

The characteristics and sanctioning of tackles during the 2011-2015 under 18 Craven Week rugby tournament

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Thesis presented in fulfilment of the requirements for the degree

Master of Science in Sport Science

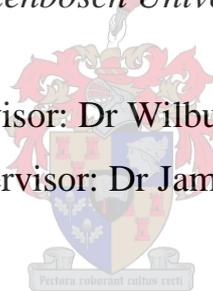
in the Department of Sport Science, Faculty of Education

at

Stellenbosch University

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March 2017

DECLARATION

By submitting this thesis 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 two articles that form part of this thesis, Dr Wilbur Kraak (supervisor) and Dr James Brown (co-supervisor), hereby give permission to the candidate, Mr Shannon Boucher, to include the two articles as part of a Masters thesis. The contribution (advice and support) of the co-authors was kept within reasonable limits, thereby enabling the candidate to submit this thesis for examination purposes. This thesis therefore serves as fulfilment of the requirements for the degree Master of Science at Stellenbosch University.

March 2017

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ACKNOWLEDGEMENTS

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

- Dr. Wilbur Kraak, my supervisor, who constantly had to put up with my hockey schedule and me being away from Stellenbosch and South Africa. Thank you for allowing this thesis to be my own work and for steering me in the right direction whenever I needed it.
- Dr. James Brown, my co-supervisor, thank you for the useful comments, remarks and engagement through the learning process of this thesis.
- Thomas Burgers and Dr. Bradley Fryer for acting as my bouncing board and helping me with the statistics. They have also been an immense help by encouraging me, I do not believe I would've finished this thesis without their help.
- Prof Daan Nel statistician at Stellenbosch University, for his time and assistance.
- Division of Exercise Science and Sports Medicine (ESSM) video analysis department at the University of Cape Town for providing the match videos.
- Finally, I must express my very profound gratitude to my parents and my girlfriend Aoife Dalton for providing me with unfailing support and continuous encouragement throughout my years of studies and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

SUMMARY

Rugby is one of the most popular team sports in the world, however, the high injury rate associated with it is an area of concern for coaches, players, parents and referees. The tackle is the most common contact event in the game and because of this accounts for the most injuries during training and matches. Due to the nature of the game the tackle event will always be present. Sport participation among children and adolescents is increasing globally, due to the many health related-benefits attributable to engaging in sport including enjoyment, social interaction and health. Research into schoolboy rugby tackle characteristics is limited and even less is known regarding the sanctioning of illegal tackles by the referees during match-play, particularly in South Africa. The primary aim of the study was to determine the number of illegal tackles and if they were sanctioned or not sanctioned by the referee's during the 2011-2015 under 18 Craven Week tournaments. The secondary aim was to assess which factors were associated with sanctioning and non-sanctioning of illegal tackles. This thesis followed a research article format, with the specific aims being investigated in each article. Research article one assessed the legal and illegal tackles characteristics during the 2011-2015 under 18 Craven Week tournament. Research article two focused on the sanctioning and non-sanctioning of illegal rugby tackles during the 2011-2015 under 18 Craven Week tournament.

Research article one revealed an average of 123 tackles per match. The tackles were spread evenly throughout the four quarters of the match. Most of the tackles occurred front-on (65%) which is consistent with other literature. Also in agreement with other literature was the finding that most tackle events involved one tackler (66%). The study revealed that 12103 (99%) tackles were deemed legal and only 113 (1%) tackles were found to be illegal, as judged by the coding of the match videos. Most of these occurred front-on (66%) and involved one tackler (91%). Most of the illegal tackles took place in quarter two (29%) and four (29%) of the match, which highlights the effect of fatigue, leading to poorer tackling technique and decision making by the tackler.

The second research article revealed 113 illegal tackles, of which 46 tackles were sanctioned and 67 tackles were non-sanctioned by the referee. The high tackle (72%) being the most common type of illegal tackle. Most of the illegal tackles took place in quarter two (29%) and four (29%). Illegal tackles mainly took place front-on (66%) and involved one tackler (91%). Most illegal tackles (59%) were not sanctioned by the referees, especially in 2012 (84%). A high percentage of high tackles (65%) and dangerous charging tackles (67%) were not

sanctioned by the referee. This is an area of concern for players, coaches and referees as illegal tackles have the highest propensity for injury in comparison to any other contact event.

Full understanding of the characteristics surrounding the tackle and sanctioning of illegal tackles is the initial step in the injury prevention model. This information will guide the rugby education programmes into what law, technique and coaching changes need to be put in place in order to make rugby safer across all level of play. Strict enforcement of the laws by referees will help make the game safer for all involved.

OPSOMMING

Rugby is een van die mees populêre spansportsoorte ter wêreld, maar 'n hoë insidensie van beserings wat met rugby gepaardgaan, is vir afrigters, spelers, ouers en skeidsregters 'n bron van kommer. Die duikslag is die mees algemene vorm van kontak in die spel en daarom is dit verantwoordelik vir die meeste beserings tydens inoefening en wedstryde. Die aard van die spel bepaal dat die duikslag altyd teenwoordig sal wees. Navorsing wat fokus op duikslag eienskappe in skole rugby is beperk en selfs minder is bekend aangaande die bekragting van onwettige duikslae deur skeidsregters tydens wedstryde veral in Suid-Afrika. Die primêre doel van die huidige studie was om die aantal onwettige duikslae, en of hulle deur die skeidsregters tydens die 2011 tot 2015 onder 18 Craven Week toernooie, bekragtig is, te bepaal. Die sekondêre doel was om vas te stel watter faktore met bekragting geassosieer was (in teenstelling met nie-bekragting) van onwettige duikslae. Hierdie tesis is geskoei op 'n navorsing artikel formaat. In elke artikel word die spesifieke doelwitte nagevors en vergelyk. Artikel een het die duikslag eienskappe tydens die 2011 tot 2015 onder 18 Craven week toernooie assesseer. Die bekragting en nie-bekragting van onwettige duikslae tydens dieselfde toernooie was die fokus van artikel twee.

Artikel een toon 'n gemiddelde van 123 duikslae per wedstryd. Die duikslae was egalig versprei deur die vier kwarte van die wedstryd. Die meeste duikslae was reg van voor (65%) wat met die literatuur ooreenstem. Die bevinding dat die meeste duikslae deur slegs een speler (66%) uitgevoer is, is ook in ooreenstemming met die literatuur. Die studie het getoon dat 99% van die duikslae as wettig geag is en slegs 1% as onwettig soos bepaal deur die kodering van die wedstryd video's. Die meeste duikslae was reg van voor (66%) en het slegs een speler (91%) behels. Die meeste van die onwettige duikslae het in die tweede (29%) en vierde kwart (29%) plaasgevind wat daarop dui dat uitputting aanleiding gee tot swakker duik tegnieke en besluitneming.

In die tweede artikel word getoon dat 113 onwettige duikslae uitgevoer is, met die hoogvat (72%) as die mees algemene onwettige duikslag. Die meeste onwettige duikslae het in die tweede (29%) en vierde kwart (29%) plaasgevind. Onwettige duikslae het hoofsaaklik direk van voor (66%) plaasgevind en slegs een speler (91%) betrek. Die meeste (59%) onwettige duikslae was nie deur die skeidsregters bekragtig nie, veral in 2012 (84%). 'n Hoë persentasie van hoogvatte (65%) en gevaarlike instormende duikslae (67%) was nie bekragtig deur die

wedstryd skeidsregter nie. Onwettige duikslae het die hoogste geneigdheid tot beserings in vergelyking met enige ander kontak en daarom is dit en bly dit 'n probleem area.

Die eerste stap in die besering-voorkomingsmodel is volle begrip van die kenmerke rakende die duikslag en bekragting van onwettige duikslae. Hierdie inligting sal leiding verskaf aan rugby opvoedingsprogramme na watter wet, tegniek en afrigting veranderinge in plek gesit moet word om die spel veiliger te maak. Indien ons die huidige openbare gesondheidsbeleid om fisieke aktiwiteite te bevorder (Albernethy *et al.*, 2003) gaan implementeer, moet skoolsport veilig en genotvol wees. Streng toepassing van die wette deur skeidsregters sal help om die spel veiliger te maak vir almal betrokke.

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LIST OF ABBREVIATIONS

IRB	International Rugby Board
WR	World Rugby
PIs	Performance indicators
SARU	South African Rugby Union
CI	Confidence Intervals
N	Total number of tackles
n	Tackles per variable
SD	Standard Deviation
M	Mean
%	Percentage

APPENDICES

Appendix A **International Journal of Performance Analysis in Sport**

Appendix B **European Journal of Sport Science**

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).

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1.1. Introduction

Rugby union (hereafter referred to as rugby) has the highest overall injury risk (69 injuries per 1 000 hours exposure) when compared to soccer (28 injuries per 1 000 hours exposure), cricket (2 injuries per 1 000 hours exposure) and ice hockey (53 injuries per 1 000 hours exposure) during match-play (Fuller & Drawer, 2004). According to Lee and Garraway (1996), as well as Horsely *et al.* (2013), the incidence rate of schoolboy match injuries was 86.8 per 1000 hours-exposure and the most common cause of injury was tackling (40%) or being tackled (24%). The majority of injuries at the senior and elite levels of rugby result from contact phases of play, with the main causes attributed to being tackled (29 injuries per 1 000 hours exposure), tackling (19 injuries per 1 000 hours exposure), collisions (11 injuries per 1 000 hours exposure), scrums (7 injuries per 1 000 hours exposure) and lineouts (1 injuries per 1 000 hours exposure) (Williams *et al.*, 2013).

The tackle event has been identified as the most common contact event in a game of rugby and the total number of tackles per game has increased by approximately 50% over the years. The high impact and physical nature of the tackle during a rugby match places the tackler(s) and ball carrier at risk of injury (Hendricks & Lambert, 2010; Sarembock, 2014). A tackle is

characterised by a ball-carrier contacting an opposing player(s), known as the tackler, bringing the ball-carrier to ground (WR, 2016). The tackler tries to stop the ball-carrier from progressing toward the try-line, and tries to regain ball possession. Failure to tackle will lead to the opposition team gaining territory and possibly scoring points. A team's success has been associated with effective engagement in tackle situations (Sarembock, 2014). The risk of injury will always be present in rugby due to the nature of the game. Therefore, coaching of proper tackling techniques and skills may help to reduce the risk of injury, and at the same time improve performance. It is clear that the tackle is an injury prevention priority and therefore numerous interventions have tried to reduce the risk including coach education programmes, and laws to reduce illegal tackles (Burger *et al.*, 2016).

The tackles shown in Table 1.1 are deemed illegal and can result in conceding a penalty, penalty and yellow card or penalty and red card (WR, 2016). Illegal tackles are considered dangerous, and have been associated with serious head, neck injuries or spinal injury (Sinibaldi & Smith, 2007). According to Fuller *et al.* (2007), illegal tackles are a lot less common, but are 70% more likely to result in an injury in comparison to a legal tackle. Roberts *et al.* (2015) found that collision tackles (illegal tackles involving a shoulder charge) had a higher propensity for injury than any other event. In rugby the risk associated with this event is recognised within Law 10.4 of the law book. To discourage players from engaging in illegal tackles, tacklers are often sent off the field of play for a short period or the entire match (depending on the severity and intent of the tackle) (Sarembock, 2014). However, a study conducted by Fuller *et al.* (2007), which assessed English Club rugby, found that despite the injury concerns surrounding tackles, referees didn't always penalise illegal tackles as the law required them to.

Table 1.1 Types of illegal tackles and a description (WR, 2016)

Types of illegal tackles	Description
High Tackle	When the tackler contacts the ball-carrier above the shoulder line
Early/Late tackle	When the player is tackled without the ball
Tip tackle	When the tackler inverts the ball-carrier contacting the ground head first
Shoulder charge (no arms)	When the tackler fails to use his arms during the tackle
Tackle in air	When the ball carrier jumps for a high ball and is tackled before his feet touch the ground
Stiff arm tackle	A close line movement, where no intention is made by the tackler to wrap his arms around the ball carrier

Referees play an integral part in professional team sports, as they are tasked with considering numerous sources of information simultaneously, and making rapid decisions based on this information (Mascarenhas *et al.*, 2005b). A study that included English rugby's 130 top referees found that since rugby turned professional in 1995, there has been an increased demand on the standard of refereeing (Mascarenhas *et al.*, 2005a). Rugby referees are responsible for maintaining flow and control and ensuring fair play both in accordance with the laws and the spirit of the game, while performing optimally in a dynamic and somewhat tumultuous environment (Kraak *et al.*, 2011b; Mascarenhas *et al.*, 2005b; World Rugby, 2016). Due to the complex demands of the profession (Rix-Lievre *et al.*, 2011), numerous skills are required to referee professionally. These include a high degree of physical fitness, the ability to apply accurate interpretation of the laws of the game, as well as personality and management skills to convey resulting decisions to the players (Mascarenhas *et al.*, 2005a). Considering the ever increasing pressure placed on referees in elite level sport, the importance and transparency of fairness is critical to the perception regarding the integrity of sporting encounters (Mellick *et al.*, 2005; Kraak *et al.*, 2011b).

Similarly, referees play a major role in carrying out injury prevention programmes put forward by various rugby safety programmes, such as BokSmart and RugbySmart (Gianotti *et al.*, 2009). Rugby safety programmes are put in place to record and educate coaches and referees on the prevalence of injury in rugby and how to overcome them, in order to make the game as safe as possible for all involved (Viljoen & Patricios, 2012). In order to decrease the risk of injury it is of utmost importance to coach correct technique, correct player behaviour and continue the strict enforcement of penalising illegal tackles (Roberts *et al.*, 2015). Due to the evolving nature of the game the amount of tackles carried out in rugby matches will not decrease, therefore efforts to reduce injuries in contact events should focus on how events are carried out and managed by the players. It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Roberts *et al.*, 2015). If referees are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced. The first step in injury prevention is surveillance (Van Mechelen & Hlobil, 1992). Surveillance of tackles and the sanctions imposed by referees will help WR and BokSmart identify whether the referees are actually enforcing the laws of the game, which will lead to the creation and implementation of further prevention strategies. This is an ongoing process, which will help make the sport safer for all involved.

This study focused on the Craven Week rugby tournament. Craven Week is an annual schoolboy rugby tournament, endorsed by the South African Rugby Union (SARU), organised for under-18 schoolboys in South Africa. It is an elite merit based tournament, not only for players but also referees. The rugby referees in South Africa are ranked on either of the following panels, namely national, provincial, contender, women, assistant referee and television match official, depending on their referee performance the previous year and results of the pre-season fitness testing (Kraak *et al.*, 2011a). The referees use the Craven Week tournament to improve their refereeing and their status as referee. The tournament is comprised of 18 teams from around the country and a team from Namibia and Zimbabwe. A South African Schools team is selected at the end of the tournament as well as a South African Schools A team.

1.2. Problem statement

Since professionalism in 1995, rugby has undergone changes both on and off the field. The main problem is that, to date, it has not yet been established how these changes have affected the sanctioning and non-sanctioning of illegal rugby tackles by referees at provincial schoolboy level in South Africa. Referees are critical to enforcing the laws of rugby as well the safety regulations as stipulated in safety programmes like BokSmart in South Africa and Rugby Ready world-wide. Despite the importance of the role of the referees in injury prevention, the sanctioning and non-sanctioning of illegal tackles by referees at provincial schoolboy level in South Africa has to be investigated.

1.3. Aims of the study

The primary aim of the study was to determine the number of illegal tackles and if they were sanctioned or not sanctioned by the referee's during the 2011-2015 under 18 Craven Week tournaments. The secondary aim was to assess which factors were associated with sanctioning and non-sanctioning of illegal tackles.

The specific objectives of the articles were to investigate and compare:

Research article one: Investigation into tackle characteristics during the 2011-2015 under 18 Craven Week tournament.

Research article two: Sanctioning and non-sanctioning of illegal rugby tackles during the 2011-2015 under 18 Craven Week tournament.

1.4. Motivation for the study

Sport participation among children and adolescents is increasing globally, due to the many health related-benefits attributable to engaging in sport including enjoyment, social interaction and health (Allender *et al.*, 2006). Sport in this instance rugby is seen as a way to increase physical and mental health, however with this added benefit comes a risk of injury (Junge *et al.*, 2004).

Rugby is the most popular collision sport in the world, however, concerns have been raised regarding the safety of the sport due to the physical high impact nature of the game (Nicol *et al.*, 2010). Injuries sustained in schoolboy sport may have significant consequences for physical development and activity (Haseler *et al.*, 2010). The tackle is the most common phase of play in rugby and is the cause of the most injuries. According to Quarrie and Hopkins (2008), Haseler *et al.* (2010), Hendricks and Lambert (2010), the tackle accounts for 58%, 59% and 61% of all injuries respectively, which occur during a rugby match. Players are involved in 20-40 physical confrontations per game and wear minimal or no protective gear (Hoskins *et al.*, 2006; Hendricks & Lambert, 2010). These statistics make the tackle the most important phase to be studied and improved to limit injuries and make the game safer (Vaz *et al.*, 2010).

To ensure safety during a match, players must be taught the rules and techniques involved during a tackle that are in place specifically for player's safety (Hendricks & Lambert, 2010). Learning the proper tackle technique at an early stage is very important with regards to the safety of the tackler and the player to be tackled. Illegal tackles, such as the dump and high tackle, lead to sanctions from the referee so as to act as a deterrent for this type of dangerous play (Hendricks & Lambert, 2010; Sinne & Fogel, 2013). It is important for the coach to make sure that each player understands the rules and possible repercussions if a player is to break the rules. It is also important for coaches to take the responsibility to take a player off no matter their skill level or importance to winning the match if that player is acting dangerously. Players need to understand the laws as well as the reasons why safety laws are in place and what can happen if the laws are broken (Sinne & Fogel, 2013).

