables and lists, the following is convenient (mean±s) or (±s), with the tabulated values in the form: 13.4 ± 7.2. Authors should, therefore, avoid the use of abbreviations such as S.D. and S.E.M.
- When using a word which is or is asserted to be a proprietary term or trade mark, authors must use the symbol ® or TM.

2. Style guidelines

- Description of the Journal's article style.
- Description of the Journal's reference style.
- Guide to using mathematical scripts and equations.

3. Figures

- Please provide the highest quality figure format possible. Please be sure that all imported scanned material is scanned at the appropriate resolution: 1200 dpi for line art, 600 dpi for grayscale and 300 dpi for colour.
- Figures must be saved separate to text. Please do not embed figures in the manuscript file.
- Files should be saved as one of the following formats: TIFF (tagged image file format), PostScript or EPS (encapsulated PostScript), and should contain all the necessary font information and the source file of the application (e.g. CorelDraw/Mac, CorelDraw/PC).
- All figures must be numbered in the order in which they appear in the manuscript (e.g. Figure 1, Figure 2). In multi-part figures, each part should be labelled (e.g. Figure 1(a), Figure 1(b)).
- Figure captions must be saved separately, as part of the file containing the complete text of the manuscript, and numbered correspondingly.
- The filename for a graphic should be descriptive of the graphic, e.g. Figure1, Figure2a.

4. Publication charges

Submission fee

There is no submission fee for *European Journal of Sport Science*.

Page charges

There are no page charges for *European Journal of Sport Science*.

Colour charges

Authors should restrict their use of colour to situations where it is necessary on scientific, and not merely cosmetic, grounds. Colour figures will be reproduced in colour in the online edition of the journal free of charge. If it is necessary for the figures to be reproduced in colour in the print version, a charge will apply. Charges for colour pages are £250 per figure ($395 US Dollars; $385 Australian Dollars; 315 Euros). If you wish to have more than 4 colour figures, figures 5 and above will be charged at £50 per figure ($80 US Dollars; $75 Australian Dollars; 63 Euros). Waivers may apply for some articles – please consult the Production Editor regarding waivers.

Depending on your location, these charges may be subject to Value Added Tax.

5. Reproduction of copyright material

If you wish to include any material in your manuscript in which you do not hold copyright, you must obtain written permission from the copyright owner, prior to submission. Such material may be in the form of text, data, table, illustration, photograph, line drawing, audio clip, video clip, film still, and screenshot, and any supplemental material you propose to include. This applies to direct (verbatim or facsimile) reproduction as well as “derivative reproduction” (where you have created a new figure or table which derives substantially from a copyrighted source).

You must ensure appropriate acknowledgement is given to the permission granted to you for reuse by the copyright holder in each figure or table caption. You are solely responsible for any fees which the copyright holder may charge for reuse.

The reproduction of short extracts of text, excluding poetry and song lyrics, for the purposes of criticism may be possible without formal permission on the basis that the quotation is reproduced accurately and full attribution is given.

For further information and FAQs on the reproduction of copyright material, please consult our Guide.

6. Supplemental online material

Authors are encouraged to submit animations, movie files, sound files or any additional information for online publication.

- Information about supplemental online material

Manuscript submission

All submissions should be made online at the *European Journal of Sport Science* Scholar One Manuscripts website. New users should first create an account. Once logged on to the site, submissions should be made via the Author Centre. Online user guides and access to a helpdesk are available on this website.

Manuscripts may be submitted in any standard editable format, including Word and EndNote. These files will be automatically converted into a PDF file for the review process. LaTeX files should be converted to PDF prior to submission because ScholarOne Manuscripts is not able to convert LaTeX files into PDFs directly. All LaTeX source files should be uploaded alongside the PDF.

Click here for information regarding anonymous peer review.

Copyright and authors' rights

To assure the integrity, dissemination, and protection against copyright infringement of published articles, you will be asked to assign to ECSS, via a Publishing Agreement, the copyright in your article. Your Article is defined as the final, definitive, and citable Version of Record, and includes: (a) the accepted manuscript in its final form, including the abstract, text, bibliography, and all accompanying tables, illustrations, data; and (b) any supplemental material hosted by Taylor & Francis. Our Publishing Agreement with you will constitute the entire agreement and the sole understanding between ECSS and you; no amendment, addendum, or other communication will be taken into account when interpreting your and ECSS rights and obligations under this Agreement.

Copyright policy is explained in detail here.

