Tackling the Contact in Collision Sports: A Mixed-Methods Approach to Understanding Elite Rugby Collisions

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Abstract

The rugby tackle event is a physical contest whereby the tackler aims to limit territory and point scoring opportunities of a ball carrier. The tackle has gained a significant level of traction in recent research due to its proclivity to injury, given its chaotic nature and the high-level transfer of force. Despite the progress in recent literature, concussion rates in both codes remain significant, highlighting the complexity in reducing the injurious event. Moreover, the implications for long term health outcomes from sustaining concussions highlight this as an area for further investigation. Prior research has aimed to explore the tackle through a descriptive lens, without attempting to understand the lived experiences of elite stakeholders involved in training and performing it. As such, there is a substantial void in the literature for qualitative and experimental research investigating the tackle. Through four interrelated studies, this thesis addressed this gap by exploring the tackle event across both codes of rugby (league and union). Therefore, this study aims to explore the rugby tackle event, contributing to the current landscape and apply new methodologies for understanding the tackle. Employing a mixed-methods approach, the thesis comprised two different sets of focus groups with 18 elite RL players and 18 elite RU players, semi-structured interviews with 19 elite stakeholders (coaches, physiotherapists, doctors, and strength coaches) and an experimental design assessing tackle proficiency in 13 highly trained RL players. The overall findings demonstrated that controlling the ruck as a pivotal philosophical underpinning in elite rugby, as tackle type in comparison to tackle proficiency cues, were highlighted. A key interplay between mean match speed, ball in play and contact load was documented, illustrating the requirement to fully understand the unintended consequences of rule changes prior to enacting them. Finally, the socio-ecological influences on the tackle are illuminated, providing key insights for policymakers to reduce injury risk and guide future decision making on the tackle.

Publications and Presentations

Books and Journals

- Dixon AJ, Littlewood MA, Cronin CJ, Twist C, Close GL. Understanding elite rugby league players' experience of collision, effective contact coaching techniques, and player contact psychology: A focus group study. J Sports Sci. 2024 Feb 7:1-8. doi: 10.1080/02640414.2024.2313377. Epub ahead of print. PMID: 38326242.
- Dixon, A. J., Littlewood, M. A., Cronin, C. J., Twist, C., & Close, G. L. (2024). Physical collisions during elite rugby league match play and training: A stakeholder's perspective. *International Journal of Sports Science & Coaching*, *20*(1), 210-224. https://doi.org/10.1177/17479541241296978 (Original work published 2025).

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Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Liverpool John Moores University. Apart from the help and advice acknowledged, the work within was solely completed and carried out by the author.

Any views expressed in this thesis are those of the author and in no way represent those of Liverpool John Moores University and the School of Sport and Exercise Sciences.

This thesis has not been presented to any other University for examination in the United Kingdom or overseas. No portion of the work referred to in this research project has been submitted in support of an application for another degree or qualification of this or any other university or institute of learning.

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Glossary of Terms

Term	Definition
Coaching Philosophies	The core beliefs and values underpinning the coaches purpose and decision making (Cushion & Partington, 2016).
Coaching methodologies	The specific techniques and drills used to apply philosophical beliefs in training and competition (Hughes, 2022).
Simultaneous Contact	A dual contact made by two defending players, timed to reduce the momentum of the attacker.
Standardized Tackle Proficiency Test	A one-on-one tackle drill aimed at testing a player's tackling technique quality and success (Hollander, Ponce, et al., 2021b).
Microtechnology	The combination of GNSS and imbedded inertial sensors (Naughton et al., 2020)
Coaching Behaviours	The communication styles and feedback that direct drills and activities performed in practice. (Lyle, 2002)
Skill Acquisition	The movement of body segments to solve a motor skill problem and achieve a task goal (Williams & Hodges, 2005).
Mental Toughness	The maintenance of psychological stability under conditions of stress, pressure and adversity. (Demir et al., 2025)

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Chapter 1

General Introduction

1.1 Background

Rugby is a worldwide sport, originating in England during the 19th century and has two distinct codes whereby the contrasting evolution of both laws has changed match play into two disparate games (World Rugby, 2024b). Upon the splitting of the codes, twenty-one clubs based in the north of England decided to break away from the current governing body, the English Rugby Union (RU), and form their own competition, the Northern Rugby Union, now known as Rugby League (RL) (Rugby Football League, 2023a). In subsequent years (1987 and 1906), major law changes came in the form of a reduction to thirteen players a side, the removal of lineouts and penalty/ conversions reduced to two points. Herein dawned the birth of RL match play and the two different sports as they're known today. Although both codes have common origins, they have evolved distinct characteristics through rule changes and playing styles reflected in the contrasting game demands and, as such, contact demands.

Yet, some similarities remain as both games take place over two 40-minute halves and are characterised by high and low-intensity efforts performed by players, such as repetitive sprinting, collisions, wrestling, walking and jogging (Jones et al., 2015b; Twist et al., 2014). Moreover, the aim of the game is identical as a team's objective is to advance the ball down the field over a series of six tackles in RL or continuous phases in RU to score points. Distinctive scores are awarded in each sport with 4 and 5 offered for a try (the act of placing the ball down on or over the try line), 2 and 3 for a penalty conversion (kicking the ball through the sticks from a penalty) and 1 and 3 for a drop goal (kicking the ball through the sticks in open play with the ball hitting the floor) for both RL and RU respectively (Rugby

Football League, 2021; World Rugby, 2025b). However, once a team has scored a try, they have the option of scoring further points by adding a conversion (the same as a penalty conversion), which is the same points in both sports (2), allowing a total of 6 (RL) and 7 (RU) total points for a converted try.

As a global sport, 120 countries play RU, with 11 tier 1 nations (World Rugby, 2025c), and several notable leagues and cup competitions around the world. In England, RU professionalised in 1995 after the International Rugby Board (IRB) allowed open payments, hailing the fall of the game's amateur status (Ryan, 2008). Birthing the top tier of RU, named the Premiership, originally consisting of eleven teams, restructured in recent times to ten (Golding et al., 2025). There are several divisions below the Premiership, separating into north and south upon reaching the national tier level of competition (Malcolm et al., 2000). In the UK, teams compete from September until May, where a 9-month season includes league, play-off games and cup matches (Gannon et al., 2016). A significant portion of the premiership teams in RU are based in the south of England, with only two teams in the north (Collins, 2009). Despite being allocated into either forwards or backs, players can be further grouped into positional sub-divisions of front row (loose head prop, tight head prop and hooker), second row (locks), back row (six, seven and eight), halves (scrum half and fly half), centres (inside and outside centres) and back three (wingers and fullback) (Cahill et al., 2013).

There are two major full-time competitions in RL, comprised of the National Rugby League (NRL) in the southern hemisphere and the European Super League (ESL) in the northern hemisphere (Johnston et al., 2019). The ESL has recently expanded to 14 teams, whereas the NRL comprises 17 teams and is due to expand to 18 in the 2026 season (National

Rugby League, 2025; Rugby Football League, 2025). The two competitions eventually meet in the World Club Challenge, whereby the winners of each league play off in a one-off game (National Rugby League, 2023b). Both leagues have reserve team competitions in which players compete in the feeder team with respect to earning a place in the first team (Hulin & Gabbett, 2015; Till et al., 2010). After 101 years of top-level British RL, the 1996 season heralded the first ESL season (Betfred Super League, 2023). Similarly, the NRL was formed in 1998, succeeding the unification of the Australian Rugby League and Australian Super League (National Rugby League, 2023a). During a nine-month season, the competitive stage starts in February and finishes in October, with pre-season forming the November to January period in the ESL (Phillips et al., 1998). The predominant location for teams in the ESL is the north of England, with one sole team in the top-flight based in Perpignan, France (Mackreth & Bond, 2021). RL is played by thirteen players with four replacements and eight total substitutions (Hills et al., 2023). Eight different playing positions encompass the thirteen on-field players (fullback, winger, centre, halfback, prop, second row, loose forward, hooker) (Dalton-Barron et al., 2022); however, research commonly divides players into four playing groups based on commonalities (outside back, adjustable, wide running forward, hit-up forward) (Gabbett et al., 2012).

In contrast to other collision-based sports such as Australian Rules Football (AFL), pitch dimensions in Rugby are smaller, with a 68m – 70m width and 106m – 144m length in RU and 68m width and 112m – 122m length in RL (Johnston et al., 2022). Nevertheless, due to the elevated number of tackles players are involved in and the physical contact that occurs in the tackle, the game of rugby exposes players to a significant level of injury risk (King et al., 2022; RFU, 2024). Therefore, injury sites, mechanisms and incidences are comparable between the codes, with concussion, hamstring injuries and knee injuries being some of the most prevalent. As such, some of the injury and performance mechanisms have been compared across the sport to gain insights into key risks of injury (Hollander, Ponce, et al., 2021b).

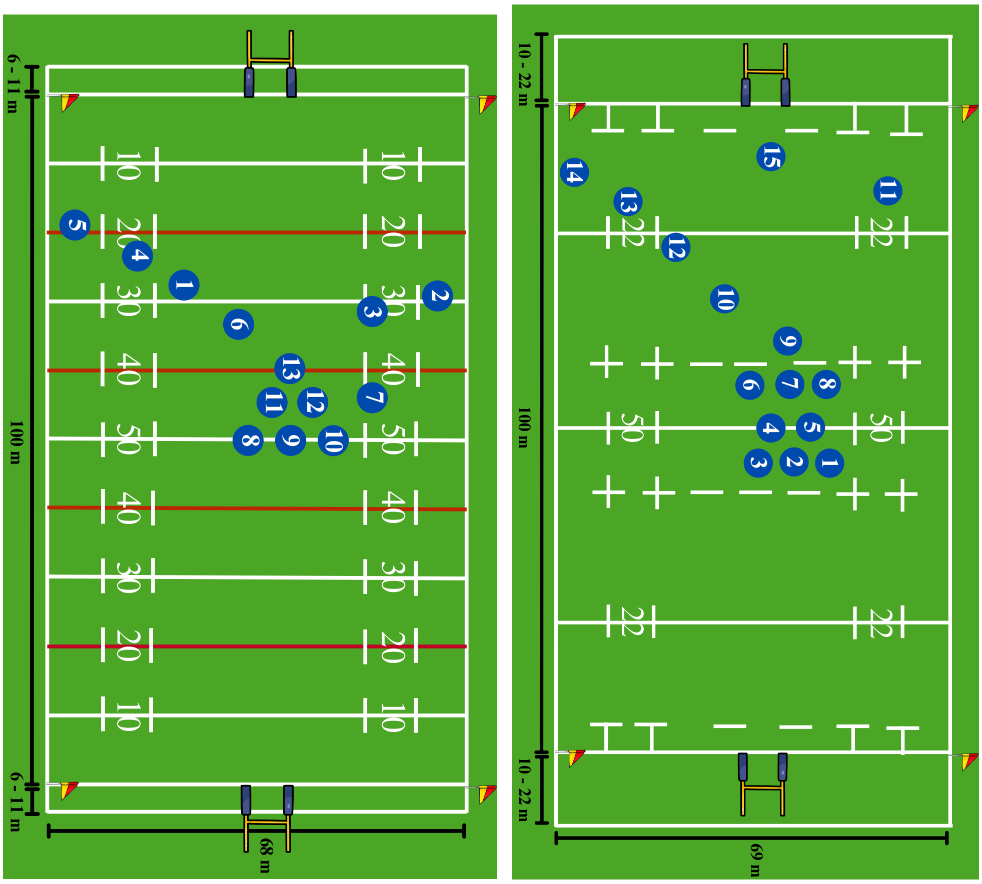

Figure 1, Composition of RL and RU pitch dimensions with playing positions.

1.2 Rationale

In Rugby, tackling is arguably one of the most crucial skill components influencing match outcome (Scott et al., 2023). As such, there is a considerable amount of descriptive research that has been performed, exploring foundational themes such as match demands and key performance markers (Cunningham et al., 2018; Parmar et al., 2017). Woods et al. (2017) has illustrated 'all run metres' when carrying the ball and line breaks as a key indicator of predicting ladder position in the NRL. Demonstrating the importance of restricting metres in defence and stopping line breaks through sufficient tackling proficiency. Yet, amidst the plethora of research undertaken, the most significant injury linked to collision (concussion) has increased over recent times (Eastwood et al., 2023a; Fitzpatrick et al., 2018; Gardner et al., 2014; RFU, 2024). As both codes' most prevalent injury, there has been a continual effort to understand the association of head impacts in the form of accumulated sub-concussive impacts or concussions from both codes and neurodegeneration (Alanazi et al., 2024b). To combat this, current research has aimed to understand the precursors that increase the risk of concussion in both codes of rugby (Cross et al., 2019a; Gardner et al., 2021a). Key findings from this research found accelerating players, high speed, head contact type and tackle type to be the four underpinnings to increase the risk of concussion. Consequently, further research has aimed to reduce the risk of concussion by reducing the exposure to the four variables, culminating in one of the most significant changes being a reduction in tackle height.

Recent studies have been undertaken to incorporate rule changes aimed at reducing the highlighted actions that increase injury risk (Van Tonder et al., 2023). A significant amount of research has examined the role of tackle type in reducing head contact type (Davidow et al., 2018b; Gardner et al., 2021b). This has culminated in a move to reduce the height of the tackler to either below the armpit or below the navel to prevent the ball carrier and tackler from sharing head space and reduce direct contact with the head of the ball carrier (Stokes et al., 2021a). Despite being based on sound empirical evidence, the currently published trials in RU reducing tackle height have yielded an increase in concussion of 30% over a 12-week period in semi-professional and a non-statistically significant reduction of 31% in concussion at the university level (Stokes et al., 2021a; V Tonder et al., 2023). Moreover, other collision sports, such as the NFL, have aimed to reduce the high-exposure events that increase players' speed entering the collision, such as the kick-off, by reducing the distance and run-up between blockers and chasers (NFL, 2024). These major changes have been employed to reduce the speed of players and reduce the acceleration of players into the tackle. However, the kick-off change is due to be enforced during the 2025 season, as such, we do not have the conclusions of the effectiveness of this rule change.

Whilst much of the literature has quite rightly focused on the incidences and risks from the tackle, few studies in Rugby have utilised qualitative approaches to gain further insight into optimal ways to perform them and the mechanisms behind injuries. No research in elite RL or RU has aimed to delineate the tackle utilising a qualitative lens, with the most contemporary enquiry by Fazackerley et al. (2023) exploring RL stakeholders' perceptions of the annual calendar. Recent investigations in RU such as Dane et al. (2023), have attempted to focus on the experiences of coaching in current women's players. The semi-structured interviews performed here presented positive insights into best practices to empower women's tackle development in RU. Nonetheless, no investigations have focused on a qualitative exploration of collision using elite men's cohorts. A principal reason for this may be the difficulty which researchers may find in accessing elite populations, as Mikecz (2012) has been demonstrated by the challenges when attempting to recruit elite participants for areas like qualitative research, even though this is not specific to sports. Moreover, when performing qualitative research, a moderator must be able to build a credible rapport with the stakeholders involved to provide insightful discussion and produce novel themes. This may also be another key reason as to why such an investigation has not been performed. However, despite extensive quantitative research describing the physical and technical aspects of the tackle event, there is a paucity of qualitative insight into how elite players and coaches perceive, teach, and experience tackle performance and safety. While quantitative data describes what happens during the tackle, qualitative approaches are required to understand why players tackle in certain ways, how they perceive risk, and what psychological and coaching factors shape these behaviours.

Importantly, the tackle event does not happen in isolation, even at its most basic level of the individual athlete. Instead, the tackle is affected by a plethora of internal factors, such as fatigue, technique and physical anthropometrics (Gabbett, 2008; Gabbett et al., 2011a), along with external factors such as the opposition, refereeing decisions and match laws (Delves et al., 2023; Woods et al., 2017). Yet, the impact of different components on the tackle is not fully understood. Socio-ecological approaches have aimed to delineate human behaviours and development in complex environments (Bronfenbrenner, 1979). In recent times, the application of models like Bronfenbrenner (2005) have been utilised in sporting contexts to generate novel insights exploring the experiences of elite athletes in the non-disclosure of concussions. Adopting such models allows a broader lens to be utilised in exploring the tackle event and the factors acting upon it. This ecological approach underpins the latter stages of the qualitative chapters in this thesis, where the tackle is explored from a holistic perspective.

1.3 Aims and Objectives

This study aims to explore the rugby tackle event, contributing to the current landscape and apply new methodologies for understanding the tackle. To achieve this goal, the following objectives will be met.

1. To identify the technical and physical characteristics of optimal methods for players to perform contacts in training and match-play.

2. To identify components of the tackle in match play and training associated with elevated levels of risk of injury and concussion.
3. To conceptualise coaching methodologies and philosophies behind the techniques used to succeed in contact.
4. To explore the psychological underpinnings of performing the tackle and the strategies that players use to cope with participating in a contact sport.
5. To investigate the physical match demands of rugby and their relationship with tackle proficiency.

1.4 Thesis Scope

Chapter 1, Introduction, provides the background, rationale, aims and objectives, highlighting the importance of the tackle in rugby match-play and training. This chapter outlines the intricacies of rugby as a sport and the current dearth of quantitative descriptive research performed to date. It also outlines the scarcity of previous literature grounded in tackle event from a qualitative standpoint and investigative quantitative research in rugby.

Chapter 2, Review of the Literature, examines the previous literature investigating the tackle event in both codes and similar collision sports of note, such as American football. Firstly, it discusses the prior literature exploring injury incidences, mechanisms and severity linked with the tackle. Subsequently, delineating tackle proficiency research and quantifying the tackle event, including microtechnology's recent influence on the tackle. Key coaching philosophies in rugby, as discussed, along with behaviours and skill acquisition frameworks. Lastly, finishing with tackle psychology and mental toughness in contact sports.

Chapter 3, General Methods, describes the overall methodology utilised for this project, signposting the individual methods used in each chapter. An overview of a mixed-methods investigation is discussed, whilst providing insight into the sequential process of the thesis.

Chapter 4, Understanding Elite Rugby League Players' Experience of Collision, Effective Contact Coaching Techniques, and Player Contact Psychology: A focus group study, offers insight into the RL tackle by offering the perspectives of elite RL players. This chapter utilises the focus group methodology to elucidate the players' lived experiences and the nuances that accompany them. Key aspects of simultaneous contact as the optimal way to perform the tackle, blind-sided collisions along long closing distances increasing injury risk, along with a reduced psychological preparation for games that are deemed easier, are all discussed.

Chapter 5, Physical Collisions during Elite Rugby League Match Play and Training: A Stakeholder's Perspective, describes stakeholders' perspectives of the tackle in the applied environment. This was performed through the qualitative approach of semi-structured interviews, highlighting an agreement with playing stakeholders that the optimal way to perform the tackle was discussed as simultaneous contact. Further agreement was discussed regarding contacts with larger closing distances. However, a novel theme to this chapter is the focus on increasing match demands for players through rule changes, inducing further fatigue.