Referees are expected to act as witness, jury and judge in sporting contests. Mindful of health, safety and welfare of participants, they are expected to control the play by applying laws, and

make judgements on rule infringements, appropriate sanctions, performance, time and score (Mellick *et al.*, 2005; Sinne & Fogel, 2013). There are few other societal roles wherein an individual accepts the risk of being held accountable for decisions made with such frequency (Mellick *et al.*, 2005). They also have to balance their interpretation of the laws with the organisation's philosophy on the way the game should be officiated (Mascarenhas *et al.*, 2005b; Mellick *et al.*, 2005). Referees are responsible for protecting the safety of the players and ensuring a fair match by enforcing the game's laws. However, because rugby is a sport of fast paced action involving 30 players moving over a large field of play presided over by a single referee, interactions, including foul play, may go undetected and/or unpenalised if referees are not properly trained/educated (Comstock & Fields, 2005). Referees are also particularly important role players in South Africa with the safety responsibility that BokSmart places on them (Gianotti *et al.*, 2009; Viljoen & Patricios, 2012). As the popularity of youth rugby continues to grow worldwide, a rising number of specialists and coaches will find themselves treating rugby related injuries and answering rugby related questions from parents (Collins *et al.*, 2008). Through injury prevalence data collection, more evidence will be available on risk factors, which will allow the implementation of various injury prevention and education strategies (Collins *et al.*, 2008; Nicol *et al.*, 2010). In contrast to professional sport, the level of medical coverage at the game and training is often minimal at youth and community levels, therefore adequate education/prehabilitation (injury prevention) programmes need to be put into place so as to help with injury prevention.

In the specific context of rugby, the diverse and dynamic environment of the tackle (Law 15) provides a uniquely demanding task that is important for referees to assess accurately. Exploring factors that are associated with referees not sanctioning illegal tackles will help assist rugby referees and coaches in constructing referee specific training programmes to help make the game safer for all involved through improved decision making. To make sport safer, efforts should be made to minimise foul play. This can be done through educating referees, coaches and players about the prevalence of foul play and the association between foul play and injury (Comstock & Fields, 2005; Sinne & Fogel, 2013). Due to limited research on investigating the sanctioning and non-sanctioning of illegal tackles by the referee, it is important to expand the area of research so that the game is safer for all involved. This poses a challenge, but at the same time provides an excellent opportunity for innovative and valuable research to be conducted and published. As a result, this study may initiate future research in order to increase our understanding and providing knowledge surrounding the rugby tackle.

1.5. Structure of the thesis

The thesis is presented in research article format. The two research articles (Chapters three and four) were prepared in accordance with the guidelines of specific journals. Consequently, the referencing style used in the different chapters of this thesis 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: Investigation into tackle characteristics during the 2011-2015 under 18 Craven Week tournament. This chapter is included herewith in accordance with the guidelines of **International Journal of Performance Analysis in Sport** (Appendix A).

Chapter Four: Research article two: Sanctioning and non-sanctioning of illegal rugby tackles during the 2011-2015 under 18 Craven Week tournament. This chapter is included herewith in accordance with the guidelines of the **European Journal of Sport Science** (Appendix B).

Chapter Five: Summary and conclusions.

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CHAPTER 2

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).

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2.1. Introduction

Rugby union, hereafter referred to as rugby, is one of the most popular team sports world-wide, second only to soccer in terms of the number of nations in which it is played (Brown *et al.*, 2012). Figures from World Rugby (WR) show that rugby is increasingly popular with teenagers, who represent 22% to 39% of registered players in the top 5 rugby playing nations (Bleakley *et al.*, 2011). WR is the international governing body of rugby, which governs the game and the way it is played and managed with regards to the laws, news, member unions, regional associations, tournaments, results and education strategies.

Rugby is a contact game, made up of multiple high speed collisions per match. Professionalism in rugby was introduced in August 1995, and since then there has been an increase in the incidence of injury in rugby (Boksmart, 2009). Rugby carries the highest risk of injury to the player in comparison to all other team sports. Injury risk is magnified in sports that entail impacts, collisions at speed, and vigorous body contact (Beardmore *et al.*, 2005; Patricios, 2014).

The health benefits associated with exercise are well documented, and school sport is recognized as an important means of promoting physical activity in children (Albernethy *et al.*, 2003). According to Diego *et al.* (2001), students with a high level of exercise had better relationships with their parents, were less depressed, spent more time involved in sports, used drugs less frequently, and had higher grade point averages in comparison to students with a low level of exercise. It is widely accepted that sport has a positive effect on physical and mental health, however; school sport is not risk free (Allender *et al.*, 2006). With considerable emphasis placed not just on the benefits of exercise, but on the potential improvement in sporting expertise, it is easy to forget the potential impact of injury in school sport. Sport improves physical, psychological, and social outcomes, however, it is also the largest contributing factor to injury at school level (Albetnethy & MacAuley, 2003; Junge *et al.*, 2004; Nicol *et al.*, 2010). Due to increasing commercialism and professionalism the already high training and game demands of youth sport are becoming progressively more adult like, leading to higher injury rates at the adolescent level (Wall, 2011). The risk of accidental injuries peaks in adolescence, when teenagers are more inclined to partake in risk taking behaviours (Kontos, 2004). If these heightened risks taking behaviours influence an individual's decisions on the sporting field, and they are not accompanied by protective behaviours, they could lead to increased risk of injuries in adolescent players (Finch *et al.*, 2001).

The South African Rugby Union (SARU) has introduced an educational safety programme, namely BokSmart, to increase the level of understanding by players, coaches and referees to help reduce the amount of catastrophic injuries (Dunn, 2009; Viljoen & Patricios, 2012). Full understanding of the incidence and aetiology of injuries in professional rugby are the initial steps in the injury prevention model (Van Mechelen & Hlobil, 1992; Williams *et al.*, 2013). Law changes, cutting down on foul play, improving protective equipment as well as increasing the emphasis on proper conditioning are but a few steps taken with the goal of reducing the risk of injury. School sport needs to be safe and enjoyable if we are to implement the current public health policy in promoting physical activity (Albernethy *et al.*, 2003). Strict enforcement of the laws by referees will help make the game safer for all involved.

Kaplan *et al.* (2008) found that foul play represented 9% of all injuries sustained at the professional level. Punch (2013) found that rugby players commit a variety of illegal offences – including eye-gouging, biting, late or high-tackles, stamping, kicking, punching, and head-butting. The intention of the illegal offences being intimidation, revenge and provocation. These illegal offences increase the risk of injury. Kaplan *et al.* (2008) stated that, “the identification of mechanisms of sporting injury can facilitate specific interventions and has been shown to ultimately lead to a decrease in the incidence of injury.” Thus, unsanctioned violence should be eliminated where possible as these actions often lead to unnecessary injury in players (Punch, 2013). Therefore, accurate data on the incidence, nature and factors associated with injury in rugby is essential. The available research on unsanctioned violence is often of limited value because of the differences in study design, such as methods of data collection, definition of injury and differences in expression of injury rates (Kaplan *et al.*, 2008; Williams *et al.*, 2013).

The tackle is an intrinsic part of rugby, which is associated with a large number of injuries. It is a display of physical strength and technical proficiency and is a skill that is required across all playing positions (Hendricks *et al.*, 2016). Research associated with the tackle in rugby has mainly focused on the senior level and therefore less is known at schoolboy (youth) levels of the game (Quarrie & Hopkins, 2008; Fuller *et al.*, 2010).

This review will firstly give background on rugby, schoolboy rugby in South Africa, the role of rugby safety programmes and their effect on injury prevention, rugby referees and performance analysis in sport. Secondly, the tackle technique will be discussed, along with the laws surrounding the tackle as well as how the tackle is coached across different levels.

2.2. Rugby Union

2.2.1. Background

Rugby is played over two 40-minute halves separated by a break of 10 minutes to 15 minutes, at the senior level. There are very few stoppages to the game, except in the event of: a) players sustaining an injury being replaced or substituted, b) players committing an infringement of the game laws and c) the referee consulting with the assistant referees (Duthie *et al.*, 2003; Biscombe & Drewett, 2010). In rugby, each player is assigned a number and position recommended by WR, as seen in Figure 2.1. In general, forwards (positions 1-8), who are typically taller and heavier than backs, are primarily responsible for contesting the ball. Backs (positions 9-15), who are typically quicker than forwards, are mainly charged with gaining field position and scoring points (Duthie *et al.*, 2003). Each team is permitted up to eight replacements at senior level and seven rolling replacements at schoolboy level, either for injuries or tactical purposes (Caddell, 2005; Quarrie & Hopkins, 2008). The game is physically demanding, with frequent bouts of high intensity activity such as running, sprinting, rucking, mauling and tackling, interspersed by periods of low intensity work, such as walking and jogging. A range of physical attributes are necessary for elite rugby players, including strength, power, speed, agility and endurance (Gabbett, 2008b). The combination of high physical demands, alongside exposure to collisions and contacts, means the inherent risk for injury whilst playing rugby is substantial (Williams *et al.*, 2013).

Rugby includes four main phases of play, the tackle, ruck and maul, set pieces (scrum; lineout; kicking; restarts), and open play (Kaplan *et al.*, 2008). Rugby is a collision sport, where the contest for the ball in the tackle has been identified as a key determinant of performance (Wheeler & Sayers, 2009). Rugby is a high injury rate contact sport, with most of the injuries being caused by the tackle situation (Posthumus & Viljoen, 2008; Strauss, 2013). Although the tackle situation is associated with the majority of injuries in South African schoolboy (55%) and senior rugby players (40%), the scrum carries a 60% greater risk per event in competition (Posthumus & Viljoen, 2008).

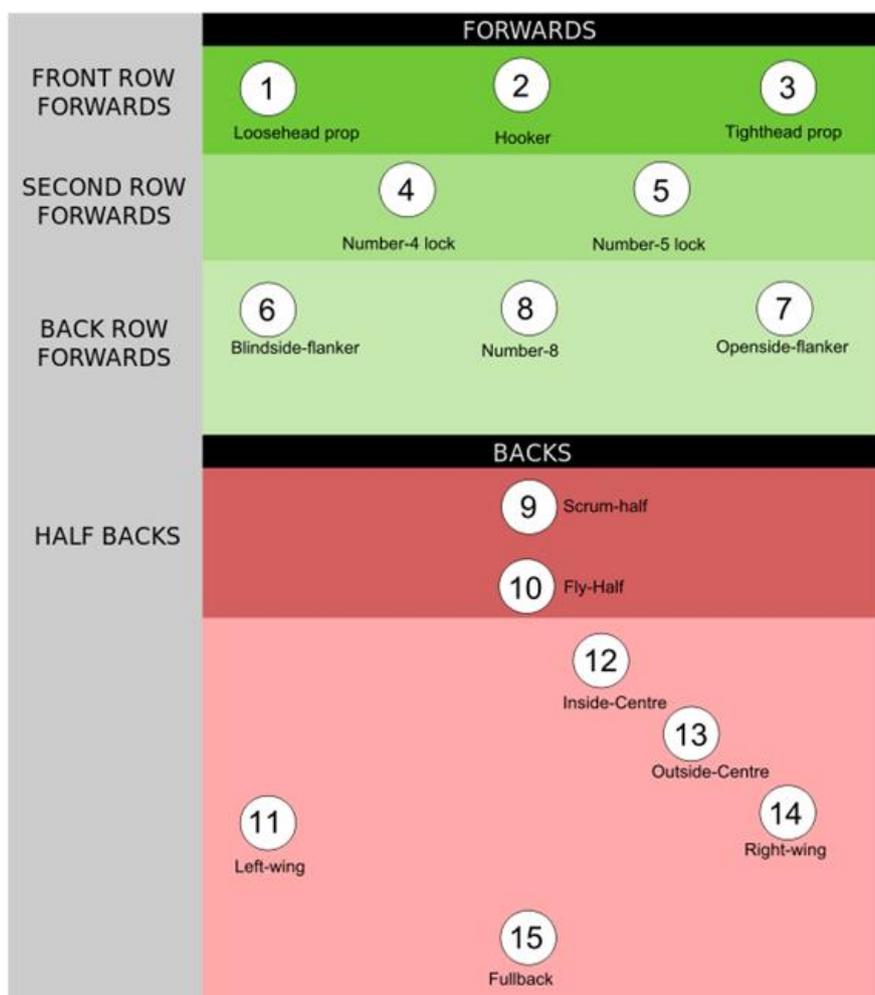


Figure 2.1: Player groups and positions (Copyright of Creative Commons. Permission has been given to reproduce this figure in its entirety (http://www.wikiwand.com/en/Rugby_union)).

2.2.2. Schoolboy rugby in South Africa

Rugby is extremely popular in South Africa with an estimated 500 000 players nationwide. Despite the plethora of studies focusing on senior rugby players, less is known about youth cohorts. Historically in South Africa, the incidence of catastrophic head, neck and spine injuries in particular has been viewed as unacceptably high (Patricios, 2014). Schoolboy rugby (under-18) have slight law variations, in comparison to senior rugby. These variations include that the duration of the match at under-18 level is 70 minutes, instead of 80 minutes (35 minutes per half) and that a team must not push the scrum more than 1.5 metres towards their opponent's goal line. A team must have fewer than 8 players in its scrum when either the team cannot field a complete team, or a player is sent off for foul play, or a player leaves the field because of injury (WR, 2016). Sport improves physical, psychological, and social outcomes, however, it

is also the largest contributing factor to injury at school. However, when emphasis is placed not just on the benefits of exercise, but on the improvement in sporting expertise, the potential impact of injury in school sport may decline (Albethney & MacAuley, 2003; Jungle *et al.*, 2004; Nicol *et al.*, 2010)

In contrast to youth players, senior elite players executed complete tackles more frequently, whereas missed or broken tackles were more frequent in the school-aged players. Younger players engaged in more passive tackles and tended to stay on their feet more than experienced players (McIntosh *et al.*, 2010; Burger *et al.*, 2016). Senior elite rugby was observed to have more multiplayer tackles than the other levels, which increases the force of the tackle (McIntosh *et al.*, 2010). The level of play in rugby influences the tackle through the speed at which the tackle takes place. Literature shows that high speeds going into the tackle and high impact force had a significantly higher risk for injury in English Premiership rugby. Whereas in English youth community rugby the speed in collisions were lower than professional rugby and although the tackle was still the main phase responsible for injury (59% of injuries occurred in the tackle), this was because of other factors such as level of coaching and tackle technique (Haseler *et al.*, 2010).

The Craven Week is an annual under 18 provincial rugby schoolboy tournament, organised by the South African Rugby Union. It is an elite merit based tournament, not only for players but also referees. The referees for the tournament are appointed based on their performance prior to the tournament as well as their potential to referee at a higher level. These referees are included from the contender (developmental programme) and national panel referees (Kraak *et al.*, 2011a; Lawrence, 2016). The Craven Week tournament takes place over one week and is comprised of 18 teams from around the country and a team from Namibia and Zimbabwe. A South African Schools team is selected at the end of the tournament as well as a South African Schools A team.

2.2.3. Injury prevention (safety programmes and injury incidence)

School sports injuries are significant, as they account for just over half of all injuries in high school children. They cause substantial disruption to school and sport and have a negative effect on the injured individual's family (Albetnethy & MacAuley, 2003). It is worth noting that an estimated eight percent of adolescents drop out of sport activities each year because of injury (Bleakley *et al.*, 2011). Most school sports injuries are minor, causing limited physical and social disruption, but according to Albetnethy and MacAuley (2003), a recent report

identified such injuries as a major reason for unnecessary school absence. The findings from Albetnethy & MacAuley (2003), supports the conclusions of a recent report that rugby had three times the risk of new substantive injuries than the next riskiest activities among 16 – 25 year old individuals.

As with all sport, there is a risk of sustaining injury while playing rugby; the risk appears to be the highest in comparison with any other team sport. This is primarily due to the contacts and collisions that are an integral part of the game (Brooks & Kemp, 2008). Bleakley *et al.* (2011) found that injury incidence rates in high school basketball (1.94 injuries per 1000 match hours), soccer (2.4 injuries per 1000 match hours), and grid-iron football (3.5 injuries per 1000 match hours) were all lower in comparison to those reported for rugby. In Brown *et al.* (2012) similar findings were noted, of all popular team sports, rugby presented an above average overall risk of injury (69 injuries per 1000 hours exposure) to the player – greater than that of cricket (2 injuries per 1000 hours exposure), soccer (28 injuries per 1000 hours exposure) and ice hockey (53 injuries per 1000 hours exposure). Table 2.1 shows the risk of sustaining an injury in a rugby match appears to be higher than in many other sports, irrespective of the definition of injury used (Brooks & Kemp, 2008). Risk of injury may increase with age and level/grade, which could be explained by greater speed, increased competitiveness/aggression, increased height and weight and increased foul play at higher levels of play (Bleakley *et al.*, 2011; Brown *et al.*, 2012; Hendricks *et al.*, 2012a). Rugby has no compulsory protective equipment despite the fact that it is classified as a full body contact game.

Table 2.1: The incidence of injury in elite rugby compared with other elite sports using a “time-loss” from training or match play definition of injury (Adapted from Brooks & Kemp, 2008).

Sport	Injuries per 1000 hours
International rugby union	218
Club rugby union	91
International ice hockey	79.2
Club ice hockey	78.4
International soccer	50
Club soccer	40
International cricket	10
Club cricket	2

Investigating the epidemiology of specific injuries in detail is particularly useful for coaches, strength and conditioning coaches, trainers and medical staff, as this allows them to target certain high-risk positional groups with injury-specific prevention and rehabilitation programmes (Brooks & Kemp, 2008). The injury incidence is presented as a number of injuries, on average, that occur in 1000-hour match-play exposures. Several authors have investigated the injury incidence rate associated with a given type of sport, however; heterogeneous definitions, methods of data collection, observation periods, study designs and sample characteristics have made comparisons between studies extremely difficult (Junge *et al.*, 2004; Fuller *et al.*, 2007; Hendricks & Lambert, 2010).