Free article access

As an author, you will receive free access to your article on Taylor & Francis Online. You will be given access to the *My authored works* section of Taylor & Francis Online,

which shows you all your published articles. You can easily view, read, and download your published articles from there. In addition, if someone has cited your article, you will be able to see this information. We are committed to promoting and increasing the visibility of your article and have provided guidance on how you can help. Also within *My authored works*, author eprints allow you as an author to quickly and easily give anyone free access to the electronic version of your article so that your friends and contacts can read and download your published article for free. This applies to all authors (not just the corresponding author).

Reprints and journal copies

Corresponding authors can receive a complimentary copy of the issue containing their article. Article reprints can be ordered through Rightslink® when you receive your proofs. If you have any queries about reprints, please contact the Taylor & Francis Author Services team at reprints@tandf.co.uk. To order a copy of the issue containing your article, please contact our Customer Services team at Adhoc@tandf.co.uk

APPENDIX C

JOURNAL OF SPORTS SCIENCES

This journal uses ScholarOne Manuscripts (previously Manuscript Central) to peer review manuscript submissions. Please read the guide for ScholarOne authors before making a submission. Complete guidelines for preparing and submitting your manuscript to this journal are provided below.

Use these instructions if you are preparing a manuscript to submit to Journal of Sports Sciences and Science and Medicine in Football.

To explore our journals portfolio, visit http://www.tandfonline.com/, and for more author resources, visit our Author Services website.

The Journal of Sports Sciences is published on behalf of the British Association of Sport and Exercise Sciences, in partnership with the World Commission of Science and Sports and in association with the International Society for Advancement of Kinanthropometry. The emphasis is on the human sciences applied to sport and exercise. Topics covered also include technologies such as design of sports equipment, research into training, and modelling and predicting performance; papers evaluating (rather than simply presenting) new methods or procedures will also be considered. The Journal of Sports Sciences also accepts 'Letters to the Editor' and 'Case Studies'.

Journal of Sports Sciences considers all manuscripts on the strict condition that

- the manuscript is your own original work, and does not duplicate any other previously published work, including your own previously published work.
- the manuscript has been submitted only to Journal of Sports Sciences; it is not under consideration or peer review or accepted for publication or in press or published elsewhere.
- the manuscript contains nothing that is abusive, defamatory, libellous, obscene, fraudulent, or illegal.

Please note that Journal of Sports Sciences uses CrossCheck™ software to screen manuscripts for unoriginal material. By submitting your manuscript to Journal of Sports Sciences you are agreeing to any necessary originality checks your manuscript may have to undergo during the peer-review and production processes.

Any author who fails to adhere to the above conditions will be charged with costs which Journal of Sports Sciences incurs for their manuscript at the discretion of Journal of Sports Sciences Editors and Taylor & Francis, and their manuscript will be rejected.

This journal is compliant with the Research Councils UK OA policy. Please see the licence options and embargo periods here.

Contents List

Manuscript preparation

1. General guidelines

Back to top.

- Manuscripts are accepted in English. British English spelling and punctuation are preferred. Please use double quotation marks, except where "a quotation is 'within' a quotation". Long quotations should be indented without quotation marks.
- Manuscripts should be compiled in the following order: title page (including Acknowledgements as well as Funding and grant-awarding bodies); abstract; keywords; main text; acknowledgements; references; appendices (as appropriate); table(s) with caption(s) (on individual pages); figure caption(s) (as a list).
- A typical article will not exceed 4,000 words not including references, tables, figures and captions. Footnotes should not be used unless they are absolutely

necessary. Papers that greatly exceed this will be critically reviewed with respect to length. Authors should include a word count with their manuscript.

Abstracts of 200 words are required for all manuscripts submitted.

Each manuscript should have 3 to 6 keywords.

Search engine optimization (SEO) is a means of making your article more visible to anyone who might be looking for it. Please consult our guidance here.

Section headings should be concise.

All authors of a manuscript should include their full names, affiliations, postal addresses, telephone numbers and email addresses on the cover page of the manuscript. One author should be identified as the corresponding author. Please give the affiliation where the research was conducted. If any of the named co-authors moves affiliation during the peer review process, the new affiliation can be given as a footnote. Please note that no changes to affiliation can be made after the manuscript is accepted. Please note that the email address of the corresponding author will normally be displayed in the article PDF (depending on the journal style) and the online article.