Chapter 6, Mapping the Ecology of the Tackle Event: What Shapes How Elite Rugby Union Players Tackle? Describes elite RU players perspectives of contact in training and match play, highlighting key themes through a thematic analysis and mapping the ecology of the tackle via Bronfenbrenner's ecological systems models. The theoretical framework is utilised to show where the tackle event sits within the microsystem, mesosystem, exosystem and macrosystems. Key conclusions from the study centre around unintended consequences of recent rule changes regarding box kicks and the jackal influencing player contacts and areas of match pay and training that are potentially deemed problematic due to increased head contacts.

Chapter 7, The Role of Match Speed and Collision Intensity on the Tackle Proficiency of Elite Rugby League Players, describes highly trained RL players influence of fatigue on tackle proficiency. Employing a standardized one-on-one tackle technique trial in two conditions of fast vs slow, the chapter focuses on the increased running demands of match play through recent rule changes. As such,

Chapter 8, General Discussion, provides a discussion of the subsequent chapters, revisiting the aims of the research, the limitations and future directions.

Chapter 2

Review of the Literature

2.1 Introduction

This chapter aims to highlight the fundamental research in prominent areas on the tackle event in rugby, while providing additional context from further collision sports.

2.2 Movement Demands

Whilst games are made up of 80 minutes, ball-in-play times for RU are reported as an average of 36.21 ± 2.40 minutes (Quarrie et al., 2013). Contrastingly, in RL, a study by Rennie et al. (2021) demonstrated ball-in-play times to have increased in recent times to as high as 46.3 - 60.3 minutes, depending on positional group. Given the lower ball-in-play time, it is no surprise that RL notes tackle demands are elevated, as Burger et al. (2021) showed in the region of 600 per match. Conversely, in RU, although the tackles per game have increased over the last decade, from 102 tackles per team in 2013-2014 to 128 tackles per team in 2022 – 2023, which is still markedly different from RL. Yet, the stark contrast in collisions from the tackle and total match collisions is due to the inclusion of a contestation of scrums, line-outs and mauls in RU. Therefore, it is unsurprising that Rennie et al. (2022b) illustrated in the ESL from 2014 – 2022, forwards undertake 32 – 39 tackles and 6 – 15 ball carriers, whereas backs tackle and ball carries were from 7 – 21 and 6 – 12 carries, respectively. In contrast, elite RU players will perform between 4 – 14 tacklers per game (Quarrie et al., 2013), however, total contacts have been shown to be much higher for forwards (31 ± 14) and backs (16 ± 7) (Jones et al., 2014) due to the inclusion of rucks, mauls, contested scrums and lineouts. As such, the key differences noted in match play contacts are cause for inquiry into the contrasting techniques used across both codes. Given the increase in tackles and the static wrestle component associated here during RL, it could be assumed that total distance and metres per minute would be lower, yet this is not the case. Two studies performed have illustrated differences in relative running intensity of 60 – 61 m·min and 72 m·min versus 69 – 71 m/min and 80 m/min for forwards and backs, respectively (Jones et al., 2015a; Yamamoto et al., 2020). Both studies also concluded disparities in total distance covered for forwards (4750 m – 5250 m and 5731 m ± 508 m) versus backs (5900 m – 6270 m vs 6392 m ± 647 m) comparatively. However, the relative distance covered during ESL matches has been reported as 95.8 ± 18.6 m·min^{-1} (Twist et al., 2014), slightly higher than the NRL at 90.2 ± 8.3 m·min^{-1}, albeit the NRL having a higher relative high-speed distance during match play (7.8 ± 2.1 m·min^{-1} vs 6.1 ± 1.7 m·min^{-1}). Therefore, a reason for lower speeds during RU may be due to the increased number of contacts through set pieces and the ruck. Nevertheless, the contrasting component of match play warrants investigation to delineate its effect on tackling and injury incidence.

2.3 The Tackle Event Injury Epidemiology

2.3.1 Injury Severity, Incidence, Burden, and Time-loss Definitions

Making interstudy comparisons can be difficult when variations in definitions and data collection methods are consistent within the literature. Therefore, before critically examining the literature, it is prudent to establish clear definitions that will be consistent within the review. Fuller et al. (2006) published a consensus statement detailing definitions and aiding the classification of injuries that will be used here. In this statement, definitions for injury type, severity, burden, location, and exposure were included. Consequently, studies before the consensus statement may lack consistency between one another and should therefore be interpreted within the specific context in which they are discussed. The injury definition that was originally accepted by the Rugby Injury Consensus Group (RICG) is “any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities. An injury that results in a player receiving medical attention is referred to as a 'medical-attention' injury, and an injury that results in a player being unable to take a full part in future rugby training or match play as a 'time-loss' injury". Further terms, such as injury incidence, are commonly referred to as the number of injuries per 1000 hours of participation, whether that be in training or match play. For example, Palmer-Green et al. (2013) recorded a match injury incidence of 47/1000 hours during the 2006/2007 season. This means for every 1000 hours of match play, 47 injuries were recorded. Studies also use 'time-loss' as a full participant from match-play and training to define injury severity in keeping with the 2007 consensus (Williams et al., 2016). The full definition is 'the number of days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection'. Once the severity is determined, assessing the burden of an injury considers the frequency of the injury expressed per 1000 player hours of match or training exposure.

2.3.2 Background of the Tackle Event

Early research into the tackle event in RU focused on spinal cord injuries from players admitted to hospital due to playing rugby from 1985 – 89 (Scher, 1991). The study aimed to discern injury mechanisms for the ball carrier and tackler. Mechanisms of lunging tackles for tacklers and high tackles for ball carriers were thought to have the highest injury rate in match play. Whereas analysis of the tackle became a prevalent subject in RL throughout the 1988 – 2002 seasons, where defensive strategies changed across a four-year period (1988-92, 1993-95, 1997-98, 2000-02) (Eaves et al. (2008). In this research, a notable increase was reported in the frequency of 'double tackles' (tackles with two players) compared with single tackles (tackles with one player) from the 1988-92 period versus the 2000-02 period. The advantages of this strategy in RL were preventing the offload and reducing the speed of the ruck to set the defensive line, something not previously performed. The advantages of this strategy in RL were preventing the offload and reducing the speed of the ruck to set the defensive line, something not previously performed. Nevertheless, little was known about the mechanism of injuries from RL collisions in early research. The rugby tackle has the highest injury rate of any event during match-play and training, irrespective of code (Burger et al., 2021; Gardner et al., 2015; King et al., 2014). This may be due in part to the high transfer of energy between the offensive and defensive players and the chaotic nature of collisions, with the objective of the tackle being to prevent the momentum of the ball carrier, thereby restricting field territory and stopping try scoring opportunities (Hendricks, Karpul, et al., 2014). Initial literature identified 72% of all injuries attributed to contact mechanisms in RU (Hendricks, Karpul, et al., 2014). However, specific to the ESL, contact mechanisms (tackles and ball carries) have been shown to account for 61% of all injuries in match play (Fitzpatrick et al., 2018). This highlights the differences between the sports, but moreover, the effect that code, league, country, or tactic can have on epidemiological data.

Concussions are one of the most prevalent injuries in both games and are ubiquitous with the tackle, reporting a rate of 18.4/1000 player-match hours in 2022/23 in RU (RFU, 2024), and 15.5/1000 player hours in RL from 2015 to 2022 (Eastwood et al., 2023a). Moreover, in the NRL, Gardner et al. (2021a) have shown 94.5% of head injury assessments (HIA) to occur during the tackle with a reported 1.6 HIA's per 1000 tackler involvements. Similarly, RU has illustrated in elite professional players from 2013 – 2015 an overall propensity for HIA events of 1.94/1000 tackles, albeit this study did not distinguish for total tackle involvements (Tucker, Raftery, Kemp, Brown, et al., 2017). Concussion events have increased in recent years as Fitzpatrick et al. (2018) documented concussion rates in RL at 2/1000 hours, 4/1000 hours, and 8/1000 hours for 2013, 2014 and 2015 ESL seasons, respectively. Similarly, in RU, West et al. (2021) noted from 2002/03 to 2009/2010, concussion rates were 4.3/1000 hours. However, the rise in this injury could potentially be due to a surge in injury surveillance as governing bodies aim to combat this injury type and limit previously undiagnosed cases (Griffin et al., 2021). Consequently, a plethora of recent research has investigated concussions in both sports, also due to their recent association with neurodegenerative diseases (Alanazi et al., 2024a). Russell et al. (2022b) demonstrated that in 412 male Scottish former international RU players, 11.4% were diagnosed with incident neurodegenerative disease compared to 5.4% in a control comparison group. However, the lone number of concussions is not the only reason purported for changes in brain structure, as Zimmerman et al. (2021) highlight the need to understand both head injuries and repeated sports-related head impacts. As such, this area warrants further investigation to aid the welfare of players and their longevity once they leave the game.

2.3.3 Injury Incidences, Types and Severity in the Tackle

The overall injury incidence rate in RU is 91/1000 hours, with 27 days on average being missed per injury (Williams et al., 2022). In RL, a similar incidence rate was reported by King et al. (2022) through a pooled analysis at 99/1000 hours for the professional game. Yet, injury incidence during training recorded a significantly lower rate for this study at 11.8/1000 hours. Contrastingly, the RU injury incidence during training has been reported as low as 3.2/1000 hours in the 2022 to 2023 (RFU, 2024). This injury surveillance report cites a lower injury incidence than the Williams et al. (2022) study in RU, as Premiership and England international match play were 76/1000 hours and 78/1000 hours. A number that is substantially lower than previous seasons for both the Premiership (86/1000 hours) and international level (122/1000 hours). Herein highlights a key issue with injury incidence data from previous research, such as differences in study designs (self-reported injuries vs observation), injury type/ site/ severity definitions and/ or data recording medium. More recent data, like the RFU report (RFU, 2024), provide clear definitions and clarity on data collection methods to provide context to the figures, establishing greater accuracy.

The injury incidence in the tackle event has accounted for 50% of all injuries at 38.6 per 1000 hours in recent RU reports (RFU, 2024), for which differences between injuries to the ball carrier (24%) and the tackler (26%) were minimal. In contrast, a systematic review by Burger et al. (2021) demonstrated time loss injuries to be between 47-94% from the tackle, with severe injuries resulting in the player being absent from matches or training being up to 73% in RL. An additional study by Gabbett (2005) reported that the two highest recorded causes of injury during match play are either being tackled (27.3%) or performing the tackle (25.2%). Both codes demonstrate a similar injury rate amongst the ball carrier and tackler, with RL ball carriers having a slight increase in injury risk. This could potentially be due to the increased distance between the ball carrier and tackler, as RL players must retreat 10m in accordance with the laws of the game. This increases the distance that tacklers have to track the ball carrier and therefore increases the difficulty of the tackle and subsequent tackler errors, such as the high tackle.

Concussions are not the sole injury related to the tackle, as several other severe injuries, such as the spine, neck and shoulder, are also commonly researched topics. Usman et al. (2015) investigated shoulder injuries in Super 14 players, whereby the overall rate of injuries to the joint was 12.7/1000 hours, with an average severity of 37 days, and the acromioclavicular joint (ACJ) was the most frequent injury. The injury with the largest severity in this study was the dislocation, totalling an average of 207 days. Similarly, the RFU (2024) reported the ACJ as the fourth (3.5/1000 hours) most common match injury and the fifth (0.1/1000 hours) most common training injury, whilst the shoulder dislocation was the third-highest burden match injury with an absence of 208/1000 hours in the Premiership. In the Super 14 study (Usman et al., 2015), 50% of all ACJ injuries occurred when the shoulder/arm was in a combination of horizontal adduction, flexion, and internal rotation on impact, which was deemed to be a common orientation for the tackler. This study also reported that 43% of dislocations occurred due to a combination of abduction, extension, and external rotation at impact (Usman et al., 2015). A study by Crichton et al. (2012) outlined comparable mechanisms in RL shoulder injuries, identifying three main mechanisms of injury. These mechanisms were the 'try scorer' characterised by the hyperflexion of an outstretched arm in the act of scoring a try, the 'tackler', having extension of the abducted arm behind the player when tackling, and the 'direct impact', being a direct blow when held in neutral or a slight abduction to the shoulder or arm. The glenohumeral joint (GHJ) dislocation, with Bankart, reverse Bankart, and superior labrum anterior-posterior tears, came from the 'try scorer' and 'tackler' mechanisms. The 'direct hit' mechanism resulted in GHJ dislocation and labral injury in 37.5% of players and was most likely to cause ACJ dislocation and scapular fractures. Understanding key mechanisms associated with injuries provides scope for studies such as Helgeson and Stoneman (2014) to provide assessment testing and rehabilitation protocols specific to rugby.

Injuries to the neck and spine are much rarer than shoulder injuries in terms of incidence; however, the severity remains very high (Swain et al., 2011). Simulations, as seen in Silvestros et al. (2024) have highlighted how a player's head position before the impact of a tackle can influence forces experienced in the neck and spine. A backwards tilted neck before the tackle resulted in forces and movements that extended beyond what the spine can withstand safely. Moreover, Kuster et al. (2012) underscored bilateral facet dislocations are the most common type of cervical spine injury in rugby, as a result of the same buckling effect mentioned in the prior simulation literature. Neck stingers were amongst the highest burden injuries during the 2020/21 season in the Premiership at an overall absence day rate of 4.5/1000 hours (RFU, 2024). However, this injury type did not make the top five list of injuries in subsequent seasons of 2021/22 or 2022/23. The scrum was responsible for 54% of spinal injuries, with the maul attributed to 15% and the tackle 31% in RU (Quarrie et al., 2002). However, due to the contestation of scrums in RU, and the lack of this in RL, spinal and neck injuries are much lower in RL, meaning the research investigating this injury type remains scarce (King et al., 2011). Understanding mechanisms of key injuries allows a governing body to put policies in place to aid player safety. The International Review Board Laws change in language for the scrum from 'crouch-touch-pause-engage' used up until 2012-2013 to 'crouch-touch-set' from this point onwards are an example of injury surveillance influencing policy (Reboursiere et al., 2018) . This minor difference was to aid the binding of the scrum and reduce the initial hit from a 1.5 m distance to being connected, which was purported as the origin of scrum injuries due to the lack of control and force exerted in this section. The conclusions of Reboursiere et al. (2018) showed a reduction in catastrophic injuries in the scrum phase. The change in the scrum engagement distance occurred through increased surveillance of scrums collapsing. However, as crucial as injury surveillance is, it does not always provide such a comprehensive overview. Levy et al. (2004) exhibited this, as early injury surveillance data that was combined with player perceptions when discussing head, spine, and neck injuries in American football. Players perceived using the helmet during tackling as reducing injury risk, when in fact, it increased injury risk.

Combining this information with the data from the injury surveillance allows governing bodies to make informed decisions on how to alter the game to aid player safety. This was the case in the National Football League (NFL), where players were prohibited from initiating contact with the helmet, and players who contacted the helmet of a defenceless player would now be suspended (Sheth et al., 2018). However, early research in this field found no change in the resultant injuries from 2010 to 2017. It wasn't until the 2018/ 2019 season that Stapleton et al. (2020) reported a decrease in injury risk as a new law prohibited players from lowering their head to initiate contact with opponents, alongside the previous laws.

2.3.4 Tackler Injury Mechanisms

To aid injury prevention strategies, recent research has aimed to separate and identify the characteristics of tackler and ball carrier events. A major reason for this is the unique behaviours accompanying each match play event and their influence on injury. The main injury sites for the tackler are the head/neck and/or the shoulder and upper limb regions (King et al., 2012b). For example, studies such as Usman et al. (2015) illustrated tacklers to sustain shoulder injuries at a higher rate than ball carriers. It has also been documented that the tackler experiences more concussions (64.4%) than the ball carrier (23.9%) (McKinlay & McLellan, 2014). Nevertheless, tackler injury mechanisms remain similar across the codes, as further research has shown identical concussion rates in the ball carrier (30%) and the tackler (70%) (Lang et al., 2024; Owen et al., 2025). This potentially highlights the pre-contact and contact phases in the tackle to be crucial for the tackler, as the way both codes recycle play is wholly diverse. Yet, the impact of the ruck and the effect of controlling this component on the tackle has not been compared across codes. Colomer et al. (2020b) showed rule changes during 2007 and 2013 led to fewer players being involved in ruck situations, resulting in an increased speed of play. It is important to recognise that coordinating the tackle event with a teammate may influence how RU and RL players differ in the way they perform the tackle. An initial study by Quarrie and Hopkins (2008) investigated the tackle in professional RU players competing in New Zealand from 2003 – 2005 in the National Championship, Super 12 and World Cup competitions. This study assessed 434 matches, coding 140249 tackles, of which there were 1348 injury assessments. The key findings were that the tackles with the highest injury burden were the most common in the sport (height: high or middle; direction: front or side; tackler speed: jogging). Tackles in which players sprinted resulted in injuries 3 to 5 times more often than lower-speed tackles, which may be in part due to the lack of control or reduced reaction time the tackler would have going into the collision. Fuller et al. (2010) performed a similar study in Premiership players from the 2003/04 and 2005/06 seasons, grouping variables into the pre-tackle, tackle, and post-tackle phases. Four risk factors were highlighted in this study, shown to be associated with an increased propensity for injury as high speed, a collision-type tackle, contact with the head/neck and a high impact force for the tackler. McIntosh et al. (2010a) used tackle descriptors when assessing 6618 tackles from male rugby players competing in mixed cohorts of 15 years, 18 years, 20 years, grade, and elite (Super 12 and Wallabies) levels. The results of this study yielded six primary descriptors of tackle technique, such as active shoulder tackle, passive shoulder tackle, jersey tackle, ankle tap, smother tackle and arm tackle. The active shoulder tackle (30.5%) and smother tackle (37.7%) were the most executed tackles in the elite-level cohort. The factors associated with the most significant injury risk were the direction of the tackle, tackle speed, height of the tackle and numbers in the tackle. Tierney et al. (2018b) investigated the propensity of HIA's in the tackler in Pro 12 and European Rugby Champions Cup games from one Irish professional club from 2014 to 2017, and matches from the RBS 6 Nations from 2014 to 2017. Further games were added from the Guinness Test series 2013 to 2016, the Rugby World Cup 2015 and the British Lions Tour of 2017. A number of tackle proficiency variables were identified as a lower propensity to result in a HIA, such as identifying/ tracking the ball carrier onto the shoulder, head up and forward, straight back, centre of gravity forward of support base and head placement to the correct side. This culminated in a study by Cross et al. (2019b), analysing 2029 first-team male professional rugby players from the Premiership, Pro 12 and Rugby World Cup, citing 182 clips leading to clinically diagnosed concussions and 4619 tackles that did not. Again, four key variables associated with concussion were documented as the player accelerating, tackler speed, head contact type and tackle type. Out of the four variables noted, the player's acceleration and the tackler's speed had the largest influence on whether a concussion took place. Furthermore, specific to the tackler, concussion significantly increased if a) both players or the tackler alone were accelerating as opposed to the ball carrier accelerating, b) the speed of the tackler was high rather than low, or c) the opposing player's head, knee or the ground contacted the opposing player's head in contrast with the trunk. In sum, the literature above highlights that the tackler is more likely to sustain a concussion in RU, with four significant variables commonly discussed, with three (accelerating player, the player at high speed, contact made with the tackler's head) the most noted.