The majority of injuries at the senior and elite levels of rugby result from contact phases of play, with the main causes being the tackle (24-58%), ruck (6-17%), maul (12-16%), collision (8-9%) and scrum (2-8%) (Fuller *et al.*, 2007; Posthumus & Viljoen, 2008; Hendricks & Lambert, 2010; Roberts *et al.*, 2015). Tackles are the most common cause of some of the highest risk rugby injuries, including shoulder dislocations/episodes of shoulder instability, ACL injuries, MCL injuries, chondral or meniscal injuries of the knee and concussions (Brooks & Kemp, 2008). Numerous studies have established that players are at the highest risk of injury during the tackle. Injuries as a result of the tackle account for up to 61% of all injuries that occur during a rugby match, consequently preventing players from taking any further part in rugby activity (Hendricks & Lambert, 2010). In the 2008 and 2010 Under 20 Junior World Cup Championships and Junior World Cup Trophies, the incidence of injury was 57.2 per 1000 player hours (Fuller & Molloy, 2011). According to Williams *et al.* (2013), the overall incidence of injury in senior men's professional rugby matches was 81 per 1000 player hours. The lower limb was the body region with the highest injury incidence, while the upper limb injuries were most severe. The third quarter (40-60 minutes) of matches had the highest injury rate, and most of the injuries occurred as a result of being tackled.

Rugby safety programmes are in place to decrease the risk of injury and make the game safer for all involved (Table 2.2) (Dunn, 2009; Gianotti *et al.*, 2009; Brown, 2011; Viljoen & Patricios, 2012; Patricios, 2014). The primary aim of these safety programmes is to provide rugby coaches, referees, players, and administrators with the correct knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby (Gianotti *et al.*, 2009; Brown, 2011). These injury prevention programmes promote the 'safety first' attitude, which means that safety is the main aim in everything that is done. Adopting this 'safety first' attitude will change players' behaviour,

making the concept more attractive to coaches and players. The programmes advertise that ‘safe technique is effective technique’ in an attempt to promote the concept that the safety first attitude will not only prevent injury, but also improve performance (Hendricks *et al.*, 2012a). There are multifaceted injury prevention programmes which have developed over time as new information on risks have emerged. For example, a surveillance system is set up to help collect accurate exposure and injury data through questionnaires. The data is then used to identify patterns of injury and risk factors associated with injury. All information regarding injury risk and prevention strategies is available to coaches and referees. Educational strategies have been used in a number of public health areas, such as diabetes and cardiovascular disease, to reduce the risk of illness by changing participants’ knowledge and consequent behaviours (Dallalana *et al.*, 2007; Gianotti *et al.*, 2009). In South Africa, it is compulsory for all coaches and referees to attend BokSmart educational courses biannually in order to continue coaching and refereeing (Gianotti *et al.*, 2009; Viljoen & Patricios, 2012).

It is reasonable to assume that knowledge about safe and effective technique during the tackle can reduce the risk of injury, while at the same time producing a successful outcome of the contact event (Hendricks & Lambert, 2010; Brown, 2011). Consequently, any coaching programme for tackling should have this concept as a foundation. Worldwide, there has been much emphasis on ways to prevent tackle injuries in rugby. The major rugby playing countries have prevention programmes and initiatives like the South African BokSmart, Australian SmartRugby, New Zealand RugbySmart and the WR Rugby Ready programmes. These programmes are aimed at educating and empowering players and officials at all levels of rugby to help make rugby and in particular the tackle safer (WR, 2016).

The BokSmart programme is aimed at implementing evidence-based sports medicine and exercise research to prevent injury and enhance performance at all levels of rugby in South Africa (SA Rugby, 2012; Viljoen & Patricios, 2012). The information from rugby safety programmes can be used to direct and monitor the effectiveness of strategies designed to reduce the overall risk of injury. These strategies include modifying coaching practice by providing high quality technical coaching materials and training, altering athlete training practices, modifying equipment, or changing the laws of the sport, such as outlawing the tip tackle (Dallalana *et al.*, 2007).

Table 2.2: Rugby safety programmes currently being used world-wide

Safety programme	Country
BokSmart	South Africa
RugbySmart	New Zealand
Smart Rugby	Australia
Rugby Ready	World Rugby

Referees play a major role in carrying out injury prevention programmes such as BokSmart and RugbySmart (Gianotti *et al.*, 2009). Rugby safety programmes are put in place to assess and educate coaches and referees on the prevalence of injury in rugby and how to overcome them, in order to make the game as safe as possible for all involved (Viljoen & Patricios, 2012; Roberts *et al.*, 2015). Due to the evolving nature of the game the amount of tackles carried out in rugby matches will not decrease, therefore focus should be placed on how tackles are carried out and managed by the players. It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Sinibaldi & Smith, 2007; Roberts *et al.*, 2015; Burger *et al.*, 2016). If referees are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced.

2.2.4. Referees

Recently, rugby has become safer for players through better regulation – mainly through referees (Punch, 2013). The referee match panel is composed of the on-field referee, two assistant referees (touch-judges) and the video referee (TMO). The assistant referees can intervene through raising their flag to signal an issue or through passing on information to the referee through an ear piece. The referee has both a yellow (10-minute ban) and red card (ban for the rest of the game), which are used for sending a player to the sin-bin for a period of time. The video referee makes use of multiple cameras angles to view the game and he also has the ability to pause, stop, rewind and play each movement in slow motion. The referee can make use of the video referee when he feels that there has been foul play and he has not seen it. The video referee will then go back to the incident and state what he has seen on the video as well as the sanction necessary. The video referee may also cite a player for foul play after the game, once the match footage has been reviewed (Punch, 2013). Each disciplinary transgression can be highly ambiguous because the decision depends on the subjective perception of the danger posed by a particular foul (Souchon *et al.*, 2010).

Law interpretation and sanctioning

The laws provide the framework for a game that is enjoyable to play, entertaining to watch and acceptably safe (Long *et al.*, 2006; Murray *et al.*, 2014). When playing, there is no reason for players to think of anything except playing, because their behavior is under control of the laws (Long *et al.*, 2006). Law changes are fundamental to the development of rugby and are introduced for several reasons (Kraak & Welman, 2014). Some of these reasons, among others, 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. The laws of rugby are developed and amended by WR. WR constantly reviews and, when necessary, changes the laws to ensure safe, enjoyable and entertaining rugby events are delivered (Eaves *et al.*, 2008; Kraak & Welman, 2014).

Laws governing the scrum, including scrum engagements, and the tackle have been adapted to make the game safer and to avoid non-fatal catastrophic injuries to the cervical spine. Examples of law changes introduced to reduce the incidence of catastrophic injuries include the crouch-touch-pause-engage sequence of scrum engagement and the outlawing of the high and tip tackles (Posthumus & Viljoen, 2008; Quarrie & Hopkins 2008). WR set out a change to the interpretation of the law regarding dangerous tackles in 2008, which stated that a tackle which made contact with the ball carrier above the line of the shoulder was dangerous regardless of whether the head or neck was the point of the first or subsequent contact. This law change might reduce the risk of tackles that start at the level of the chest connecting with the head of the ball carrier and a lower risk of head to head contacts (Quarrie & Hopkins 2008). The sanction for dangerous 'tip' tackles was increased in 2009, and again reinforced during the 2011 Rugby World Cup, with decreasing the risk of injury said to be the governing principle behind the WR 'zero-tolerance' approach. The rate of tip tackles at senior international level appears to have decreased since this approach began (Murray *et al.*, 2014). Reboursiere *et al.* (2016) found that the scrum law changes, which were introduced in 2010, have led to a significant decrease in injuries.

Red and yellow cards for dangerous, tip tackles and tackles above the line of the shoulder are part of rugby law. A yellow card means that the player has to leave the field for 10 minutes, whereas a red card means that the player has to leave the field for the rest of the game. Due to various law changes the time that the ball is in play throughout a game has increased from 33% of a match in the last amateur Rugby World Cup (1995) to 44% in the 2011 Rugby World Cup

(IRB, 2011). This could explain why the number of tackles per game has increased significantly, although this increase could also be related to the “use-it-or-lose-it” law introduced in 1994. This law prevented the ball from being delayed in a maul for long periods, therefore increasing the risk of losing the ball. Ball carriers started to make deliberate contact with a tackler in order to set up a ruck where the ball had a lesser risk of being turned over and the “use-it-or-lose-it” law did not apply (Hendricks & Lambert, 2010). This explanation was supported by Quarrie and Hopkins (2008), who found an increase in ruck events per match from 25 in 1972 to 150 in 2004 and a decrease in maul events from 50 in 1972 to 25 in 2004.

Referee conditioning and fitness

Since rugby became a professional sport in August 1995 (Malcolm *et al.*, 2004) there have been numerous changes in laws and player preparation (Quarrie & Hopkins, 2007). Such changes have apparently contributed to a faster pace of play, increased ball-in play time and level of physical contact (Quarrie & Hopkins, 2007; Austin *et al.*, 2011; Quarrie *et al.*, 2013). This would suggest that the physical demands for referees have also increased. With the increase in the demand of the game, the referee needs to attain a much higher level of fitness than in the past (*Die Burger*, 2010; Suarez-Arrones *et al.*, 2013). Kuklinksi (2007), stated that fitness is a prerequisite for refereeing rugby at any competitive level and all referees need to be fit in order to meet the physiological demands of the game, and also need to apply and accurately interpret of the laws of the game (Müniroglu, 2007). Kraak *et al.* (2011a) found that referee movement patterns varied per game due to a) referee experience – as experienced referees tend to move less because they anticipate play better, b) the level or/and quality of the competition, and c) the intensity and different activities (types of play) completed by the players.

The results from Suarez-Arrones *et al.* (2013) are shown in Table 2.3. They found that during a rugby match the referees covered 6,323m, which corresponds to a relative speed of approximately 75 m/min. The average heart rate (HR) of the referees in this study was approximately 85% of their estimated HRmax and approximately 28% of the total match time was spent above 90% of the estimated HRmax, with no differences between halves. Several studies have shown that physical performance, accuracy, and velocity of decision making of players and referees could be altered by the development of exercise-induced fatigue. Therefore the ability of the referee, in rugby, to keep up with play and be in a good position is critical in allowing correct decisions to be made (Suarez-Arrones *et al.*, 2013).

Table 2.3: Referee movement in a game of rugby (Suarez-Arrones *et al.*, 2013)

<i>Referee movement in a rugby game</i>	<i>Distance covered</i>	<i>Percentage of average total distance</i>
Average Total Distance covered in a game	6 322.2m \pm 564.9m	-
Walking	2 356.9m \pm 291.3m	37.3%
Jogging	1 524.4m \pm 229.4m	24.1%
Low intensity running	656.6m \pm 130.7m	10.4%
Medium intensity running	1 110.3m \pm 212.2m	17.6%
High intensity running	347.1m \pm 27.1m	5.5%
Sprint	328.1m \pm 230.3m	5.2%

Decision-making

Rugby referees judge events, make decisions and communicate these decisions to players, coaches and spectators. When a sports official sanctions an athlete who perceives a decision as unfair, this athlete may be in psychological stress. For example, players often dispute officials' decisions and unfortunately conflict and aggression are becoming usual. Indeed, player perceptions of fairness are not only based on the decision, it is influenced by the manner in which the decision is made (Dosseville *et al.*, 2014). A rugby referee's role is to ensure that a sporting event takes place under the best possible conditions such as according to the rules of the game thus representing authority within the sport setting (Dosseville *et al.*, 2014). Referees have to make decisions under pressure from players, coaches, spectators and media. They also make decisions under time pressure and with varied, suboptimal viewing positions. Refereeing is thus a complex decision-making activity, in which the need to intervene (i.e., when a foul is perceived) is not self-evident or obvious in most cases (Souchon *et al.*, 2010). Research that has focused on referee performance found that rugby and basketball officials believed "demonstrating a mastery of the laws" to be the most important aspect of referee performance (Hendricks *et al.*, 2012a). Such mastery of the rules, or laws, demands rapid decision making. Referees are required to evaluate the important characteristics of an event and present an appropriate solution in a couple of seconds, without the opportunity for reassessment or contemplation on the implications of their decision.

The primary role of the referee is not to arbitrate over proceedings or absorb the vitriol of the spectators, but to ensure the safety of the participants through the correct and sensible application of the laws (Caddell, 2005). These laws often serve the dual purpose of regulating

the game while maintaining a safe environment for certain key facets of the sport, and a failure to apply these laws adequately can lead to the participants suffering serious injury. As such, the referee commands a considerable degree of trust from the participants, who are reliant on the match official to control proceedings in a manner that would maximize safety and not expose players to an unduly high risk of harm (Caddell, 2005). Although violence can occur at any level, including schoolboy rugby, it does appear that it is more likely in highly competitive matches where much is at stake and the ethos becomes winning at all costs, by fair means or foul (Punch, 2013).

Athletes may develop expectations with regard to the characteristics of the official who is in charge of judging and making decisions in the context of their sport. They seek out cues that will allow them to form impressions of a sport official, as both are engaged in interactions (Dosseville *et al.*, 2014). Faced with making complex decisions in limited time, research has shown that referees rely on judgmental heuristics (i.e., quick and easy decision rules) to help them make their decisions (Souchon *et al.*, 2010). Research in other sports has attempted to quantify referee decision making using retrospective video analysis. Using this method, rugby referees have been reported to be accurate 50% of the time, whereas ice hockey officials have been reported to be accurate 75% of occasions. Although video-based assessments provide valid examination of decision making performance, they do not replicate the physical, physiological, and psychological aspects of an actual match environment (Emmonds *et al.*, 2015). Lowest accuracy was observed in the last 15-minute period of the game, suggesting that physical and mental fatigue occurs in the final stages of a rugby match (Emmonds *et al.*, 2015).

2.2.5. Performance analysis

O'Donoghue (2010) defined performance analysis as the investigation of actual sports performance. Performance analysis is used to develop an understanding of sports that can inform decision-making, enhance performance and inform the coaching process (Hodges & Franks, 2002). Wright *et al.* (2012), indicated that use of notational analysis has become very accessible to trainers and coaches. Hughes and Bartlett (2002) stated that to enable objective data interpretation from performance analysis, it is necessary to compare the data to that of peer group of teams, or individuals, which compete at an appropriate standard. Hughes and Bartlett (2002) proposed four categories for performance analysis in sport; i.e. biomechanical, tactical and technical indicators as well as match classification.

Analysis of performance indicators (PIs) subsequently will lead to development of performance profiles. These performance profiles can be used to describe a pattern of performance by an individual or team. Performance profiles are typically developed from collecting frequent combinations of performance indicators that may help predict future performance. The use of performance analysis, more specifically notational analysis or match analysis services, has become increasingly accessible to rugby coaches to allow them to gain the competitive edge over the opposition as it provides trainers and coaches with detailed analysis on individuals' and teams' performances (Wright *et al.*, 2012; Burger *et al.*, 2016).

McIntosh *et al.* (2010) used video analysis to code tackles. The tackle analysis was undertaken using the sports coding software Snapper (Webbsoft Technologies, Australia). The tackle event was described as the phase of play before the tackle, the number of tackles, the sequence of tackler contact with the ball carrier, the tackle technique, the completeness of tackle, and the time in the game. The analysis of each tackle was undertaken using a Microsoft Access database prepopulated with fields from the tackle event analysis.

2.3. Rugby tackle

2.3.1. Definition of a tackle

Table 2.4 shows a few different definitions of the tackle that are used in research. McIntosh *et al.* (2010) defined the tackle event as; “a tackle event occurred when an opposition team member attempted to tackle the ball carrier. The intention of the tackle is for the ball carrier to be held and brought to the ground by an opponent (the tackler) as per the laws of the game.” Hendricks *et al.* (2012a) as well as Quarrie and Hopkins (2008) used the following as a definition for a tackle, “when the ball carrier was contacted (hit and/or held) by an opponent without reference to whether the ball carrier went to ground.” Burger *et al.* (2016) defined the tackle event as “any event where one or more tacklers attempt to stop or impede the ball carrier whether or not the ball carrier was brought to ground.” According to WR (2016) a tackle occurs “when a ball carrier (a player carrying the ball) is held by one or more opponents and is brought to the ground. The opposition player that goes to ground with the ball carrier is referred to as the tackler. The purpose of tackling is to prevent the ball-carrier from gaining territory and minimize the chance of the ball-carrier's team from retaining possession of the ball (Hendricks & Lambert, 2010). The WR definition would under estimate the number of tackles across the

board, if it used as a reference point, as it only takes successful tackles into account whereas other definitions take attempted tackles into account as well. Whichever definition is used, the purpose of the tackle is still the same, to limit the forward momentum of the ball-carrier and to restrict their possession of the ball, in order to regain possession of the ball. This section of the review will look at the laws surrounding the tackle, tackle dynamics, how to coach the tackle, the technique of the tackle, the opinion of coaches on the tackle and injury prevention.

Table 2.4: Different tackle definitions being used in research

Authors	Tackle definitions
McIntosh <i>et al.</i> , (2010)	A tackle event occurred when an opposition team member attempted to tackle the ball carrier. The intention of the tackle is for the ball carrier to be held and brought to the ground by an opponent (the tackler) as per the laws of the game
Hendricks <i>et al.</i> , (2012a)	When the ball carrier was contacted (hit and/or held) by an opponent without reference to whether the ball carrier went to ground
WR, (2016)	When a ball carrier (a player carrying the ball) is held by one or more opponents and is brought to the ground
Quarrie & Hopkins (2008)	When the ball carrier was contacted (hit and/or held) by an opponent without reference to whether the ball carrier went to ground
Burger <i>et al.</i> , (2016)	Any event where one or more tacklers attempt to stop or impede the ball carrier whether or not the ball carrier was brought to ground

Regardless of the definition of injury, most injuries occur during a tackle (36-56%), with a player either being tackled or tackling. According to Holtzhausen *et al.* (2006), the most dangerous phase of play during matches was being tackled, accounting for 46% of injuries, compared to rucks and mauls (17%). They also found that the incidence of injury to the player being tackled is nearly twice that of the tackler (23% vs. 13%). In terms of player's position during a tackle, one third of injuries occur when there is a differential in tackling speeds. The player with the lower momentum is injured four times as often as the player with higher momentum in this scenario. In addition, half of all injuries sustained during tackles occurred

during a blind tackle, that is, outside the peripheral vision of the player being tackled. When a player is tackled blind, the player who is doing the tackling usually sustains the injury (Kaplan *et al.*, 2008; Hendricks & Lambert, 2010; McIntosh *et al.*, 2010).