- All persons who have a reasonable claim to authorship must be named in the manuscript as co-authors; the corresponding author must be authorized by all co-authors to act as an agent on their behalf in all matters pertaining to publication of the manuscript, and the order of names should be agreed by all authors.
- Biographical notes on contributors are not required for this journal.
- Please supply all details required by any funding and grant-awarding bodies as an Acknowledgement on the title page of the manuscript, in a separate paragraph, as follows:
    - For single agency grants: "This work was supported by the [Funding Agency] under Grant [number xxxx]."
    - For multiple agency grants: "This work was supported by the [Funding Agency 1] under Grant [number xxxx]; [Funding Agency 2] under Grant [number xxxx]; and [Funding Agency 3] under Grant [number xxxx]."
- Authors must also incorporate a Disclosure Statement which will acknowledge any financial interest or benefit they have arising from the direct applications of their research.
- For all manuscripts non-discriminatory language is mandatory. Sexist or racist terms must not be used.
- Authors must adhere to SI units. Units are not italicised.
- When using a word which is or is asserted to be a proprietary term or trade mark, authors must use the symbol ® or TM.
- Authors must not embed equations or image files within their manuscript

2. Style guidelines

- Description of the Journal's article style.
- Description of the Journal's reference style.
- Guide to using mathematical scripts and equations.

Papers should be written and arranged in a style that is succinct and easy to follow. An informative title, a concise abstract and a well written introduction will help to achieve this. Authors should avoid some of the more common pitfalls, such as excessive use of the passive voice and past tense and unnecessary use of fabricated abbreviations within the text. The Journal would prefer authors to describe human volunteers as participants rather than subjects in the methods section. Figures and tables should be used to add to the clarity of the paper, not to pad it out. At all times, please try to think about your readers, who will not all be specialists in your discipline.

(a) General

The manuscript must be in English; British English spellings and words should be used in preference to other versions of English. It must be word-processed, double-spaced throughout, with a 4 cm margin on the left side, with no 'headers and footers' (other than page numbers), and without footnotes unless these are absolutely necessary. Arrange the manuscript under headings (such as Introduction, Methods, Results, Discussion, Conclusions) and subheadings. Ideally, the main body of the text should not exceed 4,000 words, excluding references. Longer manuscripts may be accepted at the discretion of the respective Section Editor. Authors must make every effort to ensure that manuscripts are presented as concisely as possible. The Editors cannot consider for publication papers that are seriously deficient in presentation or that depart substantially from these 'Notes and Guidelines'.

(b) Ethics of human experimentation

The Journal will accept only papers that conform to the highest standards of ethics and participant protection (see section 5 below). All experimental work in which humans are participants must conform to requirements stipulated in the Declaration of Helsinki (http://www.wma.net/en/30publications/10policies/b3/) and as appropriate, the laws of the country in which the work was undertaken. The manuscript should contain a statement to the effect that the work reported has been approved by a recognised ethics committee or review board. Even where information is in the public domain such as on a website that contains statistical or other archive-type data, formal ethics approval should be obtained to demonstrate that appropriate consideration of ethics-related matters has occurred. Similarly, where retrospective analyses of data have been performed, such as those produced as a result of long-term monitoring of athletes or other occupational categories where fitness-type testing is a contractual obligation, ethics approval is also required. Normally, statements about ethics

approval should be made at the beginning of the Methods section and should include any approval number obtained.

(c) Anonymous refereeing

Because of the adoption of anonymous refereeing by the Journal with effect from 1 January 1998, the title page and manuscript should include no information that clearly identifies the authors or their affiliations. Authors should submit a separate cover letter, which is not part of the manuscript, that can include the following information: the full title; the names of the authors without qualifications or titles; the affiliations and full addresses of the authors; the name, address, telephone and fax numbers, and e-mail address of the author responsible for all correspondence and correction of proofs. Any acknowledgements should also appear on this page, not in the manuscript. These acknowledgements will appear in the printed version if the manuscript is accepted.

(d) Title page

Include the following information on the first page of the manuscript: the full title; a running title of no more than 75 characters and spaces; and up to five keywords for indexing purposes.

(e) The abstract

The abstract must not exceed 200 words and it must summarize the paper, giving a clear indication of the conclusions it contains.

(f) Tables and illustrations

Illustrations and tables must accompany the manuscript but not be included in the text. Authors may wish to express a preference for the location of tables and figures by including comments such as ****Table 1 near here**** or ****Figure 2 near here**** separated by at least one line space from the main text. Tables, referred to as 'Table 1', 'Table 2', and so on, must be numbered in the order in which they occur in the text. Tables must be clearly and simply laid out with clear row and column legends, units where appropriate, no vertical lines and horizontal lines only between the table title and column headings, between the column headings and the main body of the table, and after the main body of the table.