These findings were mirrored by a study in RL by King et al. (2012a), documenting the highest rate of injury for both the tackler and ball carrier when the tackle involved shoulder height or mid-torso contact with the ball carrier with two or more tacklers. However, whether the tackle-related injury in the tackler occurred from contact with the ball carrier or with the subsequent tackler was not discussed. Yet, the research understanding the differences in injury mechanisms for the tackler versus the ball carrier in RL is sparse. A significant portion of the literature here has been spent aiming to understand how performance indicators of the tackle (Cummins & Orr, 2015), delineating how the level of play influences technique

(Gabbett et al., 2011a), or how fatiguing tests affect tackle technique (Gabbett, 2008). One recent study by Owen et al. (2025), using match data from ESL games from the 2018 to 2022 seasons, analysed tackler characteristics associated with concussion risk. The variables demonstrated to have an increased propensity for concussion in the tackler were the ball carrier's use of a lead arm, the number of players in the tackle, the ball carrier-tackler body position and the head placement of the tackler (Owen et al., 2025).

Taken together, head placement of the tackler is a crucial element between non-concussive and concussive tackles in both codes. Whereas high-speed, high-impact, and upright tackles were deemed more problematic for the tackler in RU. In contrast, a significant emphasis was placed on the ball carrier in the RL study and the interplay with the tackler. Therefore, the method through which the head is kept from making contact with the ball carrier may not be as important as the contact itself. Conversely, the need for more research in RL to examine if the variables that are associated with concussion in RU are the same in RL seems warranted. Enabling tacklers to acquire the correct head position at higher speeds or when accelerating may also be of benefit in reducing head contact with the ball carrier.

2.3.5 Ball Carrier Injury Mechanisms

Common injury sites for the ball carrier differ in some regard as the lower limb is more likely to be injured than the upper limb, yet, similar to the tackler, the head/neck and chest/back also remained high in RL (King et al., 2012a). Similarly, Fuller et al. (2010) found that among Premiership RU players during the 2003/04 and 2005/06 seasons, the ball carrier had an increased propensity of injury when at high speed, contact was made with the head/ neck, the tackle type was a collision, and the impact force was high. This may be potentially due to the different impact zones the tackler is able to select to alter tackle height, which is distinct to the ball carrier. In this study, injuries also occurred most often in the blind sport of the ball carrier, in comparison to when the carrier could see the impact. Also, unlike the tackler, concussions in the ball carrier are illustrated to have a direct link with the region on the ball carrier the tackler makes contact in RL (Owen et al. (2025). The two variables of the impact zone and the ball carrier's body shape were identified as key indicators for an increased propensity of injury. As such, a considerable emphasis has been placed on the tackler's duty of care towards the ball carrier and themselves in the impact placement and to not perform sanctioned illegal high tackles (Scher, 1991; Tucker et al., 2024).

A concussion is 36.5 times more likely to occur when players perform the incorrect technique and contact the head of another player (Cross et al., 2019b). As the tackler in RU is a greater risk of concussion (70%) in comparison to the ball carrier (30%), Moreover, a more recent study in RU documented that concussions and HIA's are 272 more likely to be caused by a red carded tackle than a legal tackle with sanctioned high tackles 56 times more likely to result in a concussion (Tucker et al., 2024). This study separated injuries into contact (such as tackling or carrying the ball) and non-contact (accelerating/decelerating, changing direction and high-speed running). Furthermore, they noted that when investigating the tackle mechanism, the highest propensity of tackle injuries was from the side (30%), followed by the front of an opponent (26%), and lastly, being tackled from the front of an opponent (24%). The tackle types were also associated with contact injuries across different parts of the body. The lower limb had a higher association in ball carriers with tackles from the side, whereas the upper limb and head were mainly associated with injuries from frontal tackles in both the ball carrier and the tackler (Tucker et al., 2024). Hopkinson et al. (2022a) performed a comprehensive investigation to explore the effect of tackle characteristics on overall ball carrier injuries in RL, encompassing a scope not limited to only concussion-related outcomes.

This study found six different characteristics identified as important for ball carrier injuries, included 1) the tackler twisted ball carrier's legs when legs were planted on the ground, 2) the tackler and the ball carrier collided heads, 3) the tackler used body weight to tackle the ball carrier, 4) the tackler has obvious control of the ball carrier, 5) the tackler was approaching the tackle sub-maximally, and 6) the tacklers arms were below shoulder level and elbows were flexed. The initial characteristic illustrated the greatest relative importance to injury and showed a significant association with lower limb injuries. The second main characteristic of this study was the head-to-head contact between the ball carrier and the tackler, which is consistent with previous literature. Also, of note in this study, in the third instance, the tackler using their own body weight was associated with a lack of control when bringing the ball carrier to ground, increasing the risk of injury. The final instance potentially highlights a key factor in the tackle-based injuries, as a lack of control. The above concussions were increased when the tackle and ball carrier are moving at higher speeds or accelerating. The lack of control could potentially be attributed to the recklessness of the tackler or increased fatigue, as the initiation of contact is placed on the tackler. Hollander, Lambert, et al. (2021) demonstrated some of the same characteristics associated with injury prevention for the ball carrier from across RU and RL studies in a systematic review. Notable techniques were split into three phases consistent with previous research for pre-contact, contact and post-contact. Pre-contact techniques focused on the ball carrier, body position upright to low, back straight and head up with the face forward. Whilst contact techniques were a fend into contact, side-on into contact, explosiveness on contact and body position from low up into contact. Lastly, the post-contact techniques were the use of the arm and or shoulder to push the tackler, leg drive upon contact and going to ground presenting the ball. A significant number of characteristics here denote a less fatigued ball carrier with explosiveness on contact, leg drive and body position from low up into the tackler. This aligns with the key takeaways from previous research documented before (Hopkinson et al., 2022b). Yet, other techniques illustrate how a ball carrier can protect themselves from the tackle by having an awareness of the defender's pre-contact, using a fend or agility to get side-on into the contact and the utilisation of the arm or shoulder to push the tackler away after contact. Protective elements, such as the ones documented, could aid in reducing the highest concussion-inducing event of the high tackle. Yet there is a component placed on the tackler to control the contact in their duty of care to the ball carrier.

2.4 Tackle Proficiency

2.4.1 Tackle Proficiency Background

Tackle proficiency encapsulates a player's tackling technique quality and success, including a range of skills such as the correct timing, positioning, body shapes and physical attributes like strength and power (den Hollander et al., 2019). One of the leading factors in reducing tackle injury risk has been recognised as competent contact technique for the ball carrier and tackler, as such notable comparisons of tackle proficiency have been well documented for RU and RL throughout the literature (Hollander, Ponce, et al., 2021a). This is partly owing to the similarities in definitions for the 'tackle' for both sports. However, major differences lie in the way the ball is returned to play; in RL, through the 'play the ball' and in RU, a 'ruck' or 'maul'. Nevertheless, the act in which RU and RL players initiate contact is comparable, and as such, the research has drawn consistent parallels. Consequently, this section will use tackle proficiency studies from both codes, drawing differentiators and comparisons. Through analysing tackles and rucks, studies conducted in RU have predominantly focused on establishing the relationship between contact techniques and injury risk or performance outcomes. In RL, studies have primarily concentrated on identifying factors that may influence tackle technique through the analysis of tackles by way of a standardised tackling proficiency test in controlled field sessions (Hollander, Ponce, et al., 2021b). Moreover, the standardised tackle proficiency test utilised throughout the literature was later validated in subsequent work, as players with good tackling ability were involved in fewer missed and more dominant tackles during match play (Speranza et al., 2015).

2.4.2 Determinants of Tackle Proficiency

Defensive techniques to reduce ruck speed in RL can be shown in the literature as far back as the NRL's Sydney Roosters 2002 team attempting to increase the number of players in the tackle and allow time for the defensive line to recalibrate to increase their overall line speed each tackle (Gabbett & Kelly, 2007a). This study was the first to assess sub-elite players' tackle techniques through a standardised tackle technique test. The criteria used to assess the tackle had previously been developed by two expert coaches and served as coaching cues to train tackle technique in the players participating in the study. Unfortunately, the study did not describe who rated the tackles and how sufficient intra- and inter-reliability was from the ratings, or if this was performed. The eight cues in the criteria were contacting the centre of gravity, contacting the target with the shoulder, contacting the target with the opposite shoulder to the leading leg, body position square/ aligned, arms wrapping around the target upon contact, leg drive upon contact, watching the target onto the shoulder and the centre of gravity forward to the base of support. Hendricks and Lambert (2010) published coaching techniques with some similarities used to describe the front-on tackle for varying education programmes (NZRU Rugby Smart 2007/2008, ARU Smart Rugby 2008, SA Rugby BokSmart and NZ LeagueSmart). 17 techniques were highlighted among the coaching cues from across the five coaching programmes. Commonly noted was initially tracking the ball carrier, the approach towards the ball carrier, body positioning on approach, head positioning on approach, foot position, body and head positioning upon making contact, wrapping the arms post contact, leg drive upon contact, once on the ground, regain feet quickly and recover/ compete for the ball. A key difference between the RL and RU techniques discussed was highlighted by the position of the leading leg relative to the tackling shoulder. In the RL study, this is shown to be the opposite foot and leading shoulder, whereas RU documented the same foot and leading shoulder. The authors of the education programme study underscored this point and identified practical problems with defining tackle-technique cues amongst coaches, players, and sports scientists as the prevalent issue. Further limitations in dissecting the tackle in this manner are the lack of ecological validity in the process. The tackle is a chaotic component of match play, distinguished by a higher association with injury in comparison to other match play events (Burger et al., 2020). The multifarious nature of the tackle means it's influenced by teammates aiding in the tackle, an unpredictable ball carrier with supporting teammates, and a referee directing line/ ruck speed (Burger et al., 2020). Limiting the fluctuating essence of the tackle in this way removes some of the potential injury risk, yet, along with this, the validity to make comparisons to match play tackles.

The next phase of research aimed to examine tackle characteristics during match play with the intention of understanding techniques associated with performance. Eighteen matches from the Super 14 competition during the 2010 season were analysed, resulting in 2092 coded tackles (Hendricks, Matthews, et al., 2014b). The tackler's head position was a significant predictor of tackler performance prior to the contact. A head position in motion (tackler's head moving in sync with the ball carrier to follow them through the field) reduced the likelihood of success in the tackler in comparison to a head position, whereby the tackler's face is towards the ball carrier (head up and forward). This was purported to increase the balance of the tackler and allow the tackler to focus on the placement of the head when contacting the ball carrier. Decreasing the likelihood of a successful tackle were arm or jersey tackles when compared with shoulder tackles. This was not surprising, as this will limit the control of the tackler and denotes the importance of placing the leading foot close to the ball carrier to constrain the available space and perform a shoulder tackle. Comparatively, striking the legs of the ball carrier increased tackle proficiency; however, it did increase the likelihood of an offload. Whilst any utilisation of a fend, whether it was moderate or strong, increased the likelihood of an offload (moderate) or tackle break (strong) in the ball carrier. Hendricks, van Niekerk, et al. (2018) illustrated comparable techniques in international RU, coding 4479 tackle events from the 2014 Six Nations and Championship competitions, equating to 1234 Championship tackles and 1680 Six Nations Tackles. In both competitions, a fend and/ or driving the legs as the ball carrier resulted in more tackle breaks, whereas front-on shoulder tackles with leg drive increased tackle success and reduced tackle breaks. Taken together, this research suggests that tracking (visually and physically) is a key element of tackle technique in allowing the tackle to get closer to the ball carrier and plant their lead foot. Accompanying this with the correct head position appears to allow for a safer contract.

More recent research by Hendricks et al. (2025) used video footage of 271 male rugby matches across five age categories (U12, U14, U16, U18 and Senior) from six countries (England, New Zealand, South Africa, Portugal and the USA) across two different playing standards (amateur and elite). The highest probability of tackle success was in active shoulder tackles across all levels, with the arm tackle having the lowest probability of success. However, contacting the mid-torso rather than the shoulder did not affect tackle outcome at the senior elite level. A contrasting perspective from Amayo and Tierney (2021) showed tackles at shoulder height during 10 matches from the 2019 Rugby World Cup reduced the likelihood of offloads by 91%. Given the nature of the reduction of injury risk in RU from contacting the mid-torso documented in previous studies (Tucker, Raftery, Kemp, Brown, et al., 2017), and the similarities of performance across the mid-torso and shoulder height, it could potentially be considered more beneficial to contact this area. Contact types have been central to injury mechanisms literature in both RL and RU due to their association with increased injury for different contact levels (Gardner et al., 2021a; Tucker, Raftery, Kemp, Fuller, et al., 2017). For example, high contact types (tackler head to ball carrier head or shoulder) have been shown to have a 3.2 and 4.25 increased likelihood of Head Injury Assessment (HIA) than when the contact is low, or the tackler is bent at the waist in RU (Tucker, Raftery, Kemp, Fuller, et al., 2017). Therefore, from an injury reduction standpoint, lower contacts result in fewer injuries without influencing performance measures in RU.

2.4.3 Standardised One-on-One Tackle Proficiency Tests

A significant proportion of RL literature has focused on utilising a standardised tackle test to discern the tackling capabilities of players. Studies such as (Gabbett & Kelly, 2007b) aimed to understand the effect of line speed on tackle technique. This line of inquiry stemmed from prior literature by Garraway et al. (1999) who found high-speed tackles in RU as a factor affecting injury epidemiology. In this study, eleven semi-elite players' tackle technique was assessed utilising a standardised one-on-one tackling drill in a 10 m grid through a technical tackle technique criterion. Two conditions (self-paced vs. fast) were proposed to assess tackle proficiency under different speeds, resulting in players having a reduced ability to maintain a square body position, make initial contact with the shoulder, watch the target onto the shoulder and contact the centre of gravity (Gabbett & Kelly, 2007b). The author's conclusions recommend that future coaches allow players to practice these types of collisions to be adequately prepared for match play.

A standardised one-on-one tackle test was used by the same author in a subsequent study of semi-elite RL players to assess the effect of fatigue on the contact technique (Gabbett, 2008). This study demonstrated a direct relationship between physiological capacities (i.e., aerobic capacity) and tackle technique fatigued-induced decrements. To induce fatigue, players performed a repeated effort protocol cited as game-specific. The protocol efforts were based on subsequent work delineating repeated high intensity efforts (RHIE) (King et al., 2006a), underpinned by the longest match play effort of sprinting, tackling and lateral movements at 35 seconds. This protocol used 3 sets of 6 efforts and was 30 – 45 seconds in duration with contrasting rests of 40, 20 and 10 seconds to replicate match play unpredictable rests. When the short and long rests were performed was not cited in the study, along with the justification for 3 sets of 6 repetitions. Conclusions documented that the players with the greatest non-fatigued tackle technique had the highest decrements in tackle technique in a fatigued state. Gabbett (2016) repeated this study with the same cohort, examining the role of muscular strength, endurance, and aerobic qualities. Tackling ability was assessed using the same standardised one-on-one test, and the relationship between fatigue-induced tackling ability decrements and physical qualities was assessed. A RHIE protocol was utilised again to induce fatigue. The protocol consisted of 1 x 10m sprint (performed on a 6s cycle), followed by 3 full contact one-on-one tackling efforts (each tackle lasting 4s), and a 30m recovery jog. In line with the previous study, 3 sets of 4 repetitions were performed in 40 seconds. However, the findings of the study showed that the only correlate to maintaining tackling ability under fatigue was lower body strength. Albeit not discussed by the authors in this study, given the repeatedly cited components of fatigue throughout the literature review and subsequent chapters, it is imperative that a definition of fatigue is offered. Bestwick-Stevenson et al. (2022) note the complexity of defining fatigue due to the multiple domains of recovery and adaptive processes (neuromuscular control, physical and psychological). As such, a reduction in the maximal force a muscle can exert, or the inability to sustain the required power during exercise, defines neuromuscular fatigue. Whereas physiological fatigue can be seen as the decreased response of cells, tissues or organs or a weakness from repeated exertion. And lastly, mental fatigue has been associated with cognitive activities that are sustained and demanding. In both codes of rugby, Naughton et al. (2023) established a consensus definition for fatigue, referring to ‘a reduction in performance-related task ability which is underpinned by time-dependent negative homeostasis changes within and between cognitive (e.g., tiredness, lethargy), neuromuscular (e.g. force, power), perceptual (e.g. perceived exertion), physiological (e.g. cardio-autonomic, muscle damage), emotional (e.g. motivation) and technical/ tactical (e.g. positioning, skill execution) domains.’

Subsequent tackle proficiency studies in RU have produced mixed results assessing the role of fatigue in tackle proficiency. In elite RU, Tierney et al. (2018a) investigated the effect of player time-in-game on tackle technique. This study analysed three 2014/15 European Rugby Champions Cup games, concluding there to be no significant deterioration of tackle technique. Fatigue was illustrated through player game time, separating match play into quarters. The key justification behind this rationale was due to previous research documenting findings that more head impacts occur in the final quarter of the game than any other quarter (Tierney et al., 2016). In contrast, Davidow et al. (2020a) aligned with previous work in RL, demonstrating a reduction in tackle proficiency amongst amateur RU players after a fatiguing protocol, consisting of a prolonged high-intensity intermittent running test. Players performed a prolonged high-intensity running ability test (PHIIR) between the sets of tackles to induce fatigue. The tests comprised 8 x 12-second maximum shuttle efforts (sprinting 20, turning 180, sprinting 10m, turning 180 and sprinting 20m), performing each shuttle on a 48-second cycle (8 minutes in total). The test was adopted by Gabbett et al.

(2011b) after demonstrating an intraclass correlation coefficient for test-retest reliability of 0.9% and a typical error of 4.3%. Reasons for the inconsistencies in the results between studies could be down to, 1) the fatiguing protocol performed by the players in the standardized one-on-one drill is not a true representation of match play, or 2) elite rugby players' technique does not deteriorate comparably to sub-elite and amateur as elite players have a greater resistance to fatigue (Sirotic et al., 2009a). Gabbett and Ryan (2009) also investigated the influence of playing experience on tackling technique using one-on-one collisions through the standardised tackling drill, finding that greater tackling technique was associated with superior playing experience. Specifically, those players who had played at least 150 NRL games had a significantly more proficient tackle technique than those who had played 0 – 49, 49 – 99 and 99 – 149 NRL matches. Moreover, significant relationships between the proportion of missed tackles (negative) and the proportion of dominant tackles (positive) were detected when assessing tackle technique. This research taken together suggests a potential relationship between fatigue, playing experience and tackle technique.