In addition, high tackles are the main cause of injury to the ball-carrier's head/neck region. Coaches need to discourage players from high and dangerous tackles which are illegal in rugby (Hendricks & Lambert, 2010). The reported rates of injury due to foul play, which is defined as a player being penalized while causing an injury, represent 9% of all injuries sustained at the professional level. Foul play consistently causes more injury than set pieces (Kaplan *et al.*, 2008). Collision tackles (shoulder charges) are illegal in rugby and carry the greatest incidence and severity of injury per event compared with all other contact events, similar to previous findings in contact rugby (Roberts *et al.*, 2015). Since collision tackles are illegal in rugby, the data collected in Roberts *et al.* (2015) reinforces the importance of coaching correct technique, correcting player behaviour and continued strict enforcement of penalizing this offence. The collision tackle (tackler impedes/stops ball-carrier without the use of the arm(s)) had a significantly higher propensity for injury to both tackler and ball-carrier compared to other tackles (Hendricks & Lambert, 2010). Fuller *et al.* (2007) found that illegal tackles were much less common but were 70% more likely to result in an injury than a tackle. The risk associated with this form is recognized within Law 10.4 in the 2016 law book, which identifies illegal tackles as dangerous play (WR, 2016). Despite this, however, the referees penalized few collisions as dangerous play.

2.3.2. Laws surrounding the tackle

Catastrophic cervical injuries to the ball carrier are predominately caused by illegal (dangerous) tackles. Both high tackles and tip tackles are illegal and put the ball carrier at a significant risk of cervical spine injury (Fuller *et al.*, 2007; Sinibaldi & Smith, 2007; Roberts *et al.*, 2015). A study in New Zealand and English rugby found that the ball carriers were at highest risk from tackles to the head-neck region. The laws of the game and guidance on reducing the risks associated with tackles emphasise the importance of avoiding tackles above the line of the shoulder and head/neck contact (Fuller *et al.*, 2010; McIntosh *et al.*, 2010). Tip tackling, which in rugby is described as lifting the ball carrier off his feet and driving him head first into the ground, has been outlawed and stricter enforcing of this law has been introduced (McIntosh *et al.*, 2010). Tackles around the neck may force the neck into either hyperextension (bent backwards) or hyperflexion and rotation, which may be sufficient to cause fracture or

dislocation of the cervical vertebrae and possibly severing of the spinal cord (Scher, 1978). Cervical injury due to axial loading may also occur in the ball carrier either from being tip tackled or making direct contact with the top of the head by entering the tackle with the head down (Posthumus & Viljoen, 2008; Fuller *et al.*, 2010; McIntosh *et al.*, 2010).

2.3.3. Tackle dynamics

There are mechanical aspects to the tackle that should be mastered in order to perform an effective tackle. The key factors in making a good injury free tackle are timing, momentum, and head and body position. The most common types of tackles are the side on leg tackle and the front-on ball and all tackle (Posthumus & Viljoen, 2008). There can be one, two, or more tacklers involved in a tackle situation that makes the impact forces even higher (Strauss, 2013). The speed at which the tackle takes place also determines the impact of the forces involved in the tackle (Posthumus & Viljoen, 2008; Strauss, 2013). Research into the tackle has found that on average matches contain 150-220 tackles per game, with the forwards being involved in an average of 17 tackles and the backline players 7 tackles per match. Due to the tackle being the most common phase of play in the game it is the most important area to be studied and improved to limit injuries and make the game safer (Hendricks & Lambert, 2010; Vaz *et al.*, 2010; Van Rooyen *et al.*, 2014). According to Posthumus and Viljoen (2008), tackling has been shown to be the cause of 25% and 14% of injuries in schoolboy and adult South African rugby players, respectively. Tackle injuries were most often associated with front-on tackling, rather than tackling from the side or behind (Posthumus & Viljoen, 2008; William *et al.*, 2013).

According to Fuller and Molloy (2011), tackling resulted in more injuries at the under 20 level in comparison to the senior elite level, which may reflect a poorer tackling technique among the younger players. According to a study conducted by Hendricks *et al.* (2012a), which assessed the attitude and behaviour of players in training and match play with regards to safety and performance through questionnaires. The top four behaviours, ranked by players, during matches were “bringing down the ball carrier at all costs”, “preventing the ball carrier” and “opposition team from retaining position” and “putting in a big hit”. These ranked more important than “safety of himself” or the “opposition player” (bottom 2 ranked behaviours). Hendricks *et al.* (2012a) made the point that some players may intentionally be aggressive in an attempt to harm another player (hostile aggression), or be aggressive only with the intention of producing a successful outcome (instrumental aggression). The tackle is a physical contest, and requires a high level of aggression. It seems that players are willing to sacrifice the

opponents' safety, as well as their own, to obtain a successful outcome (Hendricks *et al.*, 2012a). Injury prevention programmes revealed that the best way for ball carriers to reduce tackle injuries is to avoid tackles at speed and to keep the head/neck in the right position (Fuller *et al.*, 2008; Williams *et al.*, 2013). However, it is not possible to avoid tackles at all times, as they form an integral and important aspect of rugby, in terms of stopping an opponent's forward movement and gaining ball possession. It is essential, therefore, that referees protect ball-carriers by consistently penalizing collisions and other illegal tackles, as these events are more likely to result in injury and are specifically identified in the laws of rugby as foul play (Fuller *et al.*, 2008).

2.3.4. Coaching the tackle situation

The ability of a player to engage and tolerate frequent contact in the tackle situation, whether as a ball-carrier or tackler, influences the performance of the team and exposes the players to a high risk of injury. Therefore, in part, for safe and successful participation in rugby, coaching of tackle techniques is essential (Hendricks & Sarembok, 2013). The need for coaches to equip themselves and emphasise correct technique is extremely important and one of the few possible modes to reduce injuries, especially non-fatal catastrophic injuries to the head, neck, brain and spine (Posthumus & Viljoen, 2008; Brukner and Khan, 2012). Coaching of the correct technique has improved tackle efficiency and has led to the decrease in the incidence of injuries within senior professional rugby (SA Rugby, 2011). Rugby players were shown to be more confident and believed more in their ability (self-efficacy) to execute a skill when they perceived their coaches to have thorough knowledge of technique and implementing this knowledge (Hendricks & Lambert, 2010). Communication between the coach and player(s) need to be clear and direct so that player(s) understands the value of the drill and receives the proper instruction (Hendricks *et al.*, 2012a).

Contrary to popular belief, approaching the tackle half-heartedly may place the tackler at greater risk of injury (Posthumus and Viljoen, 2008; Hendricks & Lambert, 2010). Posthumus and Viljoen (2008), mentioned that effective ball-carrying technique requires players to dominate the contact situation, as well as gaining momentum again as soon as possible after completing a phase of play in order to reduce the probability of being injured in the next tackle in which they are involved. They also mention that a tackle event can be dominated through the tackler closing down the space between himself and the attacking player while ensuring a powerful leg drive into the tackle. Shortening steps before contact, driving forcefully with the

shoulder on the same side as the leading leg and hitting into the trunk is the most effective way to execute a tackle (Posthumus & Viljoen, 2008). However, Hendricks and Lambert (2010), found that greater differential impact between the tackler and person being tackled seems to be a major risk factor for injury to the player with the lower momentum, therefore dominating the tackle situation might be the most effective in terms of being successful, but not the safest option (Hendricks & Lambert, 2010).

It is unlikely that the number of contact events in rugby match play will be reduced given the evolution of the game, and, therefore efforts to reduce injuries during contact should focus on how activities are carried out and managed by the players (Fuller *et al.*, 2010; Roberts *et al.*, 2015). Poor level of conditioning has been shown to reduce tackle technique proficiency which may predispose players to injury (Hendricks *et al.*, 2012a). It was found that the quality of the tackle technique in Rugby League players diminished under fatigue, which may in turn lead to fatigue-related tackle injuries (Hughes & Fricker, 1994; Gabbett, 2008a). Coaches can develop the tackle technique through various different drills depending on the player's level of play, skills level, experience, body size, playing position as seen in Table 2.5 (Hendricks & Lambert, 2010; Hendricks *et al.*, 2012a). Table 2.5 shows that the coaches can change the tackle tasks and tackle environment depending on the players' level of skill. In the beginning coaches would focus on repetition of tackle techniques, through vocal and visual cues. For advanced players, coaches would focus on tackling of moving ball-carriers and set play defensive structures, as well as refinement of basic skills.

Table 2.5: Guidelines for developing tackling skills (Hendricks & Lambert, 2010)

Player	Task	Environment	Measure of Performance
Level of play, age, skill level, experience, size of player, playing position, etc.	- Basic principles and added variables	- Control vs. semi control vs. uncontrolled/match simulating	- Indication of progress
Beginner, Junior	- General front of tackle instructions Repetition of proper technique until it becomes implicit and autonomous Instruct on relevant cues when approaching the ball carrier	- Controlled – against a stationary person or bag	- Process measure – execution of proper technique - Efficacy
Intermediate	- Add reaction time and decision making - Include physical contact - Add tackles from various directions, situations and tackle types. - Add physical conditioning	- Semi-controlled – tackler has 2 or 3 options to choose from, using a stationary person or bag, or slow moving person or bag - Speed of person or bag increases - First in a controlled setting and then progress to semi-control	- Execution of proper technique, efficiency, decrease reaction time and speed
Advance	- Train tackling technique according defensive structures - Tackling of ball-carriers - Individualise training for player (s), according position, size, and team - Refinement of basic skills	- Semi-control - Match simulating conditions	- Outcome measure – Prevent ball carrier from gaining territory and minimise the chance of the ball-carrier from retaining possession of the ball

2.3.5. Tackle technique

While contact is an essential part of rugby, correct technique in contact situations may help to minimise the potential for injury (Burger *et al.*, 2016). Injury prevention in the tackle should focus on technique with strict enforcement of existing laws for illegal collision tackles (Fuller *et al.*, 2010; Roberts *et al.*, 2015). The physical nature of the tackle exposes both players (i.e. tackler and player being tackled) to injury. While injury is always a risk during collisions, the risk of injury during the tackle can be reduced through the implementation of safe and effective techniques (Hendricks & Lambert, 2010; Hendricks *et al.*, 2012a).

The variety of descriptions in Table 2.6 suggests that there is no consistency in terms of the tackle technique, even within the same programme (Hendricks & Lambert, 2010). Players should be advised that the tackle technique described in the coaching literature is not only the safest, but also results in ‘effective’ tackles being executed. Tackle technique has also been improved when players receive tackle specific coaching concentrating on key aspects of the tackle (Van Rooyen *et al.*, 2014). Information that players need to get and interpret before making a tackle includes the speed and size of the ball carrier, the direction the ball-carrier is running to, playing position of the ball-carrier, position on field, position relative to the ruck/maul/scrum/lineout, and the tacklers own ability (Hendricks & Lambert, 2010; Van Rooyen *et al.*, 2014). Once the player grasps these basic principles, the player will most likely be able to execute a safe and effective tackle. When satisfied with the player’s basic tackling skills, the coach can start introducing other variables to training the tackle (Hendricks & Lambert, 2010). Fatigue also needs to be considered as it has been shown to cause decrements in the tackling techniques of rugby players. These findings suggest that as the game progresses the tackle effectiveness may diminish due to player fatigue (Van Rooyen *et al.*, 2014).

When contact is unavoidable, the contact situation should always be entered with the head up and back straight (Posthumus & Viljoen, 2008). Dropping the chin forward into the contact appears to increase the risk of head/neck injury through hyperflexion of the cervical spine. Education measures that focus on teaching players to keep their chins off their chests, their eyes open, and to be aware of the location of other players as they move into the tackle situation may help reduce the risk of this type of injury (Posthumus & Viljoen, 2008). Although the tackler’s anatomical site of contact should always be the shoulder, safety must be ensured by keeping the face up and focused on the core of the approaching ball carrier. It is recommended that the zone between the upper thigh and the sternum be the target for contact when performing

a front-on tackle; this recommendation will ensure safe and effective technique (Posthumus & Viljoen, 2008). When executing a tackle the aim is to dominate the contact situation and prevent the ball carrier from gaining territory and retaining the ball (Hendricks *et al.*, 2012a). According to McIntosh *et al.* (2010), no specific tackle technique was observed to be associated with significantly increased risk of game injury. There was, however, a greater risk of game injury associated with simultaneous contact by tacklers.

A general lack of skill from the tackler has been highlighted as a risk factor to catastrophic cervical injuries and concussion, and as the primary reason for a much higher rate of tackling injuries sustained among schoolboys. It is therefore important, especially at lower levels, to emphasise the basics of safe and effective tackling technique. Primary emphasis should be placed on the head and neck position in the tackle. Most importantly, players should be coached to place their heads in the safest area when tackling, e.g. placing the head behind the buttocks of the ball carrier, and to ensure that the face is always up when performing a side-on tackle (Posthumus & Viljoen, 2008). Van Rooyen *et al.* (2014) found that “effective” tackle outcomes were found to have a greater percentage of the player’s torso leaning forward and oblique angle approaches to the ball-carrier. To have an ‘effective’ outcome the tackler should attempt to stop the ball-carrier from gaining forward momentum, increasing the time it takes for the opposition to free the ball from the tackle situation or dislodge the ball, and/or turn over possession of the ball in the tackle, which includes forcing the ball-carrier into conceding a penalty (Van Rooyen *et al.*, 2014).

Table 2.6: Current coaching techniques described for the front tackle (Hendricks & Lambert, 2010)

	NZRU RugbySmart 2008	NZRU RugbySmart 2007	ARU SmartRugby 2008	SA Rugby BokSmart	NZ LeagueSmart
1.	Sight target	Sight target	Position the ball carrier	Tackle the attacking player	Sight target
2.	Move forward into tackle	Position inside the ball carrier	Approach in an upright position with hands up in front, and thumbs up	Stay square to your opponent for as long as possible	Hands above waist, elbows in
3.	Move slightly inside the ball-carrier (inside shoulder)	Run in pre-tackle stance	Sight the target – above the knees	Run toward your attacking player’s inside shoulder	Move in close to the runner
4.	Face up!	Chin up	Balance and dip the body late, keeping the head up, looking forward	Deny them space	Keep your eyes on the target
5.	Keep feet alive and position lead foot close to ball carrier	Eyes open	Place lead foot in close	Shuffle and do not cross your feet	Head up and away to the side
6.	Drive with legs to make firm contact with the shoulder and with the head to the side	Back straight	Position head to the side of opponent (ear against thigh), and look forwards	Keep your face up during the tackle	Contact with your lead shoulder
7.	Punch arms forward and wrap around the ball-carrier	Hands above hips	Drive with legs and make firm contact with front shoulder	Keep your eyes open and sight your target	Wrap arms “Bear hug”
8.	Continue power drive through to complete the tackle	Go forward	Wrap arms and lock (hand to elbow), cheek to thigh (no gaps) and squeeze	Focus on the core of the attacker	
9.	Regain feet and recover ball	Zero in on target	Finish on top of the ball carrier	Keep your spine in line	

10.	Drive with legs to make firm contact with the shoulder on the target. Head behind ball carriers body	Quickly regain feet	Align your head outside of the tackler and not in front
11.	Lock on with the arms around the ball carrier		Shorter, faster steps as you approach
12.	Continue power drive		Keep your elbows low and hands up (boxer stance)
13.	Regain feet		Dip and step into the tackle with lead foot
14.	Recover ball		Punch and wrap the arms (hit-and-stick)
15.			Maintain leg drive into the tackle
16.			Once on the ground, regain feet quickly
17.			Compete for the ball

2.3.6. Coaching behaviors

The coaches' role in the communication of injury prevention information and attitudes to player safety has become very important. Coaches should select the right players in the right positions, based on the functional role for the position, to avoid injuries (Gianotti *et al.*, 2009). They should have a good balance in their team talks between aggression and winning at all costs on the one hand and safety on the other (Long *et al.*, 2006; Posthumus & Viljoen, 2008; SA Rugby, 2011). Educational initiatives that focus on technique, physical conditioning and the wearing of the protective equipment are another avenue for reducing injuries in rugby. The use of incorrect technique has been identified as a risk factor for reducing injury in rugby. Players guilty of continuous dirty play and not playing within the rules should not be selected for a team (SA Rugby, 2011). The principles of fair play should be upheld to reduce the risk of injury. This is the responsibility of everyone involved including coaches, players, referees and supporters. Proper implementing of laws in a specific sporting code can also play a major role in preventing sports injuries. The laws of different sports are also adjusted to make sports safer and prevent injuries (Brukner & Khan, 2012).

At higher levels of rugby the coaching is of a higher standard and the technique of players in the tackle is better than players at club or school level. Higher levels of rugby are usually associated with better quality of coaching. Coaches equipped with a better understanding of injury mechanisms and a thorough knowledge of a safe and effective tackle technique have a major role in preventing or reducing tackle injuries. Conditioning should focus on specific tackling drills at a high speed during training to improve tackle specific fitness and technique (SA Rugby, 2012). Players, coaches and administrators need to find the most suitable balance between injury prevention and performance during training with their team setting (Hendricks *et al.*, 2012a). In other words, training the tackle should be customized according to the team's or individual level of play, age, skill level, experience, position (Hendricks *et al.*, 2012a). Administrators and coaches should ensure that sporting facilities and equipment are safe, and players have the correct gear. Training and competing/playing should be on surfaces suitable for rugby (Brukner and Khan, 2012). According to the WR law book (2016) the surface may be grass but may also be sand, clay, snow or artificial grass.