Photographs and line drawings, referred to as 'Figure 1', 'Figure 2', and so on, must be numbered in the order in which they occur in the text. Diagrams and drawings should be produced using a computer drawing or graphics package. All illustrations must be suitable for reduction to single column (84 mm) or page width (174 mm) of the Journal, with particular attention to lettering size. Photographs must be reproduced as black and white image files (see section 3 below).

(g) Terms and nomenclature

Terms and nomenclature should abide by the Système International d'Unités. For a detailed guide to symbols, units and abbreviations, please consult the following text:

The Symbols Committee of the Royal Society (1975, addenda 1981). Quantities, Units and Symbols. London: The Royal Society.

For a comprehensive review of applications to sport and physical activity, please consult the following publication:

Winter, E.M. and Fowler, N. (2009). Exercise defined and quantified according to the Système International d'Unités. Journal of Sports Sciences, 27, 447-460

(h) Statistical analyses

Authors must at least accompany conventional P values with metrics such as effect sizes, confidence intervals of difference/change and minimum clinically or practically important difference.

An effect size expresses a difference between groups or change within groups as a fraction of the variability between participants. Usually, this denominator is the standard deviation.

Effect sizes can be evaluated as trivial (0–0.19), small (0.20–0.49), medium (0.50–0.79) and large (0.80 and greater) (Cohen, J. [1992]. Psychological Bulletin, 112, 155–159). Similarly, confidence intervals of difference/change (Cumming, G. & Finch, S., [2001]. Educational and Psychological Measurement, 61, 532–574) can evaluate outcomes on the basis of their inclusion of zero, i.e. no effect.

The confidence interval represents a plausible range of values within which the true (but unknown) population value lies (Cumming, G. [2012]. Understanding the new statistics. New York: Routledge). The greatest likelihood will arise from effects with narrow confidence intervals and therefore high precision.

Another way to evaluate the effectiveness of an intervention is by way of the minimum clinically (or practically) important difference. This difference should be stated before a study commences and expresses the smallest change in the principal outcome measure that must occur if the intervention is to be considered effective. It is usually taken to be equivalent to an effect size of 0.20.

3. Figures

- Please provide the highest quality figure format possible. Please be sure that all imported scanned material is scanned at the appropriate resolution: 1200 dpi for line art, 600 dpi for grayscale and 300 dpi for colour.
- Figures must be saved separate to text. Please do not embed figures in the manuscript file.

- Files should be saved as one of the following formats: TIFF (tagged image file format), PostScript or EPS (encapsulated PostScript), and should contain all the necessary font information and the source file of the application (e.g. CorelDraw/Mac, CorelDraw/PC).
- All figures must be numbered in the order in which they appear in the manuscript (e.g. Figure 1, Figure 2). In multi-part figures, each part should be labelled (e.g. Figure 1(a), Figure 1(b)).
- Figure captions must be saved separately, as part of the file containing the complete text of the manuscript, and numbered correspondingly.
- The filename for a graphic should be descriptive of the graphic, e.g. Figure1, Figure2a.

4. Publication charges

Submission fee

There is no submission fee for Journal of Sports Sciences.

Page charges

There are no page charges for Journal of Sports Sciences.

Colour charges

Colour figures will be reproduced in colour in the online edition of the journal free of charge. If it is necessary for the figures to be reproduced in colour in the print version, a charge will apply. Charges for colour figures in print are £250 per figure ($395 US Dollars; $385 Australian Dollars; 315 Euros). For more than 4 colour figures, figures 5 and above will be charged at £50 per figure ($80 US Dollars; $75 Australian Dollars; 63 Euros).

Depending on your location, these charges may be subject to Value Added Tax.

5. Compliance with ethics of experimentation

- Authors must ensure that research reported in submitted manuscripts has been conducted in an ethical and responsible manner, in full compliance with all relevant codes of experimentation and legislation. All manuscripts which report in vivo experiments or clinical trials on humans or animals must include a written Statement in the Methods section that such work was conducted with the formal approval of the local human subject or animal care committees, and that clinical trials have been registered as legislation requires.
- Authors must confirm that any patient, service user, or participant (or that person’s parent or legal guardian) in any research, experiment or clinical trial who is described in the manuscript has given written consent to the inclusion of material pertaining to themselves, and that they acknowledge that they cannot be identified via the manuscript; and that authors have anonymised them and do not identify them in any way. Where such a person is deceased,

authors must warrant they have obtained the written consent of the deceased person's family or estate.

- Authors must confirm that all mandatory laboratory health and safety procedures have been complied with in the course of conducting any experimental work reported in the manuscript; and that the manuscript contains all appropriate warnings concerning any specific and particular hazards that may be involved in carrying out experiments or procedures described in the manuscript or involved in instructions, materials, or formulae in the manuscript; and include explicitly relevant safety precautions; and cite, and if an accepted standard or code of practice is relevant, a reference to the relevant standard or code. Authors working in animal science may find it useful to consult the Guidelines for the Treatment of Animals in Behavioural Research and Teaching.