Hollander, Ponce, et al. (2021b) provided a systematic review, including 49 studies investigating tackle and ruck techniques in both rugby codes. The review highlighted the differences as shown above in RU and RL literature, with RL focusing on factors that impact tackling ability, whereas RU aimed to identify performance measures and injury outcomes from the tackle and ruck. In RU, Hollander and colleagues (2021a) identified 11 tackle techniques and five ball carrying techniques positively associated with both a reduction in injury and performance outcomes. The metrics were separated into pre-contact, contact and post-contact. In the 'pre-contact' phase, key components were cited as the body position (upright to low), back straight with centre of gravity ahead of support base, head up and face forward and shortening steps. Whereas in the 'contact' phase, crucial components were illustrated as contact with the shoulder, contact the centre of gravity and head placement on the correct side. And lastly, for the 'post-contact' phase, the study showed shoulder drive upon first contact, leg drive upon contact, punch arms forward and wrap, release the ball carrier and compete for possession (specific to RU). A considerable portion of the techniques is to enable the tackler to have control of the tackle through their head and body placement. Head placement was emphasised in the study by Davidow et al. (2018b), who reported the contact technique scores to be significantly lower during head impact tackles than in injury-free tackles for the ball carrier and tackler in the 'head impacted player' and 'impacting player'. The findings highlight a lack of control or technical deficiency associated with head impacts. Head impacted ball carriers demonstrated an 'upright to low' or 'straight back' positioning during the pre-contact and contact phases, whereas 'explosiveness upon contact' and 'leg drive' were shown to mitigate against tackle injury risk. Conversely, head impacting tacklers demonstrated lower proficiency scores on 'identifying the ball carrier onto the shoulder', 'the head up and forward', 'shortening steps into contact' and 'head placement'. Given the prevalence of concussion in both codes, it is essential to highlight literature that focuses on contact/ tackle types that result in head contact. Tierney et al. (2018b) showed in upper body tackles, when the tackler did not identify the ball carrier onto their shoulder or shortening the steps was not exhibited during the pre-contact phase, the tackler generally planted their feet, which was consistent with a risk factor for head impact. In lower body tackles, having the centre of gravity forward of the support base with the head facing down and a straight back demonstrated a lower propensity for a HIA. The tackler's face would be facing down, thus the tackler would be unaware of the impending contact from the ball carrier. Ball carrier techniques were split into pre-contact, contact and post-contact phases in a manner similar to the tackler. Attaining an upright to low body position was identified as crucial in the pre-contact phase, as utilising a fend into contact and explosiveness were highlighted during contact. For post-contact techniques, leg drive upon contact and going to ground to present the ball were illustrated as key (Tierney et al., 2018b). The findings show key techniques for safe tackling frameworks, along with highlighting some RL research (Gabbett, 2016) advocating for aerobically fitter players, with greater lower body strength and a greater tackling experience (measured in games). The key findings across research documents several similarities, which show that with the right proficiency metrics, energy system development and as athletes gain greater experience, injury risk can potentially be reduced through these mechanisms.

2.5 Quantifying the Rugby Tackle Event

2.5.1 Time motion analysis

Early research exploring tackle event in rugby investigated match demands to bridge the gap from training demands and adequately prepare players for competition (McLean, 1992). Observations from live television transmissions during five RU nations championship games during the 1989 – 90 season were analysed. The identification of high-intensity work, such as sprinting, was calculated using visual cues validated by Reilly (1976), estimating distances through pitch markings and calculating the time taken to travel. Contact events, such as scrums, lineouts or mauls, occurred every 33s, with a ball-in-play time average of 29 minutes. A key limitation of the work was the error involved in viewing the games via live transmission and the omission of tackle statistics. Meir et al. (1993) showed initial documentation of contact loads through time-motion analysis (TMA) in RL during a case study of two teams competing in the Australian Sydney Winfield competition. In this study, participants were shown to have completed approximately 20 – 40 tackles whilst covering between 5000 m and 8000 m. Duthie et al. (2003) subsequently followed this work by performing a TMA of 16 games during the 2001 and 2002 Super 12 Rugby competition. The study presented contrasting movement patterns between forwards and backs, with forwards performing a greater total of work (7:31 mins duration and >50 occurrences), resulting from a higher frequency and duration of work, comprising static exertions. The static exertions noted in the study related to contact events such as the tackle, set-piece plays or breakdowns. The conclusions of the study cited the requirement for conditioning specific training programmes to prepare players for the individual rigour of match play. Yet, a key limitation of this work noted by the authors was that although forwards had an evident importance of static exertions (contact) in the game, there was an apparent inability to accurately quantify contact load through video. Thereafter, Gabbett et al. (2008) followed this work, providing a comprehensive review of the preceding literature, citing the average in match contact demands in King et al. (2006b) study as 51, 27, and 35 for forwards, outside backs and adjustables. Here, Gabbett provides an in-depth overview of TMA and the role of contact in the repeated high-intensity efforts (RHIE) required by RL match play. As part of the review, RHIE (lateral movements, sprinting and tackling) efforts were grouped together to illustrate the considerable changes in demands during modern match play in comparison to previous research (Meir et al., 1993).

In subsequent research, video analysis was developed further to attempt to record contact intensity, utilising methods such as speed (m s^{-1}) and acceleration into contact (Gabbett & Ryan, 2009; Gabbett, 2008). However, due to the manual nature of the process of the time taken to code each frame, this method was deemed time-consuming and inadequate for the use of real-time decision-making. Ensuing research shifted focus from quantifying contact to investigating the role of player position, tackle height and tackle location on tackling in match play (King et al., 2010a). Eight professional RL matches comprised, International, NRL and the National Youth Competition (NYC) games during the 2008 season were analysed. Findings consisted of most tackles involving two or three tacklers, contact with the mid-torso and hip-thigh region of the ball carrier and the adjustable playing group being involved in significantly more tackles than hit-up forwards and outside backs.

In RU, Paul et al. (2022) showed 37 studies to have used video analysis as part of a systematic review. This study showed that on average, 22 scrums per game, 116.2 lineouts and 156 tacklers occur per match. As tackles contrasted for forwards 12.8 (5.5 – 18.1) and backs (7.6 (4.3 – 10.9)). The limitations commonly cited in RL literature were echoed in the conclusions of this work, as the method was documented as laborious and reliant on human observation. A final conclusion by the authors was that microtechnology and video-based analysis should be used simultaneously to ensure maximal accuracy of the data. Research by Hollander et al. (2018) in RU further questioned the usefulness of the research performed in video analysis. Concerns were cited as the lack of sample size calculations, consensus definitions for variables and the transferability of the study's findings. Through both codes, it is evident that quantifying the tackle and collisions in rugby match play through video analysis has its limitations. It appears that in one-on-one, trials, there may be some applications, however, to use this in game play would not be sufficiently accurate on its own.

2.5.2 Microtechnology

Microtechnology dawned as the need arose to simplify the process of recording and monitoring training and match demands (Coutts et al., 2008). Thereafter, the application for GNSS (Global Satellite Navigation System) utilisation to monitor the tackle event and collisions began (Cunniffe et al., 2009). Subsequent research in RL, such as Gabbett et al. (2010), aimed to validate one microtechnology device (Catapult, minimaxX), using a momentum rating system (mild, moderate and heavy) from time-motion analysis to validate the unit. A near-perfect correlation was cited by the authors between video-coded collisions and microtechnology collisions (r = 0.96). Yet, a subsequent study by Naughton et al. (2020) highlighted the potentially problematic nature of the validity, as the study failed to report several factors (sensitivity, specificity and accuracy) relating to the precision of this microtechnology to detect collision events. Naughton and colleagues (202) also challenged a further study by Hulin et al. (2017) validating a separate unit (Catapult, Optimeye S5), suggesting the post-collection processing of the data to remove errors as a key limitation. This has been used for several studies to consider a plethora of factors relating to collisions, such as the comparisons of collision demands between leagues (NRL vs ESL), playing level (amateur vs semi-professional vs elite), field position (attack vs defence) opposition and team success (Gabbett, 2013; Gabbett et al., 2014; Hulin et al., 2015; Sirotic et al., 2009b; Twist et al., 2014). A more recent study by Rennie et al. (2022a) also investigated the seasonal differences in total tackle events over a seven-year period from 2014 to 2020. Here, Rennie et al. (2022b) unequivocally demonstrated the large positional variability between collision exposures and the increase in total collision events from 2020 in comparison to 2014 – 2019. This was partly attributed to rule changes in 2020 due to the return to play from COVID-19, however, the study establishes the need for regular (i.e., yearly) reviews on match demands. Yet, Paul et al. (2022) provided a continuation of the Rennie et al. (2022b) study in RU and sevens. A notable metric from the study highlighted by the authors was collision density. This was expressed as collision frequencies relative to the playing time, whereby only two studies in this review cited this component. This is potentially a key metric when assessing and monitoring fatigue of athletes. Given the inter-positional differences in game contacts for rugby athletes, it is prudent that a metric such as this highlights the different kinds of fatigue placed on players. Moreover, middle playing positions (hit up forwards) who are documented to perform more contacts in a shorter playing time and the subsequent effect of this fatigue on tackle proficiency. The authors also noted the lack of reliability and validity of microtechnology to assess contact loads in RU and sevens. They did, however, offer a solution in combining the video analysis and microtechnology data to distinguish between contact events and determine its accuracy. Unfortunately, this would still be labour intensive as an analyst would need to watch the video to assess the tackles.

2.5.3 Instrumented Mouthguards

As shown in previous segments, head injuries are the most prevalent injury across both codes, with a head injury assessment (HIA), following a suspected concussion (Tierney et al., 2018b). However, during tackles that do not result in injury, a player may still experience a head acceleration event (HAE), whereby an external collision force with either the head or body causes a short-duration head acceleration response (Tierney, 2024). HAE’s are of interest in recent research due to their association with complications later in life and neurodegeneration (Tierney, 2024). Instrumented mouthguards (iMG's) are a new technology that has the potential to adequately quantify HAE's through monitoring the frequency and magnitude of the event (Tooby et al., 2022). IMG's enable the quantification of both linear and angular head kinematics, owing to their embedded accelerometers and gyroscopes that are tightly coupled with the skull (Tooby, Till, et al., 2024). Recent research has aimed to quantify HAE's in RL, showing an incidence rate of HAE's exceeding 25g for back positions ranging from 0.86 – 1.88 and 1.83 – 2.02 for forwards. A higher probability for a HAE was shown for ball carriers (6.29%) than for tacklers (4.26%) (Tooby et al., 2025). However, there was individual variance amongst players as several players exhibited considerably higher probabilities and incidences than other players. Similarly, Roe, Sawczuk, Owen, Tooby, Starling, Gilthorpe, Falvey, Hendricks, Rasmussen, Readhead, et al. (2024) found in RU tackles and ball carries to have the highest magnitude HAE in comparison to rucks. However, the results also demonstrated that the higher magnitude HAE in professional men's RU match play are relatively infrequent, yet there are certain events (e.g., winning a turnover at the ruck) associated with an increase in the maximum HAE experienced in a single event.

Nevertheless, with all technology, there is a processing of assessing the validity and reliability, especially given the numerous iMG systems available to use. Jones et al. (2022) has shown in laboratory and on-field validity to be similar for Biocore-FRI, HitlQ and Prevent, along with practitioners' perceived feasibility and player perceptions on fit, comfort and function to be similar for Prevent and HitlQ. Prevent illustrated the highest false-negative performance and was second on the false-positive performance. Therefore, a key summary from the study was the crucial nature of selecting the appropriate system for the sport. Another limitation with the utilisation of this technology is the lack of historical data to provide insights into statistical norms. However, new studies such as Tooby, Woodward, et al. (2024) provide key data sets that, if collected longitudinally, may unlock new ways in which to track HAEs and contact loads.

To conclude, prior research has documented the potential benefits of combining video analysis and the use of microtechnology to track and monitor collisions. However, combining the iMG's along with the microtechnology and video analysis may provide more in-depth insights into the intensity of a tackle event or collision than is currently illustrated in the literature.

2.6 Coaching the Tackle Event

2.6.1 Coaching Philosophies

Central to understanding a coach's behaviour is their 'philosophy', which ultimately directs and informs their coaching (Cassidy et al., 2009). A set of personal values, beliefs, patterns of thoughts and systems of ideas has been used to outline the specific descriptors of a coaching philosophy (Burton & Raedeke, 2008; Lyle, 2002). Similarly, Hardman et al. (2010) proposed two factors that consist of a philosophy of coaching as axiology, including values of importance (performance); ethics, including moral values (time wasting to run out the clock) and ontology, which includes a core set of features and beliefs about existence and coaching that provide personal significance. To develop and understand coaching practice, the ability to reflect on the attributes of a coaching philosophy and articulate it is crucial (Lyle et al., 2010). However, as coaches gravitate in part towards a 'common sense view', there remains a lack of engagement with this process. As a result, researchers from 'outside' the coaching world direct the impetus for researching the basis of coaching and coaching knowledge, as opposed to the coaches themselves (Cushion & Partington, 2016).

In RL, some coaches have attempted to articulate their coaching philosophy through research articles (Wilkinson & Palmer, 2010). Throughout this work, the author notes their coaching philosophy as 'a caring guide to athlete self-discovery and self-improvement'. Similarly, Bennie and O'Connor (2010) align with this viewpoint as coaches from RL, RU, and Cricket highlighted the importance of developing the player as a whole, which will ultimately culminate in on and off-field success. Both approaches demonstrate the perceived value of a humanistic approach to coaching, outlining the unique values, attitudes and objectives that make up their individual coaching philosophies. However, how coaches come to form philosophies is a further variable that has been well-researched, showing that most coaches form these beliefs through a folk pedagogy of past experiences of 'what works' and what is perceived to 'get results' (Partington & Cushion, 2013). Insights into the deep-rooted history of rugby were offered by Spracklen (2012), illustrating the working-class identity of RL specifically in the north of England and Wales, along with unbroken traditions of community across the codes. Given how coaches form their philosophies through personal experiences and the strong traditions of rugby, it may be surmised that coaching philosophies are, in part, handed down through coaching generations. Frequently, without critical reflection, both the content and method of coaching strategies are passed from one coach to the next without examination of their applicability to the current cohort (Stoszkowski et al., 2021). Yet, it is evident that coaching philosophies grounded in research could be of key value when coaching the tackle. And whilst this remains crucial, very few studies have aimed to delineate this in either code of rugby, demonstrating a gap between theory and practice. Unlike a lot of other sports, collision sports have a clear divide between attack and defence, with a short focus on the transition in between. Crucial to an overall coaching philosophy would be a defensive coaching philosophy, given that this will direct the types and intensities of tackles that players might make. As such, it is of paramount importance that defensive coaching philosophies that have not currently been elucidated are investigated.

2.6.2 Coaching Behaviours

Stemming from the coach's philosophy, coaching behaviours direct the drills and activities performed in practice, which ultimately impact the performance profile and injury risk of the player. Specific behaviours such as instruction, monitoring, correction, feedback and management have been broadly identified to typify the coaching role (Cope et al., 2017). Yet, due to the specific nature of coaching practice in the sport and cohort, the timings, rates, frequencies and durations of behaviours vary between coaching contexts and from coach to coach (Potrac et al., 2007). Consequently, many coaching behaviours employed may be perpetuated by historical precedence within the sport, in contrast to the foremost research as illustrated by Williams and Hodges (2005). This study highlights common myths related to sports coaching, where other behaviours, such as feedback and how traditional trends of 'more is better' may not be as effective as other methods, such as intrinsic feedback, which the athlete is already receiving from their knowledge of performance. As a result, the coaching process has been the focal point for recent research papers by Hendricks et al. (2017) demonstrating that although coaches highly rated coaching of proper tackle, only 15 of their 96 sessions included a tackle training component, and tackle sessions only lasted an average of 17 minutes, which averaged as 16% of their total session time. Previous work has highlighted an epistemological 'gap' between their actual practice, their articulated knowledge and understanding of their practice (Stodter & Cushion, 2017). Multimethod studies have been at the forefront of coaching behaviour assessments, combining interviews and observations to form insights into coaching in the practical environment (Brewer & Jones, 2002; Smith & Cushion, 2006). This approach was argued to develop a greater understanding of the 'what' and 'why' of the coaches' behaviours to explore the deeper meanings behind their approaches. Research in RU, such as Granger (2014) combining three 45-minute observations with four varying levels of coaches, followed up by a semi-structured interview after each session. Key findings from this research noted the use of instruction, praise and observation techniques, employed to facilitate performance development and develop the coach-athlete relationship.

In more recent research, verbal feedback relating to an error in technical performance aiming to improve tackle technique had the largest influence on players' response to focusing on the training objective, in comparison to coaches who did not stress safety (Hendricks et al., 2020). Introducing a paradoxical viewpoint from opposing research, where focusing instruction and feedback during the execution of a sport-specific task internally towards the body part does not correlate with athlete learning (Smith et al., 2024). In this study, the Irish Rugby Football Union (IRFU) analysed the application of a coach education framework on coaching behaviours. The conclusions highlighted that behaviour profiles of the coaches did change post-intervention, with increased management and feedback behaviours. However, instruction behaviours remained unchanged, despite the shortcomings of this type of reinforcement. Furthermore, negative specific and general feedback increased as positive specific and general feedback remained unchanged. This was further highlighted by Morgan et al. (2020), who illustrated contrasting findings from six male Welsh RU coaches, as five of the six coaches believed their role was to improve performance by giving clear instructions. The contrasting final coach believed it was more beneficial to expose players to more chaos in training. A viewpoint Mckay and O'Connor (2018) shared, as the need to provide activities related to unstructured possession sources to enable decision making during unpredictable and chaotic game conditions. However, due to the precautions required regarding the tackle event, initial coaching may be required to be overly prescriptive in line with Hendricks, Till, et al. (2018) to enhance the initial safety of performing the skill.

2.6.3 Skill Acquisition Frameworks

Tackling ability is key to match outcome in rugby, with missed tackles highly correlated to losing teams (Woods et al., 2017). Tackling, however, is a learnable skill as Gabbett and Ryan (2009) have shown the significant difference in tackling ability between players who have played under over 150 NRL games, having a superior competence. Consequently, an abundance of recent research has been performed attempting to delineate coaching practices in rugby concerning the tackle event (Hendricks & Lambert, 2010; Speranza et al., 2017). In recent research, many skill acquisition theories have been offered to enhance the learning of athletes in a specific skill (Collins & Taylor, 2025). Ecological dynamics is one approach, blending ecological psychology (Gibson, 1979) and constraints on dynamical systems (Newell, 1986) to comprehend skilled behaviour and learning as the resultant process of the athlete to regulate their performance in relation to the constraints of the environment. Working within this theoretical framework, coaches are encouraged to move towards designing practice activities that athletes can interact with, as opposed to being conveyers of declarative knowledge about how a task should be completed. McKay et al. (2021) used such an approach with Super rugby side Queensland Reds during the 2020 season, signifying their role as a coach who uses an ecological lens to guide the search and exploration of players through the designing of practice tasks. Practice tasks that involve a level of safe uncertainty and controlled chaos, to promote creative performance solutions. To help facilitate practice designs, the author noted the regular manipulation of constraints (time, space, defensive formations and opponent tactics) as key in manifesting the required attacking principles. This paper did note several increases in attacking KPI's following the implementation of this approach, although they did note this could have been due to a range of factors, such as player recruitment from season to season.