Hendricks *et al.* (2015) found that the importance of tackle training to prevent injury, and the amount of time spent on technique to prevent injuries, was associated with behaviours that reduce the risk of injury in matches. Match behaviours 'doing what is practiced', 'proper

technique’, ‘own safety’ and ‘staying on feet’ were consistently associated with both verbal instruction and demonstration, which suggest that these coaching methods may be effective for training contact skills such as tackling (Hendricks *et al.*, 2015). Hendricks and Sarembock (2013) found that verbal instruction and the use of padded equipment (shield, bag and body armour) were ranked as the most important drills to use when training the tackle, whether to reduce the risk of injury or to improve performance. One of the least ranked tackle drills in the last season was “live tackling in a 1v1 player grid”. These findings imply that coaches prefer using padded equipment such as the tackle bag or shield rather than live 1v1 tackling, perhaps in an attempt to safeguard the players from injury (Hendricks *et al.*, 2012a; Hendricks & Sarembock, 2013). While the use of padded equipment may lower the risk of injury in training compared to live tackling, it can be used to develop tackling skills. However, it has been suggested that tackle bags and shields do not mimic real match conditions, and that improper use of it may result in players developing incorrect tackle techniques during training. This has the potential to carry over into matches (Hendricks *et al.*, 2012a).

2.4. Summary

The tackle event is a common feature in rugby across all levels of play. The fundamental purpose of the tackle remains to prevent the attacking team from gaining territory and possession of the ball to score points. The tackle event in rugby has the highest propensity to cause injury compared to other areas or activities of the game with both ball-carrier and tackler being at risk (Sinibaldi & Smith, 2007). Coaches should not only focus on the front-on tackle during training, but also practice tackles from behind, from the side and situational tackles in order to prepare the players for any contact situation during the match. Referees put up with a lot of criticism both on and off the field and are crucial in ensuring the player safety during matches (Mascarenhas *et al.*, 2005; Kraak *et al.*, 2011b; WR, 2016). Therefore, referee education on laws and sanctioning is crucial in decreasing injury prevalence (Mascarenhas *et al.*, 2005; Mellick *et al.*, 2005; Kraak *et al.*, 2011b). Referees play a major role in enforcing the safety regulations of injury prevention programmes, such as BokSmart and RugbySmart (Gianotti *et al.*, 2009). Rugby safety programmes are put in place to reduce the risk of injury to players. However, these programmes would be ineffective without referees enforcing these programme’s regulations and the laws of the game (Viljoen & Patricios, 2012). It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Sinibaldi & Smith, 2007; Roberts *et al.*, 2015; Burger *et al.*, 2016). If referees

are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced.

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CHAPTER THREE
RESEARCH ARTICLE ONE:
INVESTIGATION INTO TACKLE CHARACTERISTICS DURING THE
2011-2015 UNDER 18 CRAVEN WEEK TOURNAMENT

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

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Investigation into tackle characteristics during the 2011-2015 under 18 Craven Week tournament

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Abstract

Rugby carries the highest risk of injury in comparison to other contact sports regardless of the injury definition used, with the tackle accounting for the highest injury event. The aim of the study was twofold, firstly, to investigate the tackle characteristics and secondly, to determine whether these tackles were legal or illegal during the 2011 – 2015 Craven Week rugby tournaments. 99 matches were recorded and analysed using EncodePro Analysis software, according to the set performance indicators. The performance indicators included i) the tackle, ii) the time (quarters) in the match that the tackle took place, iii) the direction of the tackle, iv) how many tacklers were involved, and v) whether the tackle was deemed legal or illegal according to the law book. An average of 123 tackles per match was observed, with most of them occurring front-on (65%). Tackles were evenly distributed across all four quarters, with most of the tackles involving 1 tackler (66%). 113 illegal tackles were identified from the analysis throughout the 5 years, most of them occurred front-on (66%), and involved one tackler (91%). Most of the illegal tackles took place in quarter two (29%) and four (29%). These findings provide information on schoolboy rugby tackle characteristics and could lead to improvements in training regimes, and safety and education programmes, for referees, players and coaches.

Key Words: *Schoolboy rugby, tackles, rugby union, notational analysis, World Rugby, illegal tackles.*

3.1. Introduction

Rugby union (hereafter referred to as rugby) is one of the world's most popular team sports since professionalism was introduced in 1995, with 96 countries participating worldwide and is governed by World Rugby (WR) (Duthie *et al.*, 2003; Biscombe & Drewett, 2010). However, it also has one of the highest incidences of injury, irrespective of the injury definition used (Fuller *et al.*, 2010). Rugby is a field-based team sport, with the match lasting 80 minutes at senior level (70 minutes running time at schoolboy level), and is characterized by short intermittent bouts of high intensity exercise with 30 players having multiple high impact contact situations throughout the match (Fuller *et al.*, 2007; Brown *et al.*, 2012).

The Craven Week is an annual under 18 provincial schoolboy rugby tournament, organised by the South African Rugby Union (SARU). The tournament is comprised of 18 teams from around the country and a team from Namibia and Zimbabwe. It is an elite merit based tournament, not only for players but also referees. The referees for the tournament are appointed based on their performance prior to the tournament as well as their potential to referee at a higher level. These referees are included from the contender (developmental programme) and national panel referees of the South African Rugby Referee Association (Kraak *et al.*, 2011; Lawrence, 2016).

Rugby is an evasion game which requires creation and use of space and is characterised by a high frequency of physical contact between players and with the ground (Hendricks *et al.*, 2012a), which consists of tackles, rucks and mauls. The tackle is a display of physical strength and technical proficiency and is a skill that is required across all playing positions (Hendricks *et al.*, 2016). Research associated with the tackle in rugby has mainly focused on the senior level and therefore less is known at schoolboy levels of the game (Quarrie & Hopkins, 2008; Fuller *et al.*, 2010). Furthermore, the tackle is the most common phase of play in rugby and is the cause of the most injuries. According to various authors, the tackle accounts for 58%, 59% and 61% of all injuries respectively, which occur during a rugby match (Quarrie & Hopkins, 2008; Haseler *et al.*, 2010; Hendricks & Lambert, 2010). Players are involved in 20-40 physical confrontations per match and wear minimal or no protective gear (Hoskins *et al.*, 2006; Hendricks & Lambert, 2010). These statistics make the tackle the most important phase to be investigated and improved to limit the number of injuries and make the game safer (Hendricks & Lambert, 2010; Vaz *et al.*, 2010; Van Rooyen *et al.*, 2014). According to Quarrie and Hopkins (2008), a tackle is made when the ball-carrier is contacted (hit and/or held) by an

opponent, known as the tackler, without reference to whether the ball-carrier went to ground. Failure to tackle will lead to the opposition team gaining territory and scoring points (Hendricks & Lambert, 2010). A player's ability to win the tackle contest has also been shown to decrease the risk of injury and has a positive influence on the outcome of the match (Hendricks *et al.*, 2012b; Hendricks *et al.*, 2015; Burger *et al.*, 2016).

The nature of rugby makes the tackle unavoidable and thus it is important to coach safe and effective tackling techniques (Posthumus & Viljoen, 2008; Hendricks *et al.*, 2015). This may help to reduce the risk of injury, and at the same time improve performance. It is clear that the tackle is an injury prevention priority and therefore numerous interventions have tried to reduce the risk including coach education programmes, and laws to reduce dangerous tackles (Fuller *et al.*, 2010; Roberts *et al.*, 2015). Referees play a major role in carrying out injury prevention programmes put forward by various rugby safety programmes, such as BokSmart and RugbySmart (Gianotti *et al.*, 2009). In order to decrease the risk of injury it is of utmost importance to coach correct technique, correct player behaviour and continue the strict enforcement of penalising illegal tackles (Roberts *et al.*, 2015). Due to the evolving nature of the game the amount of tackles carried out in rugby matches will not decrease, therefore efforts to reduce injuries in contact events should focus on how events are carried out and managed by the players. It is imperative that existing laws are applied to illegal collision tackles given the high risk of injury of these events (Roberts *et al.*, 2015). If referees are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced. Coaching and execution of the correct technique has improved tackle efficiency and has led to the decrease in the incidence of injuries (Hendricks & Lambert, 2010; SA Rugby, 2011; Burger *et al.*, 2016). The tackles shown in Table 3.1 are deemed illegal and could result in conceding a penalty (World Rugby, 2016). Illegal tackles are considered dangerous, and have been associated with serious head, neck injuries or spinal injury (Sinibaldi & Smith, 2007). According to Fuller *et al.* (2007), illegal tackles are a lot less common but are 70% more likely to result in an injury in comparison to a legal tackle. To discourage players from engaging in illegal tackles, players are often sent off the field of play for a short period or the entire match (depending on the severity and intent of the tackle) (Sarembock, 2014). It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Roberts *et al.*, 2015).

There are different mechanical aspects to the tackle that should be mastered in order to perform an effective tackle. The key factors in making a good legal tackle are timing, momentum, head and body position. The most common types of tackles are the side-on leg tackle and the front-on ball and all tackle (Posthumus & Viljoen, 2008). There can be one, two, or more tacklers involved in a tackle situation that makes the impact forces even higher (Strauss, 2013). The speed at which the tackle takes place also determines the impact of the forces involved in the tackle, the higher the speed the greater the impact (Posthumus & Viljoen, 2008; Strauss, 2013). Research into the tackle has found that on average matches contains 150-220 tackles per match, with the forwards being involved in an average of 17 tackles and the backline players 7 tackles per match. The tackle is a physical contest, and requires a high level of aggression. It seems that players are willing to sacrifice the opponents' safety, as well as their own, to obtain a successful outcome (Hendricks *et al.*, 2012a). Roberts *et al.* (2015) found that collision tackles (illegal tackles involving a shoulder charge) had an extremely high propensity for injury, 15 injuries/ per 1000 events, in comparison to any other event. To discourage players from engaging in illegal tackles, tacklers are often sent off the field of play for a short period or the entire match (depending on the severity and intent) (Sarembock, 2014). However; Fuller *et al.* (2007) found that despite the injury concerns surrounding tackles, referees penalised few illegal tackles as dangerous play.

Injury prevention programmes recommend that the best way for ball carriers to reduce tackle injuries is to limit tackles at speed and to keep the head/neck in the right position (Fuller *et al.*, 2008; Williams *et al.*, 2013). However, it is not possible to avoid tackles at all times, as they form an integral and important aspect of rugby, in terms of stopping an opponent's forward movement and gaining ball possession. Information that players need to assess before making a tackle includes the speed and size of the ball carrier, the direction the ball-carrier is running to, playing position of the ball-carrier, position on field, position relative to the ruck/maul/scrum/lineout, and the tacklers own ability (Hendricks & Lambert, 2010; Van Rooyen *et al.*, 2014). Once the player grasps these basic principles, the player will most likely be able to execute a safe and effective tackle. Fatigue also needs to be considered as it has been shown to cause decrements in the tackling techniques of rugby players. These findings suggest that as the match progresses the tackle effectiveness may diminish due to player fatigue (Van Rooyen *et al.*, 2014). Based on the background provided the aims of the study was twofold: firstly, to investigate the tackle characteristics and secondly, to determine whether these tackles were legal or illegal during the 2011 – 2015 Craven Week rugby tournaments.

3.2. Methodology

3.2.1. Sample

Video recordings of the South African under 18 Craven Week rugby tournament matches (N = 99) during the 2011-2015 period were used for the purpose of the study.

3.2.2. Data collection procedure

Video recordings

The television video recordings of the under 18 Craven Week matches were supplied by the Division of Exercise Science and Sports Medicine video analysis department, University of Cape Town. The 99 recorded matches were analysed using the EncodePro® video analysis software package (South Africa, 2016). Ethical approval (SU-HSD-001220) was obtained from the Research Ethics Committee: Human Research of the Stellenbosch University.

Performance indicators and description

In Table 3.1 are the performance indicators (PIs) analysed based on the aims of the study.

Table 3.1: Performance indicators and description

Performance indicators	Definition
Tackle (Quarrie & Hopkins, 2008).	When the ball-carrier was contacted (hit and/or held) by an opponent without reference to whether the ball-carrier went to ground
Quarters (min)	Quarter 1: 0 – 17.5min Quarter 2: 17.5 - 35 min Quarter 3: 35 – 52.5 min Quarter 4: 52.5 - 70 min
Direction of tackle (Van Rooyen <i>et al.</i> , 2014)	Front-on tackle - The tackler tackles the front of the ball-carrier. Side-on tackle - The tackler tackled the ball-carrier laterally from either the right or left hand side. Tackle from behind - The tackler tackled the ball-carrier from behind.
Number of players involved	Number of players tackling the ball carrier
Types of illegal tackles (World Rugby, 2016)	High tackle - A player must not tackle (or try to tackle) an opponent above the line of the shoulders even if the tackle starts below the line of the shoulders. A tackle around the opponents head or neck is dangerous play. Stiff arm tackle - A player makes a stiff-arm tackle when using a stiff arm to strike an opponent. Early tackle - Tackling a player before he has received the ball. Late tackle - Tackling a player after he has released the ball.

	<p>Playing the opponent without the ball - Except in a scrum, ruck or maul, a player who is not in possession of the ball must not hold, push or obstruct an opponent not carrying the ball. Also known as a no-arm tackle.</p> <p>Dangerous charging - A player must not charge or knock down an opponent carrying the ball without trying to grasp that player.</p> <p>Tackling the jumper in the air - A player must not tackle nor tap, push or pull the foot or feet of an opponent jumping for the ball in a lineout or in open play. A player must not tackle an opponent whose feet are off the ground.</p> <p>Tip tackle - Lifting a player from the ground and dropping or driving that player into the ground while that player's feet are still off the ground such that the players head and/or upper body come into contact with the ground is dangerous play.</p>
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Coding

The gold standard of coding was set by one of the international referees, using the law book definition and twenty randomly selected clips of both legal and illegal tackles. The matches were analysed using the EncodePro video analysis software (v2.99 e). The software allows an incident to be coded and appeared as a PIs. In this analysis, specific PIs were examined. The primary researcher then coded the tackles during the match according to the PIs in Table 3.1. During the coding the primary researcher was at liberty to pause, rewind and watch the tackle footage in slow motion.

Reliability

The reliability of the coded tackles was tested using intra and inter-rater reliability. After all the matches were coded, the primary researcher coded 25% of the matches that were randomly selected by drawing game numbers from a hat. Inter-rater reliability was conducted two national panel referees from the SARefs Academy in Stellenbosch. The SARefs referees re-coded all the matches according to the PIs in Table 3.1. The reliability of the intra and inter-rater reliability was determined by the Intraclass Correlation Coefficient (ICC) of the test and retest data. Intra and inter-rater agreement was interpreted as follows: poor (<0.20), fair (0.30-0.40), moderate (0.50-0.60), strong (0.70-0.95) and almost perfect (>0.95). The analysis showed the agreement between all the variables were almost perfect (Table 3.2) and thus considered as very reliable.

Table 3.2: Intra and inter-rater reliability correlations coefficient (ICC) of the coding test-retest.

Reliability	Tackle	Quarter	Number of players	Direction of tackle	Illegal tackles	Types of illegal tackle
Intra-rater reliability	0.99	1.00	0.98	0.99	1.00	0.97
Inter-rater reliability	0.99	1.00	0.98	0.99	0.98	0.97

Statistical Analysis

The Statistica Data Processing package (Statsoft Inc., 2013) was used to process the data. Descriptive data was reported as frequencies (number of observations), percentages, 95% confidence intervals (CI), averages and a significance level of 5% ($p < 0.05$) was applied. Some indicators are expressed as percentages, which according to Hughes and Bartlett (2002) provides a more accurate analysis of team performance. Outcome measures were presented as the mean \pm standard deviation (s). Cohen's d effect sizes (Thomas *et al.*, 1997) were calculated, using the difference in means divided by the pooled standard deviation, to characterize the differences between the years. The magnitude of Cohen's d effect sizes evaluated according to the following criteria: 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) (Hopkins, 2011).

3.3. Results

Table 3.3 presents the descriptive statistics of the tackle characteristics for the Craven Week tournament from 2011 to 2015. It includes the overall results for the number of tackles completed, tackles per year, the direction of the tackle, the quarter the tackle took place as well as the number of tackler(s) used to complete the tackle. From 2011 to 2015 a total of 12216 tackles took place, at an average of 123.39 ± 17.34 tackles per match. A total of 12103 and 113 tackles were deemed legal and illegal, respectively. Legal tackles (99%) were completed at an average of 122.25 ± 17.02 times per match, in comparison to illegal tackles (1%), which were completed at a rate of 1.14 ± 1.44 times per match.

Table 3.3: Descriptive statistics of the tackle characteristics for the Craven Week tournament during 2011 and 2015

Performance indicators	<i>n</i>	<i>M</i> ± <i>SD</i>	95% <i>CI</i>	%
Total tackles				
Tackles	12216	123.39 ± 17.34	12212 - 12216	-
Legal tackles	12103	122.25 ± 17.02	12080 - 12122	99
Illegal tackles	113	1.14 ± 1.44	109 - 113	1
Year				
2011	1874	117.13 ± 15.36	1797 - 1953	15
2012	2877	137 ± 16.61	2786 - 2970	24
2013	2561	121.95 ± 12.21	2474 - 2650	21
2014	2188	109.40 ± 13.99	2106 - 2272	18
2015	2716	129.33 ± 15.00	2627 - 2807	22
Quarter				
Quarter 1	3085	31.16 ± 7.52	2992 - 3180	25
Quarter 2	3007	30.37 ± 7.71	2915 - 3101	25
Quarter 3	2890	29.19 ± 6.83	2799 - 2983	24
Quarter 4	3234	32.67 ± 9.19	3139 - 3330	26
Direction of tackle				
Front-on	7967	80.47 ± 15.44	7863 - 8070	65
Side-on	2939	29.69 ± 10.82	2847 - 3033	24
From behind	1310	13.23 ± 5.72	1244 - 1379	11
Number of tackler (s)				
1 tackler	8071	81.53 ± 16.87	7968 - 8173	66
2 tacklers	3875	39.14 ± 9.43	3775 - 3977	32
3 tacklers	263	2.66 ± 2.59	233 - 296	2
4 tacklers	7	0.07 ± 0.26	3 - 14	0

Note: *SD* – standard deviation, *M* – mean, *CI* – confidence intervals, % – percentage

Most of the tackles were completed in 2012 (24%), at a rate of 137 ± 16.61 tackles per match. The number of tackles then decreased to 121.95 ± 12.21 tackles per match in 2013, with the least amount of tackles per match tacking place in 2014, at a rate of 109.4 ± 13.99 tackles per match. The average tackles per match increased again in 2015 to 129.33 ± 15.00 tackles per match.