6. Reproduction of copyright material

If you wish to include any material in your manuscript in which you do not hold copyright, you must obtain written permission from the copyright owner, prior to submission. Such material may be in the form of text, data, table, illustration, photograph, line drawing, audio clip, video clip, film still, and screenshot, and any supplemental material you propose to include. This applies to direct (verbatim or facsimile) reproduction as well as "derivative reproduction" (where you have created a new figure or table which derives substantially from a copyrighted source).

You must ensure appropriate acknowledgement is given to the permission granted to you for reuse by the copyright holder in each figure or table caption. You are solely responsible for any fees which the copyright holder may charge for reuse.

The reproduction of short extracts of text, excluding poetry and song lyrics, for the purposes of criticism may be possible without formal permission on the basis that the quotation is reproduced accurately and full attribution is given.

For further information and FAQs on the reproduction of copyright material, please consult our Guide.

7. Supplemental online material

Authors are encouraged to submit animations, movie files, sound files or any additional information for online publication.

- Information about supplemental online material

Manuscript submission

All submissions should be made online at the Journal of Sports Sciences Scholar One Manuscripts website.

All submissions to Science and Medicine in Football should be made online at the Scholar One Manuscripts website.

New users should first create an account. Once logged on to the site, submissions should be made via the Author Centre. Online user guides and access to a helpdesk are available on this website.

On submission, authors should select the relevant Section Editor (see Editorial Board) or, in case of any doubt, submit to the Editor-in-Chief. Authors should keep a copy of all materials sent for later reference. Papers submitted to the Journal will be refereed anonymously by acknowledged experts in the subject; at least two such referees will be involved in this process. In the event of conflicting reviews, the Section Editor will normally seek a further independent review. As the Journal operates an anonymous peer-review policy, please ensure that your manuscript submission has all information identifying the author(s) removed. If you are submitting a revised manuscript and have used track changes, please make sure that any comments are anonymous in order to ensure your anonymity. Alternatively, please highlight your text changes through the use of red font.

On submission, authors are required to nominate up to four expert referees for their paper; these potential referees must not have been informed that they have been nominated or be members of the authors' institutions. The nominated referees may or may not be used, at the Section Editor's discretion, and at least one of the referees involved in the review of the paper will be independent of the nominated list.

Manuscripts may be submitted in any standard editable format, including Word and EndNote. These files will be automatically converted into a PDF file for the review process. LaTeX files should be converted to PDF prior to submission because ScholarOne Manuscripts is not able to convert LaTeX files into PDFs directly. All LaTeX source files should be uploaded alongside the PDF.

Click here for information regarding anonymous peer review.

Copyright and authors' rights

To assure the integrity, dissemination, and protection against copyright infringement of published articles, you will be asked to assign us, via a Publishing Agreement, the copyright in your article. Your Article is defined as the final, definitive, and citable Version of Record, and includes: (a) the accepted manuscript in its final form, including the abstract, text, bibliography, and all accompanying tables, illustrations, data; and (b) any supplemental material hosted by Taylor & Francis. Our Publishing Agreement with you will constitute the entire agreement and the sole understanding between you and us; no amendment, addendum, or other communication will be taken into account when interpreting your and our rights and obligations under this Agreement.

Copyright policy is explained in detail here.

Free article access

As an author, you will receive free access to your article on Taylor & Francis Online. You will be given access to the My authored works section of Taylor & Francis Online, which shows you all your published articles. You can easily view, read, and download your published articles from there. In addition, if someone has cited your article, you will be able to see this information. We are committed to promoting and increasing the visibility of your article and have provided guidance on how you can help. Also within My authored works, author eprints allow you as an author to quickly and easily give anyone free access to the electronic version of your article so that your friends and contacts can read and download your published article for free. This applies to all authors (not just the corresponding author).

Reprints and journal copies

Article reprints can be ordered through Rightslink® when you receive your proofs. If you have any queries about reprints, please contact the Taylor & Francis Author Services team at reprints@tandf.co.uk. To order a copy of the issue containing your article, please contact our Customer Services team at Adhoc@tandf.co.uk.

Open Access

Taylor & Francis Open Select provides authors or their research sponsors and funders with the option of paying a publishing fee and thereby making an article permanently available for free online access – open access – immediately on publication to anyone, anywhere, at any time. This option is made available once an article has been accepted in peer review.