Where ecological dynamics is a theoretical framework, focusing on how learning occurs, a constraints-led approach (CLA) is an applied coaching framework on how to coach using principles from ecological dynamics (Renshaw et al., 2019). CLA aims for the performer to generate effective movement solutions through the interaction of the task, environment, and the individual (Renshaw et al., 2010). Four key principles guide this framework and are as follows 1) match to the needs of the players, practice activities should have clear learning objectives, 2) the manipulation of constraints to guide and enable players to explore their environment, 3) training replicates the specific demands of the game and 4) through the use of variability in the drills, building instability within the learning activities to a degree

(Renshaw et al., 2019). Marshall et al. (2024) investigated the use of CLA in semi-professional RU players to cultivate and encourage the key conditions for creativity. The conclusions from this study were that CLA was effective in challenging the players to adapt to the environment when playing, explore various action possibilities and when implementing their skill behaviours, removed the perceived risks. Both theoretical (ecological dynamics) and applied (CLA) frameworks had positive outcomes on their respective tasks, both in RU. However, no current research has explored the use of this within a tackling context in RL or RU. Adding to the gap of investigative quantitative research required in subsequent investigations. Moreover, coaching practice structure is of interest in this area, as this will influence the nature of training and the way in which constraints are manipulated.

2.6.4 Coaching Practice Structure

In traditional coaching, it is typical for coaches to begin a session with a blocked (a fixed skill in isolation), constant practice (repetitive in nature) of a single skill, before progressing towards small-sided games and a more variable/ random practice (Williams & Hodges, 2005). However, a potential critique highlighted in the previous research is that progress in this fashion is invariably slow, as coaches measure themselves using performances in training. More recent research has advocated for practice that is specific to the competition (Williams & Hodges, 2023), theorising that the performance in training could potentially be secondary to the learning effect of the session. Collins et al. (2022) highlighted a similar point in elite RU players, showing a significant importance was placed on training replicating match conditions and being exposed to position-specific game scenarios to become perceptually attuned. A key element cited for RU players' decision-making capabilities in games were related to having previously experienced the situation consciously in training to perform it unconsciously in games. Here, players felt they were performing the skill unconsciously, even though there was a process of plotting and planning to assess the context of the situation. Although there may be a place for blocked, constant skill practice, focusing on more variable and random practice has clear benefits for a player in terms of transfer and application of learning. However, a crucial element here is how this relates to the tackle event. Unlike passing or side-stepping, given the significant transfer of energy in the tackle (Hendricks, Karpul, et al., 2014), it comes at a physical cost (Cummins et al., 2016). Therefore, how this is trained may be crucial in terms of skill acquisition and tackle proficiency in games.

Game-based approaches (GBA) have been utilised to enhance the cardiorespiratory performance of elite RU athletes (Gamble, 2004). Initially demonstrated as a model to develop students' understanding called Teaching Games for Understanding (TGfU); Bunker and Thorpe (1982). Since its introduction, there have been several other GBA's that have emerged, such as Game Sense (Light, 2004), Tactical Games Model (Mitchell et al., 2020) and the Play Model (Launder & Piltz, 2013) as notable examples. Kinnerk et al. (2018) has shown the advantages of GBA in team sports through improving players' tactical awareness and decision-making skills. Gabbett et al. (2009) summarised the advantages and disadvantages of a GBA in RL, documenting the value this method offers in improving skill and decision-making. Whereas limitations may lay in the inability to direct and control the intensity of the games. Light et al. (2014) reported similar disadvantages in GBA, illustrating a limitation of this method was coaches providing concurrent feedback. However, in New Zealand, four elite coaches considered GBA crucial for not only enhancing athletes' enjoyment and motivation but also preparing rugby players for match play. Unfortunately, there is little research on GBA with contact and collision sports that focus on the tackle event. This may be in part due to the high-cost nature of tackling and its lack of association with play form of games. However, in breaking down the crucial components of the tackle, there could potentially be key areas that are able to feed into constraints manipulated in game-based activities in future work.

2.7 The Tackle and Psychology

2.7.1 Psychology and Contact Sport Athletes

Since the professionalisation of both codes in the mid-90's, the utilisation of sports psychology in sports such as rugby has become ever apparent (Mellalieu, 2017). Despite this, Green et al. (2012a) have shown that although elite RL players displayed positive attitudes and a willingness to engage with sports psychology, only one confirmed having access to a full-time sports psychologist. Moreover, some perceptions of players cited that the attitudes towards sports psychology held by clubs' senior management and coaches were a significant deterrent in them accessing the support.

More recent research by Kola-Palmer et al. (2020) performed a cross-sectional survey with 167 professional RL players, citing that players who had sought help for mental health had a greater mental health literacy. Players spoke about several barriers to seeking mental health help, such as pride, embarrassment, fear and shame. Illustrating seeking mental health help to be crucial a further study by Kola-Palmer et al. (2018) found in two surveys (n = 77, n = 169) completed in consecutive seasons with ESL players, half of the respondent's experienced anxiety and depression. This study showed 45.5% and 38.5% of respondents to surveys one and two had experienced common mental health disorders in comparison to the general population of men in England at 13.2%. Potential reasons for this were cited as chronic psychological stress, which did emerge as the strongest correlate of mental health, with higher psychological stress being associated with worse mental health. Similar results were documented by Nicholls et al. (2020), who found in 233 ESL players from the 2019 season having higher mild, and moderate/ severe depressive symptoms along with mild anxiety symptoms. Which was higher than the general population of the UK when compared in line with previous work.

Comparable results were reported in Japanese RU Top League players, as 32.2% had experienced mild anxiety and depression, 4.8% had experienced moderate symptoms, with 5.2% experiencing severe symptoms (Ojio et al., 2021). A new finding in this study was 7.2% had experienced suicidal ideation within the last 30 days, however, this was purported to be in line with population norms (Van Orden et al., 2010). Missing games and a reduced competitiveness were athlete-specific factors associated with higher rates of anxiety and depression in the study, with athletes feeling a burden towards the team and a lack of belongingness. Taken together, the results of the previous research show rugby athletes across both codes having a higher proclivity towards anxiety and depression, potentially due to higher levels of chronic stress from performing in an elite environment. How this impacts performance has somewhat been delineated, however, how this influences performance in the tackle event has not.

The holistic development of players has been a key area of research in recent times, with merit given the prior documented research as illustrated by (Campo, Laborde, et al., 2019). This study investigated the applicability of psychological skills being employed by coaches, physiotherapists or trained sports psychologists, with the outcome providing mixed beliefs. A positive impact was shown by all instructors, as players were able to express their emotions, impacted by coaches specifically on measures of emotional intelligence. Therefore, the authors concluded, to improve mental preparation, with the appropriate training, coaches could deliver psychosocial workshops. However, to assist in the regulation of player emotions effectively, a sports psychologist was deemed more appropriate. Being able to cope with stressors was highlighted in prior work as part of the holistic approach to player performance (Nicholls et al., 2006). In this study, 8 male elite RU players took part in a 28-day diary recording of their coping with stressors. The study found that injury, mental and physical stressors were the most frequently reported amongst the players. To cope with the stressors, players cited concentration on the task, blocking, increased effort, and positive reappraisal as having the highest frequency.

This could potentially be the difference in the way in which players view their emotions, as Robazza and Bortoli (2007) assessed whether RU players perceptions of anxiety or anger and whether they found this facilitative or debilitative when performing. On the whole, players perceived anger and specifically controlled anger as facilitative. Whilst a moderate level of anxiety and a higher level of self-confidence were also seen as facilitative. Normally, anxiety and anger are viewed as negatively toned emotions, having a detrimental effect on performance. However, a potential reasoning for this, not offered by the author, could potentially be due to the physical nature of rugby through the tackle event. Moreover, the intensity of the anxiety may have also been a deciding factor as the previously documented work by Campo, Champely, et al. (2019) suggested high levels of anxiety or anger were associated with poor performances. Nevertheless, more research is required here to understand the association of psychological stressors and facilitators associated with performance to fully understand their relationship.

2.7.2 Mental Toughness

Understanding the mental strengths of elite performers has been a well-researched area due to its association with success (Jones et al., 2002). A systematic review of mental toughness Cowden (2017b) found superior performing athletes to have a greater level of mental toughness. Therefore, it is no surprise that this came as one of the initial investigations by Golby et al. (2003), aiming to identify psychological factors associated with mental toughness and hardiness in seventy international RL players competing in the 2000 RL World Cup from Wales (n = 15), France (n = 21), England (n = 21) and Ireland (n = 13). The overall findings from this research demonstrated that higher hardiness is related to improved performance in RL. Positive hardiness sub-scales such as commitment, control and challenge were key attributes documented by players. Whereas lower mean scores were shown for negative energy, imagery, and visualisation, which was surprising to the authors, given the reported efficacy on performance that these psychological variables bring. Given the benefits associated with performance, subsequent literature has explored the mechanisms to develop mental toughness to optimise performance (Parkes & Mallett, 2011b). The study employed cognitive behavioural techniques through identifying automatic thoughts to retrain attributional style. Semi-structured interviews with seven first-grade male RU players showed that participants developed an explanatory style for negative events that was more optimistic, had a greater resilience in adversity, and had higher confidence levels in their sport. The conclusions of this study illustrate that mental toughness is an ability that can be trained. Yet, the link with positive mental mindset indices has not been linked with the contact side of the sport in the form of the tackle event.

A further study in RL by Golby and Sheard (2004) investigated the different mental toughness and hardiness at contrasting levels. 115 athletes from international standard (n = 70), super league standard (n = 22) and division one (n = 23) took part in a questionnaire for both areas. The results suggested that international players were characterised by the most prevalent levels of hardiness, such as commitment, control, and challenge. International players also reported elevated mental toughness scores, scoring higher for negative energy control and attention control, albeit by a smaller contribution. It was theorised by the authors that players were able to control negative emotions and concentrate for longer periods than their counterparts at lower levels. Similar results were found in a study whereby 76 Italian RU players participating in the men's Six Nations took part in assessments of self-confidence and mental toughness (Robazza et al., 2025). Positive correlations were found between self-confidence and mental toughness, citing that athletes with higher confidence see a competition as a challenge in comparison to a threat. Nonetheless, there is a lack of research into understanding the implications of mental toughness or self-confidence in elite RU and RL. Gaining insights into these areas would provide a critical understanding of a complex area.

2.8 Literature Review Summary

This literature review covers several key sections and components of research related to the tackle event, such as injury epidemiology, proficiency, quantification, coaching and psychology. The tackle is a crucial skill performed in match play and training, influencing match outcome (Scott et al., 2023), whilst accounting for 72% of all injuries in RU (Hendricks, Karpul, et al., 2014), and 61% of all injuries in RL (Fitzpatrick et al., 2018). Concussion is the most prevalent injury amongst both codes related to the tackle, with an injury incidence of 15.5/ 1000 hours and 18.4/ 1000 hours in RL and RU, respectively (Eastwood et al., 2023a; RFU, 2024). Recent research has separated the tackle into tackler injury mechanisms and ball carrier injury mechanisms due to their notable differences. Variables that increased concussions for the tackler tended to be the ball carrier's use of a lead arm, the number of players in the tackle and the head placement of the tackler (Owen et al., 2025). Whereas ball carrier concussion mechanisms highlighted a 272 greater likelihood of a HIA in red carded tackles and a 56 greater likelihood in high tackles (Tucker et al., 2024). Other common mechanisms of increased likelihood of concussions across both events were a) both players accelerating, b) the speed of the tackler is higher, c) the opposition player's head is made contact within RU (Cross et al., 2019b).

Consequently, contact techniques have been at the forefront of tackle injury reduction research. Hollander, Ponce, et al. (2021a) identified eleven tackle techniques separated into pre-contact (body position upright to low, back straight with centre of gravity ahead of support base, head up and face forward and shortening steps), contact (contact with shoulder, contact the centre of gravity, head placement on the correct side) and post-contact (shoulder drive upon first contact, punch arms forward and wrap, and release the ball carrier and compete for possession). Yet, despite the importance of tackle technique in reducing injuries and increasing performance, coaches were shown to only attribute 16% of their total session time to this crucial component of match play (Hendricks et al., 2017). Moreover, there is little research utilising theoretical frameworks such as Ecological Dynamics or a Constraints Led Approach (CLA) to elicit rugby athletes to generate efficient movement solutions through interaction of the task, environment and individual. Therefore, the coaching practices, structure, and behaviours to garner optimal techniques need further clarification. Similarly, there is a paucity of research adequately quantifying tackle load, as IMG's build historical data to track concussion and HAE loads. However, notwithstanding the documented research exploring the tackle event, there remains a significant lack of inquiry utilising the stakeholders of the game to gain further insights. Additionally, there is little experimental research aiming to understand tackle proficiency adequately.

Chapter 3

General Methods

3.1 Introduction

The purpose of this chapter is to outline the approach to the research investigation and how the work was designed and carried out. Research paradigms, along with the chosen epistemological and ontological outlook, will be discussed. Further insights into the methodology and methods, such as reflexive thematic analysis used for data analysis, along with theoretical models utilised to contextualise the tackle event, will be explored. Ethics details for each study are available in Chapters 4, 5, and 6.

3.2 Autobiographical Positioning

As a resource to tackle personal reflexivity, a narrative biography was initially developed in the methodological literature focused on autoethnography (Ellis, 2004). In this process, researchers write freely about their background and discuss the motives that led to the initial undertaking of the research project, documenting the specific life experiences that might influence the research (Olmos-Vega et al., 2023). A central component of this approach is researchers reflecting on how their understandings of participants' accounts may be influenced by their personal experiences and potentially shape the results (Koopman et al., 2020). The primary role of reflexivity is not to neutralise the researcher or simply acknowledge the influence but to reflect and transparently outline how previous experiences might influence the decisions throughout the project (Olmos-Vega et al., 2018). Therefore, the current section offers several vignettes to serve as a biographical positioning, but also to serve as a reflexive journal for the thesis.

At the outset of this thesis, I was a current second-row forward for the French team Toulouse Olympique, having already completed 13 years as a full-time professional RL player. By the conclusion of my studies, I had played 248 games for five different clubs (St Helens, Leigh, Salford, Toronto, and Toulouse) over a 16-year period and retired at Salford Red Devils as a middle playing forward. Upon retirement, I remained in the sport as the current Head of Performance of Oldham Roughyeds, whilst also becoming a lecturer at the University UCFB and joining the Rugby Football League's (RFL) brain health subcommittee. Over the course of my career, I played in two grand finals, whilst at St Helens, won the championship on five separate occasions, and gained promotion with three teams (Leigh, Toronto, and Toulouse). The second-row position provides a specialist insight into the tackle event. Due to the pitch location, this position offers the connection between the forwards and the backs, usually playing 80 minutes per game, and as such is involved in a significant number of tackles. In my case, I performed a season high of 931 tackles over a 27-game season, whilst playing for the Salford Red Devils in 2013. What follows are two short stories that share brief insights into how the idea for this research came to fruition.

Whilst at Salford in 2014, our defensive philosophy was based on inside pressure from marker defender and what is referred to as 'A' defender, a common tactic employed by most teams. In round 17 of the 2014 season, Salford played Warrington Wolves at the Halliwell Jones Stadium. I complete an edge tackle, break from the marker position to pressure the inside and then I wake up on the floor. Roy Asotasi had span out of a tackle and unknowingly broke my cheekbone with his elbow, ending my season. As of the 2015 season, I joined Leigh Centurions but had not played since the prior June. I'd left ESL for the championship after a tumultuous end to my time at Salford with the aim of finding my love for the game again. The championship was and still is a much slower and physical competition. After a significant period on the side-lines, I underestimated the effect that breaking my cheekbone would have on my tackle technique and my overall tackling confidence. In my first game back, I was reluctant to place my head near an attacker for the fear of breaking it again, even though in this game I took a significant hit to the plate, which should've built my confidence. For this entire season, I struggled with my tackling, ultimately negatively impacting my playing form. I was also playing on the left side of the pitch, which was alien to me. After a relatively poor season by my own standards, I was staring down the barrel of what was once a promising career as an international youth player, playing in grand finals, to now being potentially moved on from a top championship team further down the leagues. I had recently moved out and bought a house, and now the pressure was beginning to build. During the off-season, I had a turn back moment. It was a point of going all in on my tackling, which I'd been criticised for all season, or keep going as I am and potentially find a new club, which meant financial ramifications and potentially having to sell my house. Every extra training session that I performed that preseason was based on my defence. I broke the tackle into sections and focused on each section, building my technique and confidence back up. Coming into the 2016 season, Leigh had signed a plethora of new players in my position. Yet, I kept my position in the team, having a form season and being asked to re-sign me for the subsequent ESL season. The coach who almost replaced me after the initial season left the team and asked me to follow him, to which I agreed.

In 2018, I was playing for Toronto Wolfpack, a new transatlantic team, in a more familiar position of right-sided second row for my previous coach at Leigh Centurions, who had transitioned to the team. The club had a lot of resources, and as such, we were one of the very few teams in the championship with Global Navigation Satellite Systems (GNSS) units to track and monitor training sessions. I had come across GNSS as early as my time at St

Helens, where RL was at the forefront of tracking training load. For the first year, I held a dual role within the club as a strength and conditioning (S&C) coach, where, during the second year, I transitioned out of this role as the club brought in a new S&C coach, and I could focus on playing. In the first year, we didn't have GNSS but operated on the rate of perceived exertion (RPE), multiplied by time to give an arbitrary unit (AU) of load. Yet, in my early days at St Helens, the data collected was used to describe training and match play. Whereas this was the first time I had come across GPS running loads influencing the training that players would perform. If our training load was high in terms of total distance, we would have a reduced training load for the subsequent week. As a player, I couldn't understand why our metres were reduced when we had performed too many metres in games or training, but our contacts in training were not reduced when we had performed elevated numbers. In the second row, I would usually perform 30 – 40 tackles per game. However, due to being a right-sided player who typically defends more, this could be in excess of 50 tackles. As such, I could not quite fathom why running loads were altered, and although my contact load was high, this was not tracked or considered. It was at this moment that I decided to research this area to add to the players' perspective, which I felt was sorely missing in the literature.

Throughout my studies, I had several trials and tribulations with injuries, no more impactful than the concussion I received in what would be the final game of my career, not by choice. The injury that medically retired me resulted in post-concussion syndrome that lasted four months feeling the full effects of the syndrome with some lasting effects to this day. This was easily the toughest challenge of my adult life, and without the support of my wife in particular, I don't know how I would have dragged myself out of it. The inherent nature of participating in contact sports is injury. To this effect, I would not discourage young people from participating in contact sports, quite the contrary, RL has given me some of the best memories in my life. However, it is up to us, the researchers, to now find ways to enhance the spectacle of the game whilst making it as safe as possible. This experience has given me a unique insight into the effects of the highest associated injury with the tackle, concussion. I have played the game for a long time at a high level, researched this area extensively, undertaken and received my coaching badges and journeyed through one of the most difficult injuries linked to the event. As such, my insights reflect the perspective of someone ingrained in all areas of the sport, using the rhythm, language, and terminology of ‘rugby people’. The findings should be considered within the context of the background provided.