The tackles were evenly distributed across the four quarters of the match. Quarter one and two remained even (25%), with an average tackle rate per quarter of 31.16 ± 7.52 and 30.37 ± 7.71 respectively. However, slightly more tackles were completed in quarter four (26%), at a rate of 32.67 ± 9.19 tackles per fourth quarter. And slightly less (24%) were completed in quarter three, at a rate of 29.19 ± 6.83 tackles per third quarter. The front-on tackle was the predominant

direction of tackle used (65%), taking place at a rate of 80.47 ± 15.44 times per match, followed by the side-on tackle (24%), at an average of 29.19 ± 10.82 times per match. The tackle from behind accounted for the least tackles (11%), at an average of 13.23 ± 5.72 times per match. For the number of tacklers needed one tackler was predominately used (66%) at a rate of 81.53 ± 16.87 times per match. This was followed by two tacklers (32%), at an average of 39.14 ± 9.43 times per match. Tackles involving 3 or more tacklers only occurred 270 times over the complete study, making up 2% of all tackles.

The comparison between legal and illegal tackles according to year, quarter, direction of tackle and number of tackler(s) for the Craven Week tournament is presented in Table 3.4. All the PIs revealed very large levels of practical significant differences in favour of legal tackles, except for tackles involving three tacklers (large practical significant difference) and four tacklers (small practical significant difference). The highest rate of legal tackles took place in 2012 (24%), at a rate of 135.81 ± 16.08 , and the lowest rate of legal tackles took place in 2014 (18%), at a rate of 108.85 ± 13.82 tackles per match. The highest rate of illegal tackles took place in 2011 (34%), at a rate of 2.38 ± 2.06 tackles per match. A low percentage of illegal tackles took place in 2013 (11%) and 2014 (10%), at a rate of 0.57 ± 0.98 and 0.55 ± 0.83 times per match, respectively. The largest level of practical significant difference was found in 2013 ($d = 13.94$), and the lowest level was found 2011 ($d = 11.26$), in favour of legal tackles.

Legal tackles were spread evenly across the four quarters. With quarter one (25%) and two (25%), averaging a similar 30.92 ± 7.57 and 30.04 ± 7.52 tackles per quarter respectively. Quarter four contained the most tackles (26%), at an average of 32.33 ± 9.28 tackles per quarter. Whereas quarter three contained the least tackles (24%), with an average of 28.96 ± 6.72 tackles per match. Illegal tackles took place predominantly in quarter two (29%) and four (29%), at a rate of 0.33 ± 0.74 and 0.33 ± 0.62 times in per quarter respectively. Quarter one (21%) and three (21%) accounted for the rest of the illegal tackles, at a rate of 0.24 ± 0.50 and 0.23 ± 0.51 illegal tackles per quarter respectively. The highest level of practical significant difference between legal and illegal tackles was found in quarter three ($d = 6.06$) and the least level of practical significant difference was found in quarter four ($d = 4.89$).

The front-on tackle was the most common legal tackle (65%), occurring at a rate of 79.72 ± 15.29 times per match. Legal side-on tackles (24%) as well as tackles from behind (11%), occurred at a rate of 39.05 ± 9.39 and 13.03 ± 5.58 times per match respectively. Illegal front-on tackles (66%) were most prevalent in terms of tackle direction, occurring at 0.76 ± 1.11

times per match respectively. Illegal tackles from behind (18%) as well as side-on tackles (16%), occurred at a rate of 0.20 ± 0.45 and 0.18 ± 0.39 times per match respectively. The front-on tackle revealed the biggest level of practical significant difference between legal and illegal front-on tackles ($d = 7.32$), whereas tackles from behind revealed the least ($d = 3.26$). Tackles involving one tackler accounted for the highest percentage of legal tackles (66%), at a rate of 80.48 ± 16.60 times per match. Tackles involving two tacklers (32%), occurred at a rate of 39.05 ± 9.39 times per match and tackles involving three tacklers (2%) made up for the fewest tackles, occurring 2.65 ± 2.58 times per match. Only seven tackles involving four tacklers were recorded during all tournaments. Tackles involving one tackler accounted for the highest percentage of illegal tackles (91%), at a rate of 1.04 ± 1.33 times per match. Tackles involving two tacklers made up 8% of illegal tackles and 1% was tackles involving three tacklers. No illegal tackles involving four tacklers were recorded throughout the study. Tackles involving one tackler also showed the highest level of practical significant difference between legal and illegal tackles ($d = 6.78$). The smallest level of practical significant difference was found when legal and illegal tackles involving four tacklers were compared to each other ($d = 0.38$), this is mainly due to the total number of tackles involving four tacklers in this study ($n = 7$).

Table 3.4: Comparison between legal and illegal tackles per year, quarter, tackle direction and number of tackler(s) during the Craven Week tournaments

Performance indicators	Legal				Illegal				Difference
	n	M ± SD	95% CI	%	n	M ± SD	95% CI	%	d
<i>Year</i>									
2011	1836	114.75 ± 14.43	1822 - 1846	15	38	2.38 ± 2.06	29 - 48	34	11.26 ^d (very large)
2012	2852	135.81 ± 16.08	2840 - 2860	24	25	1.19 ± 1.36	17 - 35	22	11.99 ^d (very large)
2013	2549	121.38 ± 12.52	2540 - 2554	21	12	0.57 ± 0.98	7 - 20	11	13.94 ^d (very large)
2014	2177	108.85 ± 13.82	2168 - 2182	18	11	0.55 ± 0.83	6 - 19	10	11.35 ^d (very large)
2015	2689	128.05 ± 14.59	2677 - 2697	22	27	1.29 ± 1.23	19 - 37	24	12.55 ^d (very large)
<i>Quarter</i>									
Quarter 1	3061	30.92 ± 7.57	2968 - 3156	25	24	0.24 ± 0.50	17 - 34	21	5.75 ^d (very large)
Quarter 2	2974	30.04 ± 7.52	2882 - 3068	25	33	0.33 ± 0.74	24 - 43	29	5.59 ^d (very large)
Quarter 3	2867	28.96 ± 6.72	2776 - 2960	24	23	0.23 ± 0.51	16 - 32	21	6.06 ^d (very large)
Quarter 4	3201	32.33 ± 9.28	3107 - 3297	26	33	0.33 ± 0.62	24 - 43	29	4.89 ^d (very large)
<i>Direction of tackle</i>									
Front-on	7892	79.72 ± 15.29	7789 - 7994	65	75	0.76 ± 1.11	65 - 84	66	7.32 ^d (very large)
Side-on	2921	29.51 ± 10.75	2830 - 3014	24	18	0.18 ± 0.39	12 - 27	16	3.88 ^d (very large)
From behind	1290	13.03 ± 5.58	1225 - 1358	11	20	0.20 ± 0.45	13 - 29	18	3.26 ^d (very large)
<i>Number of tacklers</i>									
1 tackler	7968	80.48 ± 16.60	7865 - 8070	66	103	1.04 ± 1.33	95 - 107	91	6.78 ^d (very large)

2 tacklers	3866	39.05 ± 9.39	3766 - 3967	32	9	0.09 ± 0.29	5 - 16	8	5.89 ^d (very large)
3 tacklers	262	2.65 ± 2.58	232 - 295	2	1	0.01 ± 0.10	0 - 6	1	1.45 ^c (large)
4 tacklers	7	0.07 ± 0.26	3 - 14	0	0	-	-	0	0.38 ^a (small)

Note: SD – standard deviation, M – mean, CI – confidence intervals, % - percentage; Note: Practical significance (Hopkins, 2011): ^asmall = practical significant difference between legal and illegal tackles ($d \geq 0.2$ and $d < 0.6$), ^bmoderate = practical significant difference between legal and illegal tackles ($d \geq 0.6$ and $d < 1.2$), ^clarge = practical significant difference between legal and illegal tackles ($d \geq 1.2$ and $d < 2.0$) and ^dvery large = practical significant difference between legal and illegal tackles ($d \geq 2.0$).

3.4. Discussion

There is limited available research concerning tackle characteristics of under 18 provincial schoolboy rugby in South Africa and world-wide, as most of the studies focus on injury incidence across different levels of competition. The aim of the study was twofold firstly, to investigate the tackle characteristics and secondly, to determine whether these tackles were legal or illegal between the 2011 - 2015 Craven Week rugby tournaments.

The current study revealed a total of 12216 tackles, at an average of 123 tackles per game. The most tackles per match were completed in 2012, averaging 137 tackles per match, while the least tackles per match was in 2014, which averaged 109 tackles per match. Of the total tackles 99% were considered legal, leaving 1% of tackles being illegal. Most of the tackles were front-on (65%).

The findings of the current study were compared to the average number tackles across different levels of competition in Table 3.5. The number of tackles in the current study is similar to the study by Hendricks *et al.* (2014), which revealed 116 tackles per match in the Super 14 rugby competition. Van Rooyen *et al.* (2014) revealed an average of 165 tackles in the Six Nations, 141 tackles in the Tri-Nations and 156 tackles in the Rugby World Cup tournaments. However, other studies showed an average of 200 tackles during senior English premiership rugby matches (Fuller *et al.*, 2010), 270 tackles in the Bledisloe Cup (Quarrie & Hopkins, 2007) and 203 tackles in senior professional rugby (Quarrie & Hopkins, 2008). The large difference between the studies could be attributed to the tackle definition used in the study, the analysis of different competitions and the level of competitions. Senior rugby matches take place over 80 minutes, whereas schoolboy matches (Craven Week) are only 70 minutes running time; this 10-minute difference could somewhat account for the difference in the number of tackles per match. McIntosh *et al.* (2010) and Burger *et al.* (2016) revealed that in contrast to youth players, senior elite players executed complete tackles more frequently, whereas missed or broken tackles were more frequent in the schoolboy players. They found that younger players engaged in more passive tackles and tended to stay on their feet more than experienced players. Therefore, the higher number of match tackles for elite player could be attributable to higher number of tackle attempts in comparison to schoolboy rugby players.

Table 3.5 Average tackles per match across different levels of competition

Authors	Level of competition	Average tackles per match
Current study	Under 18 Provincial schoolboy	123
Hendricks <i>et al.</i> (2014)	Super 14	116
	6 Nations	165
Van Rooyen <i>et al.</i> (2014)	Tri-nations	141
	Rugby World cup	156
Fuller <i>et al.</i> , (2010)	Senior English Premiership	200
Quarrie and Hopkins, (2007)	Bledisloe Cup	270
Quarrie and Hopkins, (2008)	Senior professional rugby	203

The number of tackles were evenly distributed across all four quarters, with the fourth quarter having slightly more tackles in comparison to the third quarter. A possible reason for more tackles completed in the fourth quarter could be due to the score line in the match and that the players were doing everything they could to ensure a win for their team, after realising time is almost over and in turn keeping the ball to try and score more points, leading to more tackles being made to try and win the ball. Slightly more tackles in the fourth quarter could also be attributable to the players trying to keep the ball in play after the 70 minutes to score more points to win the match, which in turn would lead to more tackles. The onset of fatigue towards the end of the match may lead to a poorer tackle technique and decrease in the effectiveness of the tackle, which in turn would lead to more tackle attempts having to be made in order to stop the opposition from scoring points (Van Rooyen *et al.*, 2014).

The current study found that the front-on tackle predominated, making up 65% of all tackles, followed by the side-on tackle (24%) and tackle from behind (11%). The findings were different to that of Fuller *et al.* (2007) (front-on 31.4%, side-on 51.5% and from behind 17%) in English premiership rugby and Van Rooyen *et al.* (2014) (front-on 27% (± 13), side-on 53% (± 8.4) and from behind (21% (± 14)) in Six nations, Tri-Nations and Rugby World Cup tournaments. However, it was comparable to the study of Quarrie and Hopkins (2008); (front-on 59% (± 14), side-on 35% (± 8), and from behind 5% (± 3)) in senior professional rugby, as well as Posthumus and Viljoen (2008). Van Rooyen *et al.* (2014) found that effective tackles were more likely to be completed when the tackler entered the tackle from either front or side-

on position. A possible reason for more front and side-on tackles could be due to proper coaching and implementation of education programmes at school level which focused on the front-on and side-on tackle technique and safety during training (Posthumus & Viljoen, 2008; Hendricks & Lambert, 2010).

Most of the tackles completed in this study were done by 1 tackler (66%), very rarely was a tackle completed composed of 3 or more tacklers (2%). This could be attributable to improved tackle technique of players therefore the contact situation only required one tackler instead of two or more to complete the tackle. The study of Quarrie and Hopkins (2008) revealed that 49% of tackles were completed by one tackler, and two tacklers were used 41% of the time in senior professional rugby in New Zealand. Senior elite rugby was observed to have more multiplayer tackles than the other levels, which leads to an increase in the force of the tackle (McIntosh *et al.*, 2010), this could be due to the defensive systems used by the different teams. However, as in the study by Vahed *et al.* (2016), the tackle involving 1 tackler is the most common tackle event during the South African Currie Cup competition making up more than 50% of the match tackles. This could be due to the fact that one-on-one defence is better suited and would therefore not create a player overload elsewhere on the field for the attacking team.

99% of the tackles, across the 5 years of Craven Week, were legal, whereas only 1% were deemed as illegal according to the analysis of the matches. An amount of 113 illegal tackles were observed in 5 years of Craven Week rugby tournaments. A high percentage of illegal tackles took place in 2011 (34%), with the least amount of illegal tackles taking place in 2013 (11%) and 2014 (10%). Most illegal tackles took place in quarter two (29%) and quarter four (29%). Most of the illegal tackles took place in the front-on (66%) direction, followed by tackles from behind (18%) and side-on tackles (16%). Almost all illegal tackles involved one tackler (91%). Illegal tackles are considered dangerous; this is extremely concerning and is in line with what Fuller *et al.* (2007), and Roberts *et al.* (2015), found. Fuller *et al.* (2007) found that illegal tackles were a lot less common but were 70% more likely to result in an injury in comparison to a normal tackle. Roberts *et al.* (2015), found that collision tackles (illegal tackles involving a shoulder charge) had an extremely high propensity for injury, 15 injuries/ per 1000 events, in comparison to any other event. The risk associated with this event is recognised within Law 10.4 and to discourage players from engaging in illegal tackles, tacklers are often sent off the field of play for a short period or the entire match (depending on the severity and intent) (Sarembock, 2014; WR, 2016).

3.5. Conclusion

This study provides insight into the tackle characteristics and legal and illegal tackling occurring in under 18 provincial schoolboy rugby players in South Africa. In conclusion, the study firstly revealed that an average of 123 tackles were completed per match and was fairly evenly spread out across the four quarters of the match. Most of the legal, as well as the illegal tackles, took place from the front-on direction and involved one tackler, which is consistent with other studies. Although almost all of the tackles throughout the study were classified as legal, the small number of illegal tackles is still an area of concern as they are more likely to result in an injury in comparison to a normal tackle. Illegal tackles were more prevalent just before half time and the end of the game, this is consistent with what was revealed in Van Rooyen *et al.* (2014). While an elimination of illegal tackles in rugby is unlikely, continued research in this area is essential to providing a background for the development of effective education, evaluation and prevention strategies. Based on the findings, specific conditioning programmes to reduce the effects of fatigue and emphasising safe and effective playing techniques should be structured with the goal of reducing illegal tackles. Further research is required to assess if illegal tackle events were sanctioned by the referees, this is of extreme importance in order to make the game safer across all levels during match-play.

3.6. Acknowledgement

The authors would like to thank the Division of Exercise Science and Sports Medicine (ESSM) video analysis department at the University of Cape Town for providing the match videos, the referee coach and referees of the SARefs Academy for assisting with the inter-rater reliability coding and Prof Daan Nel of the Centre for Statistical Consultation, Stellenbosch University, for assisting with the statistical analysis.

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CHAPTER FOUR

RESEARCH ARTICLE TWO:

**SANCTIONING AND NON-SANCTIONING OF ILLEGAL RUGBY
TACKLES DURING THE 2011-2015 UNDER 18 CRAVEN WEEK
TOURNAMENT**

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

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Sanctioning and non-sanctioning of illegal rugby tackles during the 2011-2015 under 18 Craven Week tournament

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Sanctioning and Non-Sanctioning of Illegal Rugby Tackles during the 2011-2015 under 18 Craven Week

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Abstract

The tackle event has been identified as the most common contact event in a game of rugby. The aim of this study was to investigate factors associated with referees correctly sanctioning illegal tackles during the 2011 – 2015 under 18 Craven Week tournament. 99 matches were recorded and analysed using EncodePro analysis software, according to the set performance indicators. 113 illegal tackles were recorded. An average of just over one illegal tackle per game was observed, with 72% being high tackles. Twenty nine percent of the illegal tackles took place in quarter two and four respectively. Illegal tackles mainly took place from the front-on direction (66%) and involved one tackler (91%). 67 (59%) illegal tackles were not sanctioned by the referees. A high percentage of high tackles (65%) and dangerous charging tackles (67%) were not sanctioned by the referee. 91% of tackles involving one tackler were not sanctioned. This is an area of concern for coaches, players and referees as illegal tackles have the highest propensity for injury in comparison to any other contact event. If referees are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced. Since dangerous tackles are illegal the data from this study reinforces the importance of coaching correct tackling technique, correcting player behaviour, and continued strict enforcement of penalising illegal tackles.