3.3 Research Philosophy

A pragmatic research philosophy (Shah et al., 2018) underpinned this PhD, to answer the aims of the thesis and to plug the gaps in the tackle research that has been illustrated by the prior review. John Dewey, a classic influence on pragmatism, believed experiential learning to be key in solving real world problems and developing knowledge in an area (Luo, 2024). Pragmatism is a methodological approach that is a combination of positivism (objectivity) and interpretivism (subjectivity) that creates a focus on the researcher’s utilisation of both elements to answer and explore research questions developed from real world problems (Shan, 2022). Positivism and interpretivism differ in their ontological, epistemological, and axiological viewpoints. Positivism is defined by an objective and measurable human reality (ontology), where knowledge is gained via empirical methods (epistemology) and the researcher remains detached to minimise bias (axiology) (Park et al., 2020). Contrastingly, interpretivists suggest that many realities may exist (ontology), and the aim of the research is to understand the meanings behind human behaviour (epistemology), with the researcher is integral to the research (axiology) (William, 2024). However, the pragmatic approach merges the paradigms to hold a dynamic ontology that allows methodological flexibility through a problem-centred epistemology. Here, the axiology recognises the inevitable influence of the research but focuses on the real-world impact of the findings (Elgeddawy & Abouraia, 2024). Operating under a practical ontology, this research acknowledges that whilst there is a real physical aspect to the rugby tackle event, the experiences in relation to this event can vary. Epistemologically, this thesis accepts that to address the research question, both factual insights from quantitative data and contextual factors from qualitative research are required. Moreover, with a significant focus on the practical impact of the findings from the current research, the axiological stance reflects this viewpoint to recognise the value-laden nature of the inquiry. Pragmatism can provide a philosophical framework for mixed methods research that blends both qualitative and quantitative research (Biesta, 2021). Combining qualitative and quantitative research in this way can combine the strengths of each approach without subordinating one to the other (Gillespie et al., 2024). Within this paradigm, the research question dictates the method to effectively address a complex event such as the tackle. This provides a flexible framework for a PhD focused on an applied topic of study, generating in-depth knowledge. Therefore, a mixed methods approach is deemed optimal to provide the significant flexibility required to explore the multifaceted tackle event.

3.4 Research Design

A research design is the procedural plan for the research that encompasses the key decisions from detailed methods of data collection and analysis to broader assumptions (Creswell, 2009). Of the three approaches to designing research, mixed methods integrates both qualitative and quantitative data with the core assumption that this form of inquiry will yield greater insights beyond that of a sole approach (Creswell & Creswell, 2017). The criteria for selecting a research approach are influenced by a myriad of factors, such as the research problem and questions, audience, and personal experiences. Highlighted in the literature review, there is current descriptive research illustrating match demands and injury surveillance in elite rugby. Yet it is apparent that there is a lack of qualitative and investigative quantitative research in elite rugby. Creswell and Clark (2017) identified triangulation, embedded, explanatory and exploratory as the four key designs of mixed methods research. A triangulation design is employed to directly compare statistical results from quantitative work with qualitative findings. In contrast, an embedded design is used when one data set provides support as a secondary role to another data set. Moreover, an explanatory sequential design uses qualitative data to build upon initial quantitative research. This is a two-phased mixed methods design, where the emphasis is placed on the quantitative element of the study. The final design is the exploratory sequential design, whereby the initial phase of the research has a qualitative focus that is subsequently followed by quantitative research to further explore and extend the themes emerging from the qualitative results. Adopting an exploratory sequential design has typically been justified in the literature due to measures not being available, a lack of a guiding framework and theory or unknown variables (Creswell & Plano Clark, 2011). Therefore, this thesis opted for a multiphase exploratory sequential design, where the initial phase would consist of collecting qualitative data in an exploratory fashion. Exploring an under-researched area in this way provides crucial insights for the second phase. Thereafter, in the second phase of quantitative research builds upon the initial findings, which extends into a final exploratory qualitative phase to further explore the results (QUAL → QUANT). Therefore, allowing the findings from one research project to develop and inform the investigation of subsequent research projects. The two distinct phases represent the three initial studies in the first phase, followed by the second study in the second phase.

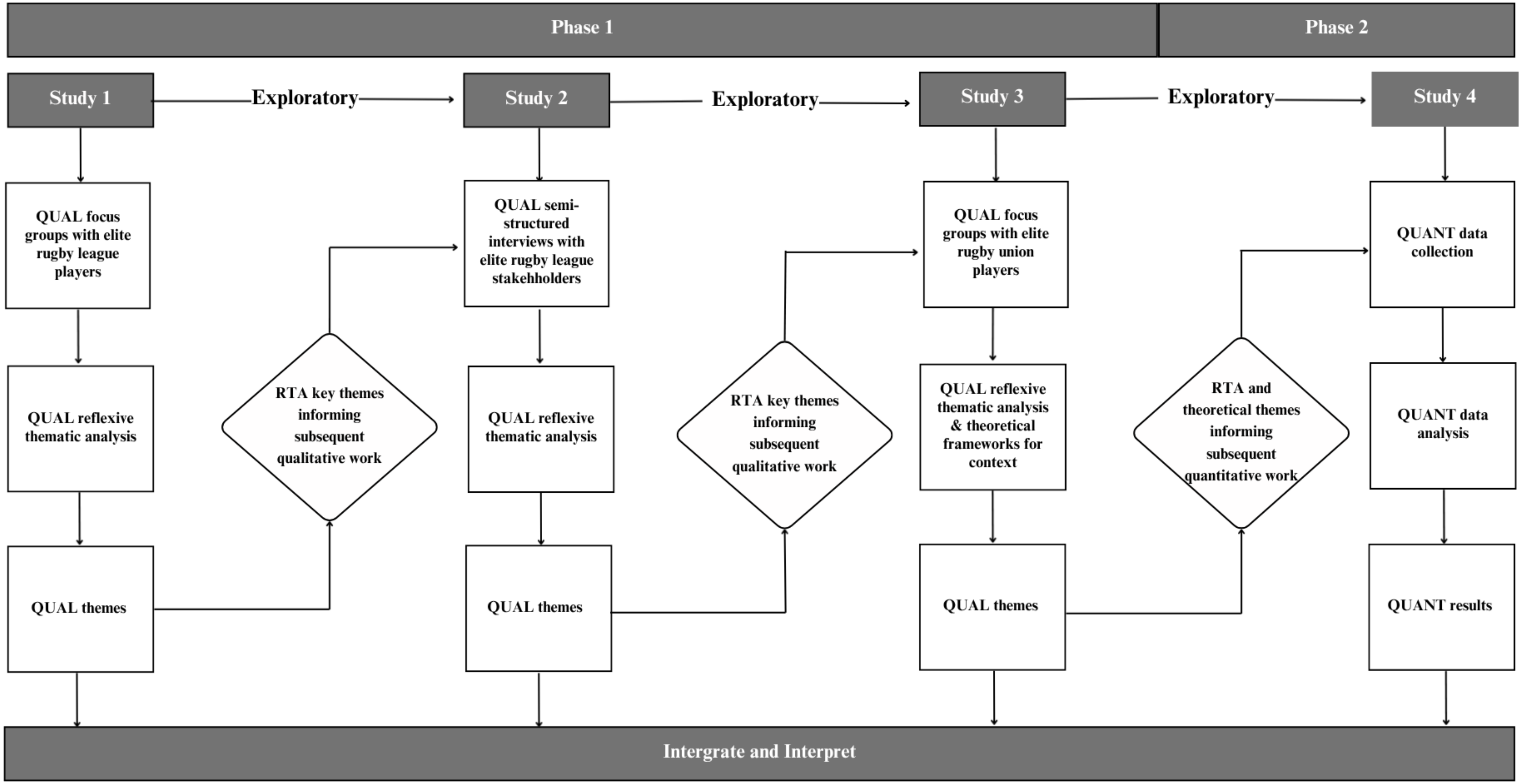

Fig 2. Research design for the entire study.

3.5 Research Methods

Encompassed by the two methodologies (quantitative and qualitative), this thesis has incorporated three contrasting methods. Method selection was chosen through the pragmatic approach to generate contextual understanding and objective measurement of the rugby tackle (Shah et al., 2018). A sequential design ensures the integration of both methodologies, as the initial qualitative research informs the final quantitative element shown below.

3.5.1 Qualitative Strand (study 1, 2, & 3)

In the premier phase, studies one, two and four employed an interpretivist exploratory qualitative approach, selected for its ability to generate rich in-depth information and nuanced perceptions that shape the tackle event.

- Study One: A focus group design to explore the tackle event with elite RL players and gain insights into their experiences of the tackle. Focus groups facilitated a deep exploration of how players experience the tackle event specific to their sport. Focus groups were the preferred method of data collection due to their advantage in generating rich amounts of data across a diverse breadth of subjects(Kitzinger, 1995).
- Study Two: A further study in the form of one-to-one semi-structured interviews was adopted, aligning with previous research designs that aimed to develop or construct knowledge about individuals and their subjective experiences (Sparkes & Smith, 2014). The semi-structured interviews aimed to investigate the tackle event through the perceptions of elite RL stakeholders (coaches, physios, strength and conditioning coaches and doctors). Semi-structured interviews were the chosen method over focus groups to protect the privacy of elite stakeholders discussing the inner workings of their club. Harrell and Bradley (2009) highlighted this as a key benefit of interviews in comparison to focus groups.
- Study Three: A final study, through the focus group medium, to explore the tackle event through the perceptions of elite RU players. Focus groups were again chosen due to the

key element of co-construction of knowledge generated during the group interaction and to replicate the depth of data provided during the first study's focus group (Bader & Rossi, 1998).

3.5.2 Thematic Analysis and Reflexivity

Thematic analysis (TA) is a widely popular qualitative data analysis method utilised in many disciplines and fields (Ahmed et al., 2025). A TA minimally organises and describes the data set in rich detail by identifying, analysing and reporting patterns (themes) within the data (Braun & Clarke, 2006). The strengths of TA lay in the detail and breadth it offers across a sample, applying a systematic process to a flexible qualitative method. Yet, TA is not a lone-standing method but rather an umbrella or set of approaches in analysing patterns of meaning in qualitative data (Braun, 2023). There are often cited three derivatives of TA, termed coding reliability TA, codebook TA and reflexive TA. More recently, Braun and Clarke (2019) cite developments in the approach to TA, forming more reflexivity in the approach. This approach, acknowledging the researcher's subjectivity as a strength of the analysis, as the themes are actively created by the researcher as opposed to 'emerging' from the data, as the initial study invoked. The process is flexible and iterative, with reflexivity central to the analysis. The quality of the analysis emerges from deep engagement with the work and thinking critically about one's own assumptions. A primary reason to choose an analysis such as this is when working with different qualitative data (focus groups/ interviews), the capacity to handle complexity and the transparency and rigour highlighted through the researcher.

Therefore, to analyse the data throughout the qualitative phase, an RTA was performed throughout the three studies. Grounded in Braun and Clarke's reflexive systematic approach to organise, identify, and report patterns within the participants' views and lived experiences.

A crucial component of RTA is its flexibility, as such, it can be used within most theoretical frameworks, data sets, and data types. Since little is known about the tackle event in RL from a qualitative perspective, the RTA's strengths provide the breadth and detail to identify nuances amongst the datasets. Furthermore, the researcher is the study's primary instrument, responsible for collecting, analysing, interpreting, and reporting the findings. This was a perceived strength of the studies in co-creating the themes. Conversely, some research suggests limitations can lay in the lack of analytical rigour behind the systematic process of generating (Javadi & Zarea, 2016). However, utilising the six-step systematic process as a guide ensures a standardised process throughout the analysis. In this process, firstly, once transcribed, familiarisation with the dataset began, and notes were made whilst thoroughly re-reading the transcriptions. Initial codes are systematically generated following this from the features in the data. Potential themes are collated from the gathered data and codes. A review process then took place with research team members over three separate meetings to establish if the themes worked in connection to the coded extracts. Clear definitions and names for each theme were then refined from the specifics of each theme. In the final analysis, extract examples were selected linking to subsequent studies and the research questions. Lastly, a report is produced whereby existing quantitative literature is examined alongside the findings of a qualitative study. All analytical approaches

3.5.3 Quantitative Strand (Study 4)

In the second and final phase, the quantitative strand was designed to follow the initial exploratory qualitative phase and test the specific hypothesis generated from the theme's findings. Study three utilises a positivist conclusive paradigm through a randomised crossover trial as a repeated measures experimental design. This approach was selected for its ability to objectively test the specific conditions in relation to tackle proficiency.

- Study Four: A randomised cross-over trial, with a repeated measures experimental design, that aimed to understand the relationship between fatigue and tackle proficiency in different match conditions. This approach was selected to allow the precise manipulation of independent variables such as match speed and contact load, along with the measurement of internal and external dependent variables such as tackle proficiency and heart rate.

3.5.4 Rigour

Reflecting the paradigmatic assumptions, in qualitative research, assuring rigour and trustworthiness is established through the transparency and credibility of the accounts expressed by the participants (Tracy, 2010). To enable this, open-ended and neutral questions were utilised during both the focus groups and semi-structured interviews to provide time and space for participants to share their experiences. It is essential that reflexivity is at the forefront of the research to critically examine one's beliefs and assumptions and how they might affect the interactions with the people and content under study. Therefore, it is good practice to reflexively detail their role and credentials (Hill & Dao, 2020). The autobiographical positioning provides this background knowledge to the reader, whilst each qualitative chapter details the experiences and qualifications of the other authors included. In keeping with recent developments in thematic analysis, these authors did not seek to demonstrate inter-coder agreement but sought to critically question and identify differences in perspectives as a means of refining codes and themes. Additionally, member reflections were undertaken in each of the studies, where each participant was provided with the fundamental outcomes of the study (Smith & McGannon, 2018). Through this process, participants confirmed that the analysis was a credible account of the focus group. Member reflections are provided in the Appendices at Figures 8, 9, and 10 from all studies.

Quantitative rigour is approached from a contrasting standpoint, aiming to assess the validity and reliability of research. Validity is established as the extent to which a quantitative study accurately measures a concept (Heale & Twycross, 2015). Whereas, reliability refers to the consistency of the measuring instrument used over time and its stability in providing similar results when applied on different occasions (Sürücü & Maslakci, 2020). Duckett (2021) describes excellent characteristics of quantitative research, having clear research aims, managing biases of researchers, selecting a suitable research design and reporting research processes transparently. All of which chapter 7 outlines in significant detail. Yet, the pragmatic paradigm, conceptualised by John Dewey, utilised in the current study, seeks to address real-world issues for the benefit of participants by utilising the best methods available to acquire of knowledge (Riga, 2020). Using both qualitative and quantitative approaches aims to solve contemporary problems utilising real-life experiences. The aim of the current study was to explore the rugby tackle event, contributing to the current landscape and to apply new methodologies for understanding the tackle. By outlining the steps taken to ensure rigour, the current thesis provides a credible account of the mixed-methods research process.

Chapter 4

Title:

Understanding Elite Rugby League Players' Experience of Collision, Effective Contact Coaching Techniques, and Player Contact Psychology: A Group Study

4.1 Abstract

The current chapter performed a series of online focus groups to understand elite RL players' experiences of collision. Eighteen RL players, comprised of different playing positions from four teams, were recruited to participate in a series of online focus groups via the Microsoft Team's platform, facilitated by a moderator. Players were competing in Europe's elite RL competition, the European Super League (ESL), during the 2021 season. All focus group data were transcribed, coded and analysed using Braun and Clarke's (2019) reflexive thematic analysis guide to ensure robust exploring, interpreting and reporting through pattern-based analysis from the dataset. The findings of this research are split into five key themes: 1) the three-man tackle - the perceived optimal defensive strategy with simultaneous contact, 2) not all collisions are the same; match play events change the collision intensity, 3) bracing and blindsiding – two factors that influence experiences of collision and concussion, 4) coaching philosophies and orientations, 5) psychological readiness for collision. Collision sports have an inherent risk of injury, however, in some players' subjective experiences, there are collision types that have a greater association with risk or intensity (blind-sided collisions or long closing distances). It is essential that future research comprehends the effects of these collision types and the further themes to fully understand optimal ways to perform collisions and collision-based injuries.

4.2 Introduction

In section 2.2, this thesis outlines the substantial tackle demands in elite RL match play with teams combining to complete more than 600 tackles per match (Burger et al., 2021). Moreover, in segment 2.3.2, the significance of the sport's most frequent injury, ubiquitous with the tackle, concussion, is illustrated at 15.5 per 1000 hrs (Eastwood et al., 2023b). Outlining the long-term health implications and potential association with neurodegeneration in contact sports athletes (Alanazi et al., 2024a). Yet, despite the considerable number of contacts elite RL players perform during match play and the association of the tackle with concussion (Gardner et al., 2021b). No current study has sought to explore the perspectives and experiences of the players undertaking the event in elite RL. As such, key mechanisms underpinning injuries resulting from the tackle have only the descriptive data tracked from matches, potentially lacking context that players can provide. Furthermore, current coaching practices continue to be deprived of player tackle insights from a performance and injury perspective. Therefore, the research has few alternative avenues to explore than the ones previously travelled, i.e. video and microtechnology-based methods (Naughton et al., 2020). Whilst future research may strengthen the effectiveness of quantitative measures by incorporating machine learning methods into microtechnology, qualitative measures remain a void in the tackle literature. Addressing this will provide an understanding of the intricacies of the tackle event through the lens of the players who experience them. Together with existing quantitative work, such qualitative insights can assist policymakers in connecting research and practice.

Qualitative research can be utilised in the exploratory phases of an investigation to refine future research questions or topics and bring creative solutions to light (Kitzinger, 1995). For example, Murray et al. (2022) have documented the ability of qualitative research to highlight novel themes from lived experiences in elite rugby and draw conclusions that may not have been possible from a quantitative perspective. There are various methods qualitative researchers may use in the process of collecting data, such as interviews and focus groups (Sparkes & Smith, 2014). Focus groups work particularly well in exploring the perceptions of participants (Krueger & Casey, 2014). This approach assembles a group of individuals to discuss a specific research topic that generates collective views and analysis of the meanings that lie behind those views (O.Nyumba et al., 2018). Accordingly, the current chapter aimed to perform a series of online focus group discussions with elite RL players to ascertain players' perception of collisions in training and match play to allow a greater understanding of the technical strategies, coaching philosophies, injury mechanisms and psychology of collision.

4.3 Methods

4.3.1 Participants

Following institutional ethical approval, and in keeping with qualitative approaches (Sparkes & Smith, 2014), the first author purposively recruited participants with direct experience of the phenomenon. Purposive sampling was employed to ensure a diverse representation of European Super League (ESL) players. The reason for this was twofold; firstly, RL players have shown varied match demands across their respective positions (Glassbrook et al., 2019), and secondly, a distinct difference in match demands between the top 4 and the bottom 4 teams has been shown, as demonstrated by Gabbett and Hulin (2018) and the polarities in skill involvements (play the balls, missed tackles and offloads) between teams finishing at the top of the table (1^{st} – 4^{th}) and the bottom (13^{th} – 16^{th}). Eighteen RL players, consisting of forwards (n = 6), adjustables (n = 7) and outside backs (n = 5), were recruited to participate. Players were competing in Europe's elite RL competition, the ESL, during the 2021 season. The mean ± SD age and playing experience in elite RL were 29 ± 4.6 and 9.3 ± 6 years. Four clubs were recruited from the ESL, two with a win percentage above 0.500 (n = 9) and two with a win percentage below 0.500 (n = 9). All participants were provided with a participant information sheet and an explanation of the study, including the risks and benefits of participation, and written consent was obtained. Exclusion criteria were in line with the Rugby Football League (RFL) medical standards (players who had unsuccessfully performed a head injury assessment, resulting in a sport-related concussion within the previous two weeks or experiencing persistent post-concussive symptoms were excluded).

4.3.2 Design

Four separate focus groups were conducted online, utilising the Microsoft team's platform, for over one hour and were facilitated by a moderator. A semi-structured interview schedule was developed to guide the discussion, termed the topic guide for the analysis, with the following four areas discussed: 1) offensive and defensive collisions, 2) collision monitoring, 3) defensive coaching philosophies and 4) the psychology behind collisions. Specific questions in the themes were discussed, however, given the dynamic nature of the focus group approach, the researcher adopted a pragmatic approach to probe and enquire before returning to the focus group guide. The questions used in the topic guide are exemplified in Appendix Figure 1. The focus groups ranged from three to seven participants in line with Barbour's (2007) recommendations. All focus groups were recorded and transcribed utilising the Jeffersonian transcription system, which records the detailed features of talk and interaction (Sidnell & Stivers, 2013).

4.3.3 Analytical Approach

The focus groups were analysed in line with the reflexive thematic analysis as outlined in the general methods section.

4.3.4 Rigour

Member reflections were undertaken to ensure the findings in the current chapter highlighted the views discussed during the focus groups. The member reflections can be seen in Appendix Figure 8.

4.4 Results and Discussion

This section is divided into five themes. Utilising the transcribed raw data, sixty-seven first-order codes were developed, following thirty second-order codes being established, and from this, the five themes were generated, which are set out below. The themes table may be found in Appendix Figure 2.

Theme 1: The Three-Man Tackle - The Optimal Defensive Strategy

Simultaneous contact (two players contacting an attacker's upper body at the same time, followed by a third lower limb tackler) was a common theme mentioned by several players from different positions to illustrate the 'perfect' collision in defence. The forces of two shoulders contacting the upper body and stopping momentum were described as a key indicator as to why this method was advantageous. For example, 'Jordan' (P2G4) describes his perception of the perfect tackle. "Yeah so the perfect tackle would be simultaneous contact two of ya um stop him in his tracks and then the third man just coming in". Below is a segment by ‘Ricky’ (P3G3) in which he furthers ‘Jordan’s’ perceptions of performing a collision simultaneously.

> ‘Ricky’: The best is to be two-man contact so you wanna hit together with your teammate next to you um down their end especially and well as often as you can really um good defences does that it’s just um I say if someone is carrying on my right shoulder I hope my teammate it’s his left shoulder so he can so you both can put forces together into the tackle and um onto just one guy so the force is just times two really. (P3G3)

Tackling proficiency has been documented throughout the literature in both match play and training, with studies such as Gabbett (2008) largely focused on one-on-one collisions. Although no studies in elite RL literature mention simultaneous contact, a video analysis study by King et al. (2010b) showed most tackles from the 2008 season involved two or three tacklers, with contact to the hip and mid-torso of the ball carrier. ‘Ricky’ illuminates the perceived benefit of players utilising simultaneous contact as forces of each shoulder affect the attacker at the same time. This, in turn, allows the ‘play the ball’ speed (i.e., the ruck) to be controlled because the attacker's momentum is stopped. Momentum is described by Gabbett et al. (2010) as a key indicator of collision intensity, and continuing momentum in the collision is a signal of a collision loss for the defensive team. In a further focus group, two instances from ‘Carlo’ (P3G2) show that although performing simultaneous contact is the initial aim of the collision, there is still an optimal process that follows to complete the tackle with the third man.

> ‘Carlo’: Yeah generally you want to do a simultaneous tackle … two men up top the person that has got the ball-carrying arm will wrap the ball up the other person will just get his body in front and then we hope we’re looking for a third man then to come around the legs and take his legs away. (P3G2)

Interestingly, the mechanisms of tackle selection and injury risk to the attacking player have been documented in prior studies (King et al., 2012a). Yet, the effect on match demands from performing the different roles in the tackle is a notable literature gap and an area for future research.

Theme 2: Not All Collisions Are The Same; Matchplay Events Change The Collision Intensity

Certain facets of RL match play, such as kick-offs, dropouts, and kick returns, potentially facilitate players increasing their speed into a collision due to the increased distance between teams. In this theme, players conveyed that collision closing distance (the distance travelled between two players before the collision) does affect the intensity of match-play collisions, given the increased velocity of the players. Interestingly, no player mentioned the risk of injury in association with this type of collision, which may demonstrate that velocity into contact is not the only indicator of risk of injury in a collision. Below, 'Carlo' (P3G2) and 'Derek' (P4G2) from one focus group cite, in reply to the moderator, kick-off carries or wingers returning the ball as some of the most intense collisions during match play.

> Mod: Are there any other determinants of where a collision might be more intense than another one?
>
> 'Carlo': Kick-off carries. (P3G2)
>
> 'Derek': [Yup]. (P4G2)
>
> 'Carlo': Or wingers returning the ball when they've got a twenty-thirty metre run up so it's the time time to pick up full speed isn't it. (P3G2)

Two different focus groups reiterated this theme with 'Lennox' (P1G3) stating "kick-offs dropouts and probably kick returns for backs are probably the most um high-intensity" and

‘Ricky’ (P3G3) “for the carries and the tackles the heaviest they are is when like long metres in front of you so kick-off and taps even taps like when you find touch get a penalty”.

Concussion rates in RL are higher (15.5 per 1000 hours) than in other contact sports such as soccer (0.06 per 1000 hours) due to a multitude of factors e.g., frequency of high-impact collisions performed being the foremost. Collision closing distance and head impact biomechanics have been the subject of a considerable amount of literature in recent years (Ocwieja et al., 2012). The outcome of this research is mixed, with some studies suggesting American football players on special teams experience greater head impacts on plays over long closing distances, and other literature such as Campolettano et al. (2019) finding no link. Nevertheless, the National Football League (NFL) have altered the rules to reduce the number of kick-offs returned and to limit the speed of the players on the kick-off coverage team. This is noteworthy because the set restart kick in RL is very similar to the new set restart distance that special team players experience in American football. Cautiously, there are differences, including the blockers that are present in the NFL but absent from RL. Nevertheless, there is no current research in RL considering the effect of closing distance on collision-related injuries. It would be reasonable to surmise, therefore, that the most intense collisions potentially carry some of the highest risks, primarily given the role of velocity in the closing distance and the influence of velocity on the difficulty of the technical execution of a tackle. However, when contemplating rule changes, it is recognised the objective is to maintain as much of the identity of the sport whilst reducing as much of the risk of injury as possible. Whilst the removal or reduction of collisions with large closing distances could be an area for future research, the lack of association with collision-related injuries and this match event mentioned by players may dictate other areas to take precedence.

Theme 3: Bracing and Blindsiding – Two Factors That Influence Experiences of Collision and Concussion

Bracing and blindsiding were two factors demonstrated by players in the current study to have associations with collision-related injury risk. This theme explores the ability of players to anticipate where the collision is coming from and the different exposure for players in the middle and adjustable positions. The influence of bracing for the tackler is also investigated, and the role of fatigue for defensive players performing a collision. 'Ross' (P1G4) demonstrates this below.

> 'Ross': I had the luxury of testing out the middle this week so and as bad as that sounded I actually found it easier carrying the ball in the middle because I knew I was gonna carry the ball so I was set for being whacked as opposed to tryna open some space up for me teammates on an edge … I honestly think twenty times I've been concussed where I've gone to the line irrelevant on whether I've thrown it or um or dummied and been whacked in the side below the jaw and it's knocked me out and nothings touched me head. (P1G4)

Here, Ross not only highlights the danger of 'blind side' tackles but also identifies how this is most likely to occur to a player on an 'edge' rather than the middle i.e. adjustables.

Previously, Kung et al. (2020) documented the potential effects of visual performance, oculomotor behaviour and anticipation on the severity and frequency of head impacts. In anticipation of contact, the head and neck are suggested to be braced, improving dynamic stabilisation of the head and reducing concussion risk. Despite bracing for collision being novel amongst RL literature, Garraway et al. (1999) showed in Scottish RU that 25% of injuries materialised as a result of tackles occurring from players' blind spots and 40% of injuries occured when a player was tackled from behind. Nonetheless, the link between bracing for impact and being tackled from behind has not been explored. This is an important area for future work with 'Gary' (P2G3) and 'Ricky' (P3G3) also suggesting that the worst collisions are the ones they do not expect when they are attacking.

> 'Gary': The blind side the one where you get blindsided are again the ones where you're not expecting it so you're not bracing generally when you're tackling you know that the contacts coming so you brace for it and you prepare for it whereas the contacts when you're not expecting it are the worst ones. (P2G3)

> 'Ricky': For me as Gary said like for us it's more like the blind-sided one um who gets heavy. (P3G3)

While 'Gary' (P2G3) expands on a player's inability to brace for blind-sided collisions, he states that defensive players know where the contact is coming from when tackling. Contrarily, from another focus group, 'Tim' documents the inverse below, citing that as a defender, the point of collision could change at the last second, with the element of fatigue making it harder to react. 'Tim's' mention of this was the only instance in the focus groups, yet prior research (Delves et al., 2023) suggests the tackler is 1.7 times more likely to experience a head injury assessment (HIA) than the ball carrier. This difference in experience may be due to interposition discrepancies, as stated by Ross, Ricky and Gary of the adjustable group. However, one component of Tim's comment that is of note is the role of fatigue in defensive collisions. This is especially significant given the introduction of rules such as the 'six-again' and the impact this has in increasing fatigue, heightening the exposure to collision-related events such as carries and tackles (Rennie et al., 2021). This point was echoed in a further study by Naughton et al. (2023) who demonstrated the influence of technical-related fatigue on aspects of match performance, including collision. Tim expresses that the combination of the unpredictability of collision as a defender and fatigue reduces reaction times and makes it more likely for tackle technique breakdown through poor head positioning. Nonetheless, the recurrent characteristic of both the bracing and reactive/ anticipatory elements is their substantial reliance on oculomotor behaviours and anticipation. 'Tim' (P2G1) and 'James' (P4G1) discuss this point below.

'Tim': Well the ball carrier knows where he's going doesn't he but as a defender you don't know where the collision is going to be so all you're doing is you're accelerating into collision but the point of collision could change at last second so that's the most like we were saying before the more fatigue comes in the harder it is to react and the more likely you're gonna get your head in the wrong place as a defender. (P2G1)

'James': Yeah it's so unpredictable as a defender isn't it. (P4G1)

As Kung's review suggests, exploring sports vision training may assist with concussion risk reduction through improved visual-motor control and eye quickness. It is also unequivocal that rule changes such as the 'six-again' are shown to have a crucial effect on all aspects of match play (King et al., 2022). Before the 2022 season, two on-field disciplinary guidances were altered for the grading of high tackles and dangerous contacts (Rugby Football League, 2022). In an effort to reduce concussive and sub-concussive impacts, the "excessive flexion" terminology was removed to lower the threshold for off-the-ball contacts. Taking into consideration 'Ross' and 'Gary's' accounts, it is evident that some players agree that these types of blind-sided collisions carry significant risk. Similarly, it is also apparent that other rule changes, like the 'six-again' according to 'Tim's' account, could potentially have some detrimental effect on players' ability to execute the optimal technique due to increased fatigue. Undoubtedly, the governing body (RFL) has aimed to augment the spectacle of the game whilst making it as safe as possible. Still, despite some rule implementations rightly attempting to aid player safety by potentially avoiding the blind-sided collisions mentioned above and some aiming to aid the spectacle of the sport, the players' experiences illustrated in this study provide additional insights as to how to increase player safety whilst maintaining the essence of the game.

Theme 4: Coaching Philosophies and Orientations

Coaching philosophies reflect the foundation that can direct and guide many aspects of the coach's delivery and coaching practice (Cushion & Partington, 2016). The current theme describes contrasting coaching philosophies and how they influence the types of collisions players make. The influence of tackle proficiency metrics in coaching philosophies is examined, along with optimal ways to cultivate player buy-in into defensive systems. One of the key underpinnings of this theme was that defensive coaching philosophies in RL derive from one of two main thoughts, collision-orientated, and wrestle-orientated. 'Allan' (P3G1) and 'Gary' (P2G3) from two separate groups elucidate these philosophies.

> 'Allan': Our coach as an example at the minute like Coach A was like ((hand motions forward)) <u>kill kill kill</u> and it was all about hard collision hit um as hard as you can whereas like Coach B has come in and it's a bit more hit the ball wrestle. (P3G1)
>
> 'Gary': Like I said, sometimes people would rather have a team of cuddlers and make it slow play the ball. (P2G3)

This was followed by the thought that although a new coach may prefer players to tackle in a certain way (collision or wrestle-orientated), players would perform collisions the way they felt suited their attributes. 'Ricky' (P3G3) shows this account. "When the new coach but it might be he wants us to tackle a bit differently but then at the end of the day it's what suits you best really".

Literature grounded in RL coaching philosophies has centred around managing players, assisting players with off-field issues and teaching improvement (Bennie & O'Connor, 2010). This is quite removed from the iterations noted in this theme relating to coaching philosophies. Recently, Hollander, Lambert, et al. (2021) found a lack of association between players' knowledge of collision and actual tackle contact technique, suggesting players may benefit from referring to a coach for technical contact cues. Interestingly, no player mentioned proficiency metrics prominent in non-injurious events as opposed to concussive events raised in studies, such as Hendricks et al. (2016) namely, head placement on the correct side of the ball carrier, shoulder usage and leg drive upon contact. Another study by Hendricks et al. (2017) illustrated this point further; they found that regardless of coaches recognising the importance of teaching the technical components of collision, only 16% of the total training volume manifested as technique training. The second significant segment of this theme is entrenched in coaching behaviours and their effect on collision frequency and intensity training. 'Ross' (P1G4) cites how collisions may be increased for poor defensive performances as a punishment.

> 'Ross': You get irrational coaches who are desperate to keep their jobs or desperate to win and they think more physicality is the way forward or they wanna punish you for being soft ((inverted commas)) and missing a tackle and I've never seen it really work and I've seen it over and over and over again - more often than not it's a technical side of thing or a lack of effort because people's minds are not fully behind it and umm and you end up with a few more injuries and it slowly starts to spiral downhill um so yeah I think a lot of its reactionary stuff not I don't see the best coaches doing. (P1G4)

This kind of reactionary behaviour was not perceived by players to be implemented by the best coaches. Research by Gibson and O'Connor (2023) identified two decisive phases integral in responding to loss in elite sports. First was the pre-losing streak phase in which coaches would set the cultural direction of the team before the season began. In this phase, individual motivations and aspirations are used by coaches to attach the highest personal meaning to performance to access greater responsibility and accountability. The second prominent phase was during the losing streak, when it was noted that some coaches emphasised the need to work harder during this period as their team was not playing hard enough. Unfortunately, this resulted in a suffocating effect, eliminating the fun and enjoyment aspect of training. This echoes the sentiments in the existing study of players' experiences of coaching behaviour which 'Allan' (P3G1) and 'David' exemplify below.

> 'Allan': That's down to what coaches do some coaches don't do any whack like you hear Club X and that I mean I wasn't there. (P3G1)
>
> 'Tim': [Yeah]. (P2G1)
>
> 'Allan': What do you think with that David it wasn't like that was it. (P3G1)
>
> 'David': No no not at all um just more technique um he wouldn't have let us chop legs or anything in training um and if anyone did go overboard he he would pull em out um similar Coach Y was a bit like that if you remember. (P6G1)

It is apparent across focus groups that coaches influence the types and intensities at which players perform collisions in training and matchplay. However, how this influences the team's performance, specifically in defence, is not clear. It is also imprecise what effect this has on the mechanisms of collision-related injuries that players following the different protocols may attain.

Theme 5: Psychological Readiness for Collision

Two main psychological elements arose in the focus groups, psychological readiness for collisions in training and the psychology of collisions in games. In the primary component, players described how training collisions hurt more than match collisions, they do not enjoy performing collisions in training, and they felt the same arousal was not in place to offset the pain from collisions. This was also documented to continue from the training week into games and affect match collisions, as 'Terry' (P2G2) demonstrates below.

‘Terry’: I always feel the contact in training hurts more than the game because obviously that boils down to the psychological side of it because obviously in training it’s not competitive you don’t really wanna be doing it. (P2G2)

A different focus group reemphasise this with ‘Gary’ (P2G3) stating “You’ve just not got the same chemicals in your body and adrenaline to deal with them big contacts” and ‘Ricky’ (P3G3) following this up with “Yeah adrenaline just get you out of like pain really you don’t feel”. To the author's knowledge, this is the first evidence of a reduction in psychological readiness to perform collisions in training for elite RL players. It would be of substantial interest to establish the influence of psychological readiness to perform collisions on training performance and if this is a difference shown between superior performing clubs or not. The focal point of the second segment was the opposition's effect on the preparation and readiness of collisions during games. Players outlined that ‘big games’ would influence their preparation positively, and conversely, matches they perceived to be easier may result in a lower intensity and aggression in their contact due to a lack of preparation. ‘Terry’ (P2G2) exemplifies in the following dialogue the difference in mindset for bigger occasions.

‘Terry’: So that reflects on your line speed on your intensity how much whack you’re gonna put into the contacts and that tends to have a better effect where you know them games where you know things in your prep hasn’t been the best you’ve got a few niggles you know you’re playing at not necessarily the top. (P2G2)

‘Brian’: Club K. (P5G2)

‘Terry’: ((Laughing)) Yeah and you go there and you haven’t got the intensity you haven’t got the aggression contacts not as good you’re on the back foot and it carries on spirals on the back of that all because your psychological preparation wasn’t as good as it can be on bigger occasions. (P2G2)

Similarly, Campo et al. (2012) noted the level of competition as a key indicator of players' arousal levels, citing top performers interpreted their anxiety symptoms as more facilitating than non-elite. For the first time, a link has been shown between the perceived challenge of the game and the force output of collision. An ability to replicate the ‘big game’ mentality is of significant interest to coaches and players and is an essential direction for future collision research.

4.5 Conclusion

The study aimed to establish players' perceptions of collisions in training and match-play through a series of online focus groups to gain a greater depth of understanding of this phenomenon. Four focus groups were analysed using Braun and Clarke’s (2019) reflexive thematic analysis, producing five themes consisting of the (1) three-man tackle – the perceived optimal defensive strategy, (2) not all collisions are the same e.g., match play events such as kick-offs and dropouts change the collision intensity, (3) bracing and blindsiding – two factors that influence experiences of collision and concussion, (4) coaching philosophies and orientations, and (5) psychological readiness for collision. Combined with existing quantitative insights, this research offers a greater understanding of the RL collision from the players that perform them and many directions for subsequent research. It moves existing research forward by providing nuanced insights and provides a platform for future research and policies to bridge the theory-practice gap in this significant area. Yet, given the novel insights generated by players in the current chapter, to fully elucidate the nuances of the tackle event, future research should aim to discern the perspectives of the other stakeholders (coaches, physiotherapists, doctors and strength coaches). Understanding their perspectives will provide a comprehensive overview of how the tackle event is being trained, the injury reduction protocols and physical preparation for the tackle.