Keywords: Tackles, rugby union, illegal tackles, referee, sanctioning

4.1. Introduction

Rugby carries the highest risk of injury in comparison to other contact sports regardless of the injury definition used, with the tackle accounting for the highest injury event (Fuller *et al.*, 2010). The tackle event has been identified as the most common contact event in a game of rugby and the total number of tackles per game has increased by approximately 50% over the years. The high impact and physical nature of the tackle during a rugby match places the tackler(s) and ball carrier at risk of injury (Hendricks & Lambert, 2010; Sarembock, 2014). Through the change in laws the game is constantly evolving into more of a running game with less stoppages and more ball in play time. Meaning that the amount of tackles carried out in

rugby matches will not decrease, therefore efforts to reduce injuries in contact events should focus on how events are carried out and managed by the players. It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Sarembock, 2014; Roberts, Trewartha, England & Stokes, 2015).

Various rugby safety programmes world-wide such as BokSmart (South Africa), SmartRugby (Australia) and Rugby Ready (World Rugby) have tried to make the game safer through education based initiatives and guidelines for players, coaches and referees. The Craven Week is an annual under 18 provincial rugby schoolboy tournament, organised by the South African Rugby Union. It is an elite merit based tournament, not only for players but also referees. The findings of this study can assist World Rugby and governing bodies of rugby safety programmes, referees and referee coaches and trainers through information on tackle characteristics and sanctioning of tackles by match referees. This information could then be used for further studies in order to help make the tackle situation safer at schoolboy level and possibly transfer it across all levels of rugby. Referee's strict enforcement of the laws make sure the game is as safe as possible.

Referees play an integral part in professional team sports, as they have to consider numerous sources of information, make rapid decisions, and contend with commentators who scrutinize their accuracy thanks to improving broadcasting technology (Mascarenhas, Collins, Mortimer & Morris, 2005b). Furthermore, they are responsible for maintaining a safe environment for the players, affording proper flow and control during the game, as well as ensuring fair play and a just result in accordance with the laws and the spirit of the game (Mascarenhas, Collins & Mortimer, 2005a; Kraak, Malan & Berg, 2011b; World Rugby, 2016). According to Mascarenhas *et al.* (2005b) the magnitude of success as a referee is dependent on their ability to accurately apply the law. They also play a major role in carrying out injury prevention programmes put forward by various rugby unions (Gianotti, Quarrie & Hume, 2009). In order to decrease the risk of injury it is of utmost importance to coach correct technique, correct player behaviour and continue the strict enforcement of penalising illegal tackles (Roberts *et al.*, 2015).

The tackles shown in (Table 4.1) are deemed illegal and can result in conceding a penalty, penalty and yellow card or penalty and red card (WR, 2016). Laws surrounding the tackle situation, with regards to dangerous tackles, have become stricter so as to reduce the risk of injury during the tackle event (Posthumus & Viljoen, 2008; Quarrie & Hopkins, 2008;

Murray, Murray & Robson., 2014). Illegal tackles are dangerous and have been associated with serious head, neck injuries or spinal injury (Sinibaldi & Smith, 2007). According to Fuller, Brooks, Cancea, Hall & Kemp (2007) illegal tackles are a lot less common in rugby matches but are 70% more likely to result in an injury in comparison to a legal tackle. Roberts *et al.* (2015), found that collision tackles (illegal tackles involving a shoulder charge) had an extremely high propensity for injury, 15 injuries/ per 1000 events, in comparison to any other event. The risk associated with this event is recognised within Law 10.4. To discourage players from engaging in illegal tackles, tacklers are often sent off the field of play for a short period or the entire match (depending on the severity and intent) (Sarembock, 2014). However, Fuller *et al.* (2007), found that despite the injury concerns surrounding tackles, referees penalised few illegal tackles as dangerous play.

The first step in injury prevention is surveillance (Van Mechelen & Hlobil, 1992). Surveillance of legal and illegal tackles and the sanctions imposed by referees will help identify whether the referees are actually enforcing the law according to the law book, which will lead to the creation and implementation of further prevention strategies. This is an ongoing process, which will help make the sport safer for all involved. Although referees have this critical role in injury prevention through enforcing laws, few studies have assessed whether they are doing this. Based on this background the purpose of this study was to investigate factors associated with referees correctly sanctioning illegal tackles during the 2011 – 2015 under 18 Craven Week tournament.

4.2. Methodology

Sample population

Video recordings of the South African under 18 Craven Week rugby tournament (N = 99) during the 2011-2015 period were used for the purpose of the study.

Video recordings

The television video recordings of the under 18 Craven Week matches were supplied by the Division of Exercise Science and Sports Medicine video analysis department, University of Cape Town. The 99 recorded matches were analysed using the EncodePro® video analysis software package (South Africa, 2016). Ethical approval (SU-HSD-001220) was obtained from the Research Ethics Committee: Human Research of the Stellenbosch University.

Coding

Before the initial analysis commenced the primary researcher approached the SARefs Academy in Stellenbosch to assist with developing a golden standard according to the WR law book for assessing the tackle situation. Ninety-nine matches were analysed according to specific PIs using the EncodePro video analysis software (v2.99 e). The software allows an incident to be coded and appeared as a PIs. The primary researcher then coded the tackles during the match according to the PIs in Table 4.1. During the coding the primary researcher was at liberty to pause, rewind and watch the tackle footage in slow motion.

Performance indicators

In (Table 4.1) are the PIs analysed based on the purpose of the study.

Table 4.1: Performance indicators and definition

Performance indicators	Definition
Types of illegal tackle (WR, 2016)	High tackle - A player must not tackle (or try to tackle) an opponent above the line of the shoulders even if the tackle starts below the line of the shoulders. A tackle around the opponents head or neck is dangerous play.
	Stiff arm tackle - A player makes a stiff-arm tackle when using a stiff arm to strike an opponent.
	Early - Tackling a player before he has received the ball
	Late tackle – Tackling a player after he has released the ball.
	Playing the opponent without the ball - Except in a scrum, ruck or maul, a player who is not in possession of the ball must not hold, push or obstruct an opponent not carrying the ball. Also known as a no-arm tackle.
	Dangerous charging - A player must not charge or knock down an opponent carrying the ball without trying to grasp that player.
	Tackling the jumper in the air - A player must not tackle nor tap, push or pull the foot or feet of an opponent jumping for the ball in a lineout or in open play. A player must not tackle an opponent whose feet are off the ground
Sanctioning of illegal tackle (WR, 2016)	Tip tackle - Lifting a player from the ground and dropping or driving that player into the ground while that player's feet are still off the ground such that the players head and/or upper body come into contact with the ground is dangerous play.
	Whether the illegal tackle was sanctioned or not by the referee according to the World Rugby law book.
Time	Quarter 1: 0 – 17.5min

	<i>Quarter 2:</i> 17.5 - 35 min
	<i>Quarter 3:</i> 35 – 52.5 min
	<i>Quarter 4:</i> 52.5 - 70 min
Direction of tackle (Van Rooyen, Yasin & Viljoen, 2014)	<i>Front-on tackle</i> - The tackler tackles the front of the ball-carrier. <i>Side-on tackle</i> - The tackler tackled the ball-carrier laterally from either the right or left hand side. <i>Tackle from behind</i> - The tackler tackled the ball-carrier from behind.
Number of players involved	Number of players tackling the ball carrier

Reliability

The reliability of the coded tackles was tested using intra and inter-rater reliability. After all the matches were coded, the primary researcher coded 25% of the matches that were randomly selected by drawing game numbers from a hat. Inter-rater reliability was conducted by a national referee coach and two national panel referees from the SAREfs Academy in Stellenbosch re-coded all the matches according to the PIs in Table 4.1. The reliability of the intra and inter-rater reliability was determined by the Intraclass Correlation Coefficient (ICC) of the test and retest data. Intra and inter-rater agreement was interpreted as follows: poor (<0.20), fair (0.30-0.40), moderate (0.50-0.60), strong (0.70-0.95) and almost perfect (>0.95). The analysis showed the agreement between all the variables were almost perfect Table 3.2 and thus considered as very reliable.

Statistical Analysis

The Statistica Data Processing package (Statsoft Inc., 2013) was used to process the data. Descriptive statistics (means, standard deviations, percentages and 95% Confidence Intervals (CI)) were calculated. Cohen's d effect sizes (Thomas, Lochbaum, Landers, & He, 1997) were calculated, using the difference in means divided by the pooled standard deviation, to characterize the differences between sanctioning and non-sanctioning of the illegal tackles. 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).

4.3. Results

Table 4.2 presents the descriptive statistics for illegal tackles across the five years of Craven Week tournaments. During this period a total of 113 illegal tackles occurred at an average rate

of 1.14 ± 1.44 tackles per match. The largest number of illegal tackles took place in 2011, with an average of 2.38 ± 2.06 . In 2015 (24%) and 2012 (22%) illegal tackles occurred at a rate of 1.29 ± 1.23 and 1.19 ± 1.36 tackles per match respectively. A major decrease in illegal tackles was noted in 2013 (11%) and 2014 (10%) with only 0.57 ± 0.98 and 0.55 ± 0.83 illegal tackles taking place per match respectively. Most of the illegal tackles took place in quarter two (29%) and four (29%), at a rate of 0.33 ± 0.74 and 0.33 ± 0.62 illegal tackles per match respectively. Whereas quarter one (21%) and three (21%) accounted for slightly lower proportions of illegal tackles, at an average of 0.24 ± 0.50 and 0.23 ± 0.51 , tackles per match respectively.

Illegal tackles from the front-on (66%) direction were most prevalent, occurring at an average of 0.76 ± 1.11 times per match. This was followed by illegal tackles from behind (18%) and side-on (16%), taking place 0.20 ± 0.45 and 0.18 ± 0.39 times per match respectively. Tackles involving one tackler accounted for the highest percentage of illegal tackles (91%), at a rate of 1.04 ± 1.33 times per match. Tackles involving two tacklers made up 8% of illegal tackles, averaging 0.09 ± 0.29 times per match, and the final 1% was made by one illegal tackle involving three illegal tacklers. No illegal tackle containing four tacklers was found. Most illegal tackles were classified as high tackles (72%), with the next highest illegal tackle being the tip tackle (11%) and the late tackle (6%). High tackles were occurring at an average of 0.81 ± 1.08 times per match, which is a fair amount more than the next highest illegal tackle being tip tackles, at a rate of 0.12 ± 0.38 times per match. The late tackle (6%) and tackling the jumper in the air (4%) averaged 0.07 ± 0.32 and 0.05 ± 0.22 times per match, respectively. Very few illegal tackles involved dangerous charging (0.03 ± 0.22), stiff arm tackles (0.03 ± 0.17) and early tackles (0.02 ± 0.14), they only accounted for 13 (8%) of the 113 illegal tackles. Between 2011 and 2015, only 41% of illegal tackles were sanctioned at an average of 0.88 ± 0.46 illegal tackles per match. Leaving 59% of illegal tackles not being sanctioned by the referees, this amounts to $1.03 (\pm 0.68)$ illegal tackles that aren't sanctioned per match.

Table 4.2: Descriptive statistics for illegal tackles of the Craven Week tournament

Performance indicators	N = 99			
	n	M ± SD	95% CI	%
Total number of illegal tackles				
Illegal tackles	113	1.14 ± 1.44	109 - 113	-
Years				
2011	38	2.38 ± 2.06	29 - 48	34
2012	25	1.19 ± 1.36	17 - 35	22
2013	12	0.57 ± 0.98	7 - 20	11
2014	11	0.55 ± 0.83	6 - 19	10
2015	27	1.29 ± 1.23	19 - 37	24
Quarters				
Quarter 1	24	0.24 ± 0.50	17 - 34	21
Quarter 2	33	0.33 ± 0.74	24 - 43	29
Quarter 3	23	0.23 ± 0.51	16 - 32	21
Quarter 4	33	0.33 ± 0.62	24 - 43	29
Direction of tackle				
Front-on	75	0.76 ± 1.11	65 - 84	66
Side-on	18	0.18 ± 0.39	12 - 27	16
From behind	20	0.20 ± 0.45	13 - 29	18
Number of tacklers				
1 tackler	103	1.04 ± 1.33	95 - 107	91
2 tacklers	9	0.09 ± 0.29	5 - 16	8
3 tacklers	1	0.01 ± 0.10	0 - 6	1
4 tacklers	0	0 ± 0	0 - 4	0
Type of illegal tackle				
High tackle	81	0.81 ± 1.08	71 - 89	72
Tip tackle	12	0.12 ± 0.38	7 - 20	11
Late tackle	7	0.07 ± 0.32	3 - 14	6
Tackling the jumper in the air	5	0.05 ± 0.22	2 - 11	4

Dangerous charging	3	0.03 ± 0.22	1 - 8	3
Stiff arm tackle	3	0.03 ± 0.17	1 - 8	3
Early tackle	2	0.02 ± 0.14	1 - 7	2
Sanctioning of illegal tackles				
Sanctioned	46	0.88 ± 0.46	36 - 56	41
Not sanctioned	67	1.03 ± 0.68	57 - 77	59

Note: n – total number, M – mean, SD – standard deviation, CI – confidence intervals, % - percentage

Table 4.3 and Table 4.4 is a comparison between sanctioning and non-sanctioning of illegal tackles during the 2011 to 2015 Craven Week tournaments. A small practically significant difference was found between sanctioned and non-sanctioned tackles in 2011 ($d = 0.30$), 2013 ($d = 0.27$), 2014 ($d = 0.57$) and 2015 ($d = 0.28$). A moderate practical significant difference was revealed in 2012 ($d = 0.86$), 84% of illegal tackles were not sanctioned, at an average of 1 ± 1.30 illegal tackles per match. In 2011, 58% of illegal tackles were not sanctioned by the referee. 2013 (67%) and 2015 (59%) were the only years where there was a higher percentage of illegal tackles that were sanctioned by the referees.

No practically significant difference was revealed between the four quarters of the match. In quarter one, the referees sanctioned 48% of illegal tackles in comparison to the 52% that were non-sanctioned. In quarter two, 41% of illegal tackles were sanctioned in comparison to 59% that were non-sanctioned. In quarter three, 35% of illegal tackles were sanctioned in comparison to 65% that were non-sanctioned. In quarter four, 41% of illegal tackles were sanctioned in comparison to 59% that were non-sanctioned.

A small practically significant difference ($d = 0.35$) was revealed in the sanctioning of high tackles, 65% of high illegal tackles were non-sanctioned by the referee at a rate of 0.53 ± 0.84 high tackles per match. Dangerous charging was non-sanctioned by the referee 67% of the time. Sanctioning of illegal tackles by referees, in comparison to non-sanctioning, was more common in the tip tackle (67%), late tackle (71%) and tackling of jumper in the air (80%). Very few stiff arm ($n = 3$) and early tackles ($n = 2$) took place, with all of them being non-sanctioned by the referee and leading to a small practically significant difference. Sanctioned front-on tackles (72%) were the most common sanctioned illegal tackle, occurring at a rate of 0.33 ± 0.73 times per match. The side-on (15%) and from behind (13%) sanctioned illegal tackle occurred at rates of 0.07 ± 0.26 and 0.06 ± 0.24 times per match respectively. The non-

sanctioned front-on (63%) illegal tackle was most common, averaging 0.42 ± 0.78 times per match. Non-sanctioned illegal tackles from behind (21%) and the side (16%), occurred at a rate of 0.14 ± 0.38 and 0.11 ± 0.32 times per match respectively. A small practically significant difference was found in tackles from behind ($d = 0.25$) in favour of non-sanctioned illegal tackles. Sanctioned illegal tackles involving one tackler (91%) was the most common sanctioned illegal tackle, occurring at a rate of 0.42 ± 0.82 times per match. Illegal sanctioned tackles involving two tacklers make up the remaining 9%, averaging 0.04 ± 0.20 times per match. No sanctioned illegal tackles involving three or four tacklers were revealed in the study. Tackles involving one tackler (91%) was the most common non-sanctioned illegal tackle, occurring at a rate of 0.62 ± 0.98 times per match. Illegal non-sanctioned tackles involving two tacklers make up 7%, averaging 0.05 ± 0.22 times per match. Illegal non-sanctioned tackles involving three tacklers make up the remaining 2%, averaging 0.01 ± 0.10 times per match. No non-sanctioned illegal tackles involving four tacklers were revealed in the study. A small practically significant difference was found in illegal tackles involving one tackler ($d = 0.22$) in favour of non-sanctioned illegal tackles.

Table 4.3: Comparison between sanctioning and non-sanctioning of illegal tackles per year and quarter during the 2011 – 2015 Craven Week tournaments

Performance indicators	Sanctioning				Non-sanctioning				Cohens Effect Sizes
	n	M ± SD	95% CI	%	n	M ± SD	95% CI	%	d-value
	Year								
2011	16	1 ± 1.21	10 - 23	42	22	1.38 ± 1.36	15 - 30	58	0.30 ^a (small)
2012	4	0.19 ± 0.40	2 - 9	16	21	1 ± 1.30	14 - 29	84	0.86 ^b (moderate)
2013	8	0.38 ± 0.92	4 - 14	67	4	0.19 ± 0.40	2 - 10	33	0.27 ^a (small)
2014	2	0.10 ± 0.45	1 - 7	18	9	0.45 ± 0.76	5 - 16	82	0.57 ^a (small)
2015	16	0.76 ± 1.00	10 - 23	59	11	0.52 ± 0.75	6 - 18	41	0.28 ^a (small)
	Quarter								
Quarter 1	10	0.10 ± 0.33	6 - 16	48	11	0.11 ± 0.31	6 - 18	52	0.03
Quarter 2	14	0.14 ± 0.42	9 - 21	41	20	0.20 ± 0.53	14 - 28	59	0.13
Quarter 3	9	0.09 ± 0.40	5 - 15	35	17	0.17 ± 0.42	11 - 25	65	0.19
Quarter 4	13	0.13 ± 0.39	8 - 20	41	9	0.19 ± 0.48	13 - 27	59	0.14

Note: Practical significance (Hopkins, 2011): ^asmall = practical significant difference sanctioning and non-sanctioning of illegal tackles ($d \geq 0.2$ and $d < 0.6$), ^bmoderate = practical significant difference between sanctioning and non-sanctioning of illegal tackles ($d \geq 0.6$ and $d < 1.2$), ^clarge = practical significant difference sanctioning and non-sanctioning of illegal tackles ($d \geq 1.2$ and $d < 2.0$) and ^dvery large = practical significant difference sanctioning and non-sanctioning of illegal tackles ($d \geq 2.0$).

Table 4.4: Comparison between sanctioning and non-sanctioning of illegal tackles for the type of illegal tackle, direction of tackle and number of tackler(s) during the 2011 – 2015 Craven Week tournaments

Performance indicators	Sanctioning				Non-sanctioning				Cohens Effect Sizes
	n	M ± SD	95% CI	%	n	M ± SD	95% CI	%	d-value
Type of illegal tackle									
High tackle	28	0.28 ± 0.59	21 - 34	35	53	0.53 ± 0.84	46 - 58	65	0.35 ^a (small)
Tip tackle	8	0.08 ± 0.30	4 - 14	67	4	0.04 ± 0.19	2 - 10	33	0.16
Late tackle	5	0.05 ± 0.30	2 - 11	71	2	0.02 ± 0.14	1 - 7	29	0.13
Tackling the jumper in the air	4	0.04 ± 0.19	2 - 9	80	1	0.01 ± 0.10	0 - 5	20	0.19
Dangerous charging	1	0.02 ± 0.20	0 - 5	33	2	0.04 ± 0.19	1 - 7	67	0.06
Stiff arm tackle	0	0 ± 0	0 - 4	0	3	0.03 ± 0.17	1 - 8	100	0.25 ^a (small)
Early tackle	0	0 ± 0	0 - 4	0	2	0.02 ± 0.14	1 - 7	100	0.20 ^a (small)
Direction of tackle									
Front-on	33	0.33 ± 0.73	26 - 38	72	42	0.42 ± 0.78	34 - 49	63	0.12
Side-on	7	0.07 ± 0.26	3 - 13	15	11	0.11 ± 0.32	6 - 18	16	0.14
From behind	6	0.06 ± 0.24	3 - 12	13	14	0.14 ± 0.38	9 - 21	21	0.25 ^a (small)
Number of tacklers									
1 tackler	42	0.42 ± 0.82	37 - 44	91	61	0.62 ± 0.98	55 - 64	91	0.22 ^a (small)
2 tacklers	4	0.04 ± 0.20	2 - 9	9	5	0.05 ± 0.22	2 - 11	7	0.05
3 tacklers	0	-	-	-	1	0.01 ± 0.10	0 - 5	2	0.14

Note: Practical significance (Hopkins, 2011): ^asmall = practical significant difference sanctioning and non-sanctioning of illegal tackles ($d \geq 0.2$ and $d < 0.6$), ^bmoderate = practical significant difference between sanctioning and non-sanctioning of illegal tackles ($d \geq 0.6$ and $d < 1.2$), ^clarge = practical significant difference sanctioning and non-sanctioning of illegal tackles ($d \geq 1.2$ and $d < 2.0$) and ^dvery large = practical significant difference sanctioning and non-sanctioning of illegal tackles ($d \geq 2.0$)

4.4. Discussion

This is the first rugby study to investigate the sanctioning and non-sanctioning of illegal tackles at under 18 provincial schoolboy rugby level during match-play. The aim of the study was to investigate the sanctioning and non-sanctioning of illegal rugby tackles by referees during the 2011-2015 Craven Week tournament. A total of 113 illegal tackles were revealed, at an average of one illegal tackle per match. Illegal tackles mainly took place front-on (66%). Almost all illegal tackles involved one tackler (91%) and most (91%) of these tackles were non-sanctioned by the referee. Most (72%) of these illegal tackles were high tackles, this was followed by the tip tackle (11%). A large amount of illegal tackles (59%) were not sanctioned by the referees. 2012 was revealed as being the worst year in terms of sanctioning, with 84% of illegal tackles not being sanctioned by the referee. This is a major area of concern as illegal tackles are dangerous and have a high injury prevalence.

Since professionalism in rugby (Malcolm, Sheard & Smith, 2004) there have been numerous changes in laws and player preparation (Quarrie & Hopkins, 2007). Such changes have apparently contributed to a faster pace of play, increased ball-in play time and level of physical contact (Quarrie & Hopkins, 2007; Austin, Gabbett & Jenkins, 2011). This would suggest that the physical demands placed on the referees have also increased. With the increase in the demands of the game, the referee needs to attain a much higher level of fitness than in the past (*Die Burger*, 2010; Suarez-Arrones *et al.*, 2013). Suarez-Arrones *et al.* (2013) revealed that physical performance, accuracy, and velocity of decision making of players and referees could be altered by the development of exercise-induced fatigue. Therefore, the ability of the referee in rugby to keep up with play to be in a good position is critical in allowing correct decisions to be made (Kraak, Malan, & Berg, 2011a; Suarez-Arrones *et al.*, 2013). Another study by Emmonds *et al.* (2015) on the movement demands of European Super League rugby referees and the influence on penalty accuracy, found that the correct decision was awarded 74% of the time with the lowest penalty accuracy occurring in the last 15 minutes of the match (67%). Suarez-Arrones *et al.* (2013) and Emmonds *et al.* (2015) assessed all penalty decisions, whereas the current study only focused on the sanctioning of illegal tackles. However, this study didn't show any statistical or practical significant difference in the sanctioning of illegal tackles in the fourth quarter. Throughout all four quarters non-sanctioned illegal tackles were more prevalent in comparison to sanctioned illegal tackles.

In this study the high tackle, which was the most frequently occurring illegal tackle, revealed a practical significance in favour of non-sanctioning and was found to not be sanctioned by the referee 65% of the time. Studies by Fuller *et al.* (2007), Sinibaldi and Smith (2007) and Roberts *et al.* (2015) found that high tackles put the ball carrier at a significant risk of cervical spine injury. Another study that focused on New Zealand and English rugby found that the ball carriers were at highest risk from tackles to the head-neck region (Fuller *et al.*, 2010; McIntosh, Savage, McCrory, Frechede, & Wolf, 2010). A small practical significance was found in stiff-arm ($d = 0.25$) and early ($d = 0.20$) tackles. However, this is attributable to the low number of stiff-arm and early tackles completed during the 5 years and the fact that 100% of the tackles were not sanctioned by the referee. A study by Murray *et al.* (2014) found that the WR 'zero tolerance' approach to tip tackles in 2011, has since led to a decrease in the rate of tip tackles across different levels of competition; this was also evident in this study. In this study the illegal tip tackle occurred 12 times, second in comparison to the 81 high tackles that occurred during the study. Although the tip-tackle, late tackle and tackling the jumper in the air was sanctioned by the referees, 67%, 71% and 80% of the time respectively. Hendricks and Lambert (2010) and Roberts *et al.* (2015) found that illegal collision tackles carry the greatest incidence and severity of injury compared with all other contact events in English community club rugby. Another study conducted by Fuller *et al.* (2007) revealed that illegal collision tackles were 70% more likely to result in injury in comparison to a legal tackle, in English Premiership rugby clubs. This is an area of concern, because this study revealed that dangerous charging occurred 3 times during the study and was only sanctioned once by the referee.

Rugby safety programmes are in place to decrease the risk of injury and make the game safer for all involved (Dunn, 2009; Gianotti *et al.*, 2009; Brown, 2011; Viljoen & Patricios, 2012; Patricios, 2014). The primary aim of these safety programmes is to provide rugby coaches, referees, players, and administrators with the correct knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby (Gianotti *et al.*, 2009; Brown, 2011; Viljoen & Patricios, 2012; Roberts *et al.*, 2015). Referees play a major role in carrying out injury prevention programmes, such as BokSmart and RugbySmart (Comstock & Fields, 2005; Gianotti *et al.*, 2009; Sinne & Fogel, 2013). Injury prevention programmes comment that the best way for ball carriers to reduce tackle injuries is to avoid tackles at speed and to keep the head/neck in the right position (Fuller *et al.*, 2008; Williams, Trewartha, & Kemp, 2013). However, it is not possible to avoid tackles

at all times, as they form an integral and important aspect of rugby, in terms of stopping an opponent's forward movement and gaining ball possession. It is essential, therefore, that referees protect ball-carriers by consistently penalizing illegal tackles, as these events are more likely to result in injury and are specifically identified in the laws of rugby as foul play (Sinibaldi & Smith, 2007; Fuller *et al.*, 2008; Roberts *et al.*, 2015; Burger *et al.*, 2016). Fuller *et al.* (2007), found that despite the injury concerns surrounding tackles, referees didn't always penalise illegal tackles as the law required them to do. A limitation in the study is that although video-based assessments provide valid examination of decision making performance, they do not replicate the physical, physiological, and psychological aspects of an actual match environment for the referee (Emmonds *et al.*, 2015).

4.5. Conclusion

This study provides insight into the sanctioning (and non-sanctioning) of illegal rugby tackles by referees, occurring in under 18 provincial schoolboy rugby players during Craven Week tournaments in South Africa. Due to the evolving nature of the game the amount of tackles carried out in rugby matches will not decrease, therefore focus should be placed on how tackles are carried out by players and managed by referees during the match. Focus should be placed on all illegal tackles, however; special focus should be placed on late tackles and dangerous charging, as they were found less likely to be sanctioned by the referee. It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Sinibaldi & Smith, 2007; Gianotti *et al.*, 2009; Viljoen & Patricios, 2012; Roberts *et al.*, 2015; Burger *et al.*, 2016). If referees are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced. Since illegal tackles are dangerous the data from this study reinforces the importance of coaching correct technique, correcting player behaviour, and continued strict enforcement of penalising illegal tackles. Referees taking a zero tolerance approach to illegal tackles is likely to reduce injury risk (Gianotti *et al.*, 2009; Viljoen & Patricios, 2012; Roberts *et al.*, 2015). Due to limited research on investigating the sanctioning and non-sanctioning of illegal tackles by the referee, it is important to expand the area of research so that the game is safer for all involved in order to assist a decrease in injury incidence.

4.6. Acknowledgements

The authors would like to thank the Division of Exercise Science and Sports Medicine video analysis department for providing us with the match videos, the referee coach and referees of the SARefs Academy for assistance with inter-rater reliability coding and Prof Daan Nel for assisting with the statistical analysis.

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CHAPTER FIVE

SUMMARY AND CONCLUSIONS

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).

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5.1. Summary

A relatively small amount of published literature exists on tackling characteristics of schoolboy rugby and even less as to how illegal tackles are sanctioned by referees, especially in a South African context. Therefore, this study sought to add knowledge to rugby in South Africa and world-wide in an attempt to decrease the gap in the literature.

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

The theoretical background (Chapter Two) focused on the background of rugby, schoolboy rugby in South Africa, the role of rugby safety programmes and their effect on injury prevention, role of referee and performance analysis. Next, the tackle technique was discussed, along with the laws surrounding the tackle as well as how the tackle is coached across different levels.

Chapter Three is in a research article format entitled: *Investigation into tackle characteristics during the 2011-2015 under 18 Craven Week tournaments.*

Chapter Four is in a research article format entitled: *Sanctioning and non-sanctioning of illegal rugby tackles during the 2011-2015 under 18 craven week tournaments.*

In summary, this study highlighted the fact that the tackle is extremely common, taking place an average of 123 times per match. These tackles were evenly distributed across the four quarters of the match. The front-on tackle was the most common direction of tackle, which correlates with other studies (Posthumus & Viljoen, 2008; Quarrie & Hopkins, 2008) and supports the idea that Van Rooyen *et al.* (2014) had in saying that the front-on tackle is the most effective tackle. This study found that most tackles took place with one tackler. 99% of the tackles were found to be legal, however an average of one tackle per game was revealed to be illegal. Most illegal tackles occurred in the front-on (66%) direction, and involved one tackler (91%). Most of the illegal tackles took place in quarter two (29%) and four (29%), this highlights fatigue, leading to poorer tackling technique and decision making. This is an area of concern as illegal tackles are also dangerous and could result in injury (Fuller *et al.*, 2007; Sinibaldi & Smith, 2007; Roberts *et al.*, 2015). The high tackle was the most prevalent illegal

tackle, making up 72% of all illegal tackles. On average 59% of illegal tackles were not sanctioned by the referees. Illegal tackles were especially prevalent in 2012 where 84% were not sanctioned. A high percentage of high tackles (65%), dangerous charging tackles (67%) and tackles involving one tackler (91%) were not sanctioned by the referee. This is an area of concern for the different role players in rugby as they have the highest propensity for injury in comparison to any other contact events. Since illegal tackles are dangerous the data from this study reinforces the importance of coaching correct technique, correcting player behaviour, and continued strict enforcement of penalising illegal tackles.

5.2. Conclusions

The conclusions drawn from this research study were presented in accordance to the set aims in Chapter One.

Research Article 1: Investigation into tackle characteristics during the 2011-2015 under 18 craven week tournament

The study firstly highlighted the fact that the tackle is extremely common, taking place an average of 123 times per match. These tackles were evenly distributed across the four quarters during the match. The front-on tackle is the most common direction of tackle, which relates with other studies (Posthumus & Viljoen, 2008; Quarrie & Hopkins, 2008) and supports the idea that Van Rooyen *et al.* (2014), had in saying that the front-on tackle is the most effective tackle. This study found that most tackles took place with one tackler. In this study 99% of the tackles were found to be legal, however an average of one tackle per game was revealed to be illegal. Most illegal tackles occurred in the front-on (66%) direction, and involved one tackler (91%). Many of the illegal tackles took place in quarter two and four (29%) respectively, this may be attributable to fatigue, leading to poorer tackling technique and decision making in terms of field positioning. This could be noted as an area of concern as illegal tackles are also dangerous and could result in injury (Fuller *et al.*, 2007; Sinibaldi & Smith, 2007; Roberts *et al.*, 2015).

Research Article 2: Sanctioning and non-sanctioning of illegal rugby tackles during the 2011-2015 under 18 Craven Week tournaments

The study firstly revealed 113 illegal tackles, with the high tackle (72%) being the most common illegal tackle. Most of the illegal tackles took place in quarter two (29%) and four

(29%). Illegal tackles mainly took place from the front-on direction (66%) and involved one tackler (91%). A large amount (59%) of illegal tackles were not sanctioned by the referees, this was most prevalent in 2012 (84%). No significant difference was found, in sanctioning by the referee, between quarters. A high percentage of high tackles (65%), dangerous charging tackles (67%) and tackles involving one tackler (91%) were not sanctioned by the referee. This is an area of concern as illegal tackles have the highest propensity for injury in comparison to any other contact event. Due to the evolving nature of the game the amount of tackles carried out in rugby matches will not decrease, therefore focus should be placed on how tackles are carried out and managed by the players. It is imperative that existing laws are applied relating to illegal collision tackles given the high risk of injury for these events (Sinibaldi & Smith, 2007; Gianotti *et al.*, 2009; Viljoen & Patricios, 2012; Roberts *et al.*, 2015; Burger *et al.*, 2016). If referees are not enforcing the laws and prevention strategies, the effectiveness of injury prevention programmes will be reduced. Since dangerous tackles are illegal the data from this study reinforces the importance of coaching correct technique, correcting player behaviour, and continued strict enforcement of penalising illegal tackles. Taking a zero tolerance approach to illegal tackles is likely to reduce injury risk (Gianotti *et al.*, 2009; Viljoen & Patricios, 2012; Roberts *et al.*, 2015).

5.3. Limitations

Certain limitations regarding this study can be indicated:

- Firstly, this study focused on the PIs surrounding the tackle in the under 18 provincial schoolboy South African Craven Week tournament. The findings may therefore not be beneficial to other schoolboy tournaments. It would thus be ideal to analyse other schoolboy tournaments and investigate their tackle characteristics as they would provide a better understanding of schoolboy rugby in several countries, in both the northern and southern hemispheres.
- Secondly, this study only investigated the tackle of the provincial schoolboy rugby under 18 Craven Week tournament. The findings may not reflect the under-13 Craven Week or under-16 Grant Khomo tournament, or schoolboy rugby in general. It would therefore be ideal to investigate each level of the tournament to determine the possible differences in performance indicators surrounding the tackle, as well as the sanctioning of illegal tackles by the referee.

- The study never assessed any of the characteristics surrounding player positions. There may be a difference between playing positions in terms of the performance indicators mentioned in the study, as well as illegal tackles and referee sanctioning.

5.4.Future Research

The results from this study emphasised the importance of further research into the sanctioning and non-sanctioning of illegal tackles by the referees. Future studies should focus on the other schoolboy rugby tournaments in South Africa and other countries, as well as senior elite, club level, and schoolboy matches as well as the tackle characteristics of different positions. This could lead to improvements in training regimes, and safety and education programmes, for referees, players and coaches. Through preparing and educating players, as well as the referees, for the specific demands, in terms of the number of tackles per quarter, the direction of tackle and the number of tacklers, of the matches and tournaments. Studies should also focus on analysing the sanctioning of tackles in the English, European and New Zealand schoolboy competitions and determining whether there are differences between the different countries.

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APPENDIX A

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 instance, 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

APPENDIX B: EUROPEAN JOURNAL OF SPORT SCIENCE

Thank you for choosing to submit your paper to us. These instructions will ensure we have everything required so your paper can move through peer review, production and publication smoothly. Please take the time to read and follow them as closely as possible, as doing so will ensure your paper matches the journal's requirements. This journal uses ScholarOne Manuscripts (previously Manuscript Central) to peer review manuscript submissions. Complete guidelines for preparing and submitting your manuscript to this journal are provided below.

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Manuscript preparation

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- 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 excluding 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).
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- Each manuscript should have 3 to 6 keywords.
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- 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

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freely access the data in the public domain and replicate the analyses. Authors must explain the reason for the lack of ethical statement in the cover letter addressed to the Editor-in-Chief.

- For all manuscripts non-discriminatory language is mandatory. Sexist or racist terms must not be used.
- 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.
- 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. 23.5°, 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 ° 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 superfixes), 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 \pm). In tables and lists, the following is convenient (mean \pm s) or (\pm 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.
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