Chapter 5

Title:

Physical Collisions During Elite Rugby League Match Play and Training: A Stakeholder's Perspective

5.1 Abstract

This chapter explored RL stakeholders' perspectives of the tackle event, utilising qualitative approaches to gain further insight into this phenomenon. Nineteen stakeholders, comprising tactical coaches (n = 5), physiotherapists (n=5), doctors (n=5) and strength and conditioning coaches (n=4) from every European 2023 Super League team (ESL), were recruited to participate in an online semi-structured interview, via the Microsoft Teams platform, facilitated by a moderator. Braun and Clarke's (2019) reflexive thematic analysis was performed to code and analyse the transcribed data; this established pattern-based interpretation and reporting from the dataset. The research findings can be divided into five crucial segments that illuminate our understanding of collision in RL: 1) simultaneous contact and the three-person tackle, 2) tackle height – calibration is critical, 3) the fundamental factors influencing tackle-related risks. 4) the graded exposure and philosophical approaches to contact training and games, 5) replacing toughness with resilience - the impact of game identity. The themes generated here provide comprehensive insights into stakeholders' perceptions of the optimal ways to perform collisions. This has implications for the identity of the game, and the subsequent law changes/ behavioural change models that aim to make the game safer, specific to RL. In line with previous research, the conclusions underline high-risk events in match play (blind-sided collisions and fatigue), providing a focus for areas of future research. Lastly, psychology in the tackle event is explored, highlighting the need for graded contact exposure from a physical and psychological perspective during tackle technique training.

5.2 Introduction

Chapter 4 explored the tackle in RL by illuminating ESL players' perspectives through a series of focus groups, providing pivotal players' experiences in a difficult to reach population, previously not heard before. The insights documented presented novel insights in areas such as the optimal ways to perform contact, elevated injury-risk components of match play associated with the tackle, contact psychology and coaching philosophies surrounding the tackle from a player's perspective. The chapter concluded that to fully elucidate the tackle in the applied environment, further investigation is warranted in this area from a stakeholder viewpoint. Stakeholders in the current chapter comprise tactical coaches, doctors, physiotherapists, and strength coaches, of whom all aid in different capacities in the tactical, technical, physical, and rehabilitative preparation of rugby players in performing the tackle during match-play and training. The value of stakeholder insights has been well documented in community RU. Using qualitative techniques in the form of semi-structured interviews, V Tonder et al. (2024) described stakeholder perceptions and the drivers of the adoption or rejection of injury prevention strategies. The conclusions of this study illustrated the need to bridge the gap between understanding the rationale behind law changes and the implementation of the changes with a more comprehensive approach. Several other studies have focused on a qualitative inquest in women's and men's RU (Dane et al., 2023; Petrie et al., 2024), yielding valuable perspectives that contribute to future investigations with the potential to influence law change. Yet, the previous chapter is the only recent qualitative work to present findings in RL and in an elite population. Consequently, considering the beneficial nature of experiences already presented by RL players, further inquiry is required to bridge the gap between the academic and applied environments specific to the RL tackle event from a stakeholder viewpoint.

Qualitative research can take many forms, such as interviews, focus groups, and surveys (Silverman, 2015). Semi-structured interviews are a qualitative research form that relies predominantly on open-ended questions, giving participants the flexibility to express their opinions, feelings and attitudes (Sparkes & Smith, 2014). A critical methodology that can be used to develop patterns of meaning (themes) in semi-structured interviews is reflexive thematic analysis (RTA) (Braun, 2023). This approach's advantage is its flexibility with different theoretical frameworks to delineate people's experiences, views, and perceptions. As such, a technique like RTA could be essential in discovering patterns from a multitude of stakeholders (tactical coaches, physiotherapists, doctors, and strength coaches). Given the crucial insights and perceptions on law changes and injury prevention strategies documented by the preceding literature, and the paucity of qualitative research in the RL tackle space, illuminating stakeholder perceptions is necessary. Therefore, the aim of the present chapter was to conduct semi-structured interviews with current key ESL stakeholders to gain insights into their experiences and understanding of collision.

5.3 Methods

5.3.1 Participants

Commensurate with qualitative approaches, purposive sampling was employed to select information-rich cases whilst providing a diverse representation of ESL stakeholders from all 12 clubs (Seidman, 2006). Nineteen participants were recruited by email for this study, comprising head tactical coaches ($n = 4$), assistant tactical coaches ($n=1$), head strength coaches ($n = 4$) and head medical staff (physiotherapists $n = 5$, doctors $n = 5$) representing all ESL clubs during the 2023 season. The mean ± SD ESL coaching experience of all the tactical coaches was 10.0 ± 7.9 years, with three of the five having coached at the international level (3.6 ± 2.5 years) and four of the five having played ESL level or higher

(315 ± 157 games). The doctors, physiotherapists, and strength coaches' mean ± SD experience at the ESL level was 10.8 ± 7.7, 4.6 ± 5.4 and 7.0 ± 5.4 years, respectively, with five of the stakeholders having experience at the international level. Written consent was obtained after all participants were provided with a participant information sheet and an explanation of the study, including the benefits and risks of participation. Institutional ethics approval was granted for this study by Liverpool John Moores University (22/SPS/070).

5.3.2 Data Collection

A qualitative enquiry in the form of online semi-structured interviews was adopted, aligning with previous research designs that aimed to develop or construct knowledge about individuals and their subjective experiences (Sparkes & Smith, 2014). The semi-structured interview schedule, termed 'topic guide' as seen in Appendix Figure 3, consisted of open-ended questions to facilitate flexibility in participants' responses. Each interview was performed and recorded online using the Microsoft Team's platform, and the first author utilised a standard *verbatim* transcription that adhered to the qualities of rigour set out by Poland (1995). All participants' identifiable information was anonymised, and pseudonyms were used in the transcription process. In line with previous research on elite interviews, each lasted 30 to 60 minutes (Partington & Cushion, 2013), with no interviews repeated, and 18 out of the 19 interviews are represented in the themes table in Appendix 5.

5.3.3 Theoretical Framework & Analytical Approach

The semi-structured interviews were analysed in line with the reflective thematic analysis as discussed in the general methods section.

5.3.4 Rigour

Member reflections were undertaken upon completion of analysis and can be seen in Appendix Figure 9. Each of the participants were provided with the fundamental outcomes to ensure the findings were a credible account of their experiences (Smith & McGannon, 2018). Participants were asked if they agreed, disagreed, or had anything further to add, with responses outlined below.

5.4 Findings and Discussion

The Findings and Discussion section is divided into five general dimension themes, as set out below. The coded extracts from the raw data were developed into different themes and presented in the themes table in Appendix Figure 5.

Theme 1: Simultaneous Contact in the Three-Person Tackle.

In the initial theme, optimal ways of performing the tackle were explored by participants, as several stakeholders noted simultaneous contact (by two players) as part of a three-person tackle (with the third defender taking the legs) as the most beneficial and efficient way to 'win the ruck' (description provided in Appendix Figure 4, Definition of Terms). This tackle type was considered one of the safest due to its control during the tackle and a significant reason for the differences in RL and RU. However, two stakeholders did cite concerns over 'catching' tackle techniques and the risk of increased numbers in the tackle during simultaneous contact. From a tactical coaching perspective, 'Ezra' (P8) documents the optimal strategy below.

> 'Ezra': So perfect tackle as people call it now which you know is a simultaneous contact you know full left shoulder from the right shoulder from the opposite side simultaneous hips together close any space down third man joining in effectively …

> they're just they are more effective and efficient tackles at times to control the ruck. (P8)

Another tactical coach followed this sentiment in a further interview with ‘Isaac’ (P2), stating one key difference between RL and other collision sports like RU n is the desire to keep attackers in the air for as long as possible to win the ruck.

> ‘Isaac’: The difference between our sport and rugby union in rugby union you’re wanting to go to ground as soon as you possibly can with the attacker because then it becomes a jackal on the floor and it becomes a fifty-fifty opportunity to get the ball back whereas in league you almost want to keep him in the air as long as you can before you go to ground … a bog standard it’s a sim hit so simultaneously hitting two defenders in between two defenders the attacker comes between two defenders and then that third man assist looking to take away the legs of the attacker or any leg drive or momentum. (P2)

Furthermore, ‘Grant’ (P4), from the medical staff, used slightly different terminology, naming this dual contact. However, he reemphasised the benefits of this type of tackle from a safety standpoint.

> ‘Grant’: We would call that dual contact and from a medical perspective what I feel about that is where it’s well coached and when players execute it correctly. I think it’s an extremely safe method of being able to elicit a tackle with the most control considering the chaotic nature of our sport. (P4)

Although different terminology was used for simultaneous contact, some stakeholders from multiple populations feel this is the safest and most efficient way to perform and win the tackle. Contrastingly, despite simultaneous contact not previously being mentioned, a reference to a catching technique was asserted to be detrimental to injury risk and the sport, as ‘Tyler’ (P3) from the tactical coaching perspective shows below.

> 'Tyler': there's a lot of catching technique in tackles nowadays there's advantages in two people tackling high catching somebody holding them up and then somebody come in and takes their legs from under him and there's an advantage in that in terms of rugby league tactics I'm not a fan of it for the sake of the sport but I'm also not a fan of it for the sake of preventing injuries and concussions and accidents in collision cause what I've learned in recent times from other studies on concussions a lot of our concussions in our sport in rugby union in contact sports are head-to-head injuries … I'm more traditional RL tackle bend over and crouch and bend your knees bend your hips and use your shoulder. (P3)

Here, Tyler (P3) offers an alternative perspective that denotes higher, more upright tacklers in a catching technique who are at a greater risk of concussion. 'Ralph' (P6) of the medical group was one of the few participants offering a similar perspective to 'Tyler' (P3), citing the negatives of simultaneous contact, "I think the more bodies that you've got in the frame, the more increased risk".

The method described by stakeholders for performing the tackle in an optimal fashion is identical to the technique discussed by players in the previous chapter. Comparatively, reducing the attacker's momentum was cited as key, with a third player taking the legs away to complete the tackle. Other research in RL by King et al. (2010b) did not mention simultaneous contact but did document most tackles involving two or three tacklers. Nevertheless, a study by McIntosh et al. (2010b) reported in RU a greater risk of injury associated with two or more tacklers and the most significant risk associated with simultaneous contact, something which had yet to be mentioned in the subsequent RL literature. Unfortunately, the author did not explain this finding or the injury type caused by this tackle type. However, this inference was featured in a study by Cross et al. (2019b), where the number of players in the tackle and head-to-head contact ranked as variables in predicting concussion in RU. As such, the iterations by ‘Tyler’ and ‘Ralph’ echo some of the conclusions of the RU research to remove tackler and ball carrier heads from sharing air space to reduce concussions. Yet simultaneous contact appears coveted in RL match play, with the stakeholders' iterations in this study aligning with players in the previous chapter. Consequently, future research should focus on the prevalence of simultaneous contact in match-play, its influence on match outcome, injury mechanisms, and the consequences of removing this type of tackle from match variables like ruck control.

Theme 2: Tackle Height – Calibration is Critical.

The second theme explores stakeholders' viewpoints on tackling height and their outlook on reductions to the armpit and waist regions. This section provided contrasting perspectives from stakeholders, with some noting an increased risk to the defender and how the game's ‘fabric’ could be affected, whilst others felt the need to address it. However, the process was deemed complex. The foundational research supporting the benefits of reductions in tackle height is illustrated, along with the lack of transfer in reducing concussion rates in the two published trials. The final segments assess whether the tackle height research performed in RU can translate to RL effectively without unintended outcomes.

'John’ (P16) from the medical cohort and ‘Dexter’ (P15) from the tactical coaching group document this below.

> ‘John’: I think there still a big risk of getting head injuries or significant collisions when you are tackling below the waist because you know your heads going to be near their feet and knees hips so from my perspective I think those kinds of rules they sound good but whether they reduce head injury rates I'm not sure … I think that's

> protecting the attacker because you know your kind of you're steering away from the shoulders and the head and chest but I think it puts the defender at risk. (P16)
>
> 'Dexter': I know other sports going down the line of tackling under the armpit or under the belly button or whatever it is and you know I think that's got huge risks attached to it from a health and safety point of view as well as the whole fabric of their game. (P15)

Conversely, 'Ralph' (P6) of the medical group provides a different perspective, stating that although tackle height is improving, it needs addressing, and altering it requires much complexity.

> 'Ralph': I think that tackle height needs to be addressed I think they are addressing it and I think it's improving but the problem is that the sports there's a lot of moving parts that have to be addressed within that rule change, so the coaches need to understand how to teach it the players need to understand what it looks like and then the refs need to know how to ref it and the match review needs to know how to judge what it is and what it isn't. (P6)

Tackle-related risk factors have been well documented in RL and RU literature (Gardner et al., 2021a; Tucker, Raftery, Kemp, Brown, et al., 2017). Both studies found a 3.2 and 4.25 times higher likelihood of a Head Injury Assessment (HIA) when the tackler is upright or high contact types (tackler head to ball carrier head or shoulder) versus bent-at-the-waist or low contact types (below the shoulder), respectively. Other high-risk elements from the RU study comprise active shoulder tackles, front-on tackles, high-speed tacklers and accelerating tacklers. Therefore, recent concussion reduction strategies have aimed to lower the body position of the tackler into the tackle. Nevertheless, the published trials in RU of tackle height reduction to armpit height from shoulder level have not produced a conclusive decrease in the incidence of concussion. Despite materialising from established empirical evidence, V Tonder et al. (2023) showed a statistically non-significant 31% reduction in concussions over two seasons at the community level, and Stokes et al. (2021a) reported a 30% increase during a 6-week intervention during a championship RU season. However, there were several self-documented limitations of the championship trial that may have influenced the lack of reduction in concussions, such as the duration of time given to observe behavioural change, the length of the preparatory period given to stakeholders for the adoption of the laws, the mixed feedback given by stakeholders on the implementation of the laws and the lack of co-laws stopping ball carriers reducing height into contact. This has led to a more recent study applying the diffusion innovation theory (a framework for understanding how innovations are adopted) to examine the effectiveness of the adoption of new injury prevention strategies (Hendricks et al., 2024). Nonetheless, the lack of transfer from theory to the implemented trials denotes the complexity of reducing concussions. Two principal explanations could be that the other high-risk elements take precedence or that armpit-level tackling does not prevent tackler and ball carrier heads from sharing airspace. As a result, further investigation is necessary to comprehend the full application of this law change.

In the previous theme, stakeholders demonstrated the uniqueness of the RL tackle and its role in controlling the ruck. Literature in RU has not discussed ruck control regarding tackle height; this may be in part due to the lack of significance this has on match play (Chéradame et al., 2021). Consequently, the conclusions drawn from RU literature may not translate effectively into RL. Therefore, given the potential impact this rule change may inadvertently have on match play and, more specifically, ruck control, the unintended outcomes of reducing tackle height and its effect on ruck control need to be investigated. A further point raised by this theme is the mixed viewpoints of stakeholders. This area was deemed vital in adopting and implementing tackle height laws in the championship trial, along with the preparatory phase. Moreover, Hendricks et al. (2023a) highlighted the importance of collaboration between stakeholders and how crucial a collective approach is in altering and tackling behaviours positively. Before the 2024 season, the Rugby Football League (2023c) (RFL) announced changes in a reduction of tackle height to armpit level at all levels of rugby, with changes to the professional game as of the 2025 season.

Given that the stakeholder views in the current study represent the professional game before the announcement of the changes, the RFL has given stakeholders adequate time to prepare for the changes in tackle height in the 2025 season. Therefore, the adoption and implementation that were missing in the RU championship trial could potentially be mitigated. The points raised here offer fundamental considerations for policymakers and future work.

Theme 3: The Fundamental Factors Influencing Tackle-Related Risks.

Throughout this theme, stakeholders explored tackle-related risks via the role of fatigue, bracing, blind-siding, and collision closing distances. Given the rugby-specific terminology used throughout this theme, a definition of terms is presented in Appendix Figure 4. The first element, fatigue, consisted of two viewpoints. Firstly, some stakeholders agreed with the proposed match thresholds to reduce season-long match tackle load for players. Secondly, the contribution of match speed/ ball-in-play on fatigue is discussed by some stakeholders, who feel the game is at a 'breaking point'. Here, we display the objective of ESL in removing stagnant time and explore the crucial relationship between fatigue and injury. The next feature of this theme discusses the impact of bracing for collision, as stakeholders discuss the out-the-back pass as one of the most challenging positions for an attacker and some potentially overlooked attacking techniques to reduce concussions. Lastly, collision closing distances and their influence on the tackle intensity are investigated, with some stakeholders considering the distance to injury risk association (i.e., the larger the closing distance, the larger the injury risk). Below is the initial element of fatigue as cited from a medical perspective by 'Grant' (P4).

> 'Grant': if I'm being really truthful I would love to see less games I would love to see a Super League with the thing that increases risk is obviously a game and that's the greatest risk a player will be exposed … I think ultimately if we're looking at a competition which helps player welfare and also assist the product of the sport less games is more of those two things. (P4)

This was followed by a tactical coaching outlook by 'Ezra', elucidating fatigue as a consideration from a match-speed position.

> 'Ezra': We're speeding everything up in the game and giving the players less time we're decreasing the time for drop outs and scrums or we brought those rules in there's a shot clock now for how many seconds you can use this for that now there's a stoppage of 5 minutes from the end of the half the game has quickened up a set to such an extent for me that it is getting on the point of breaking the players … there's a breaking point for the players so I don't necessarily feel that it's just the collisions that are causing or potentially causing trouble it's the fatigue in the game the general fatigue in the game now. (P8)

'Grant' (P3) and 'Ezra' (P8) show two different factors of fatigue that influence tackle-related risks in different ways. As of the 2024 season, the RL brought significant law changes whereby match play thresholds were addressed (Rugby Football League, 2023d). The limits differed for forwards and backs, who will be limited to 25 and 30 full-game equivalents over 12 months in players above 22. As demonstrated here, the recent changes align with some stakeholders' views to reduce overall collision exposure over a season and aid player welfare.

In the second iteration of this theme, 'Ezra' (P8) states that further changes to the in-game rules may prove detrimental by increasing the game's speed beyond players' capacities. Rule changes removing stagnant time from match-play were a central focus of the RFL from the 2018 to 2020 seasons. This aimed to increase match-play speed to ensure a faster game and reduce COVID-19 transmission during the 2020 season by lowering close contact points in areas such as scrums (Rennie et al., 2021). However, tackle-related amendments increased the average match tackle events players were exposed to (36 – 42), along with the ball-in-play duration (BIP) (35.6 min to 46.3 min) and reduced the average speed of matches (102.4 $m \cdot min^{-1}$ to 94.4 $m \cdot min^{-1}$). Through a pooled analysis, previous research has exemplified the increased risk of injury during a match versus training and, more specifically, concussion (King et al., 2022). Yet, during this time period (2016 – 2022), Eastwood et al. (2023a) demonstrated no significant differences in concussion incidences despite a slight increase in the variation from 2019 to 2020, which then decreased from 2020 to 2022. One possible reason for non-significant differences in concussion incidences could relate to the crucial interplay between BIP, average match speed, and total match play tackles. The fatigue generated by manipulating total tackles, BIP and average match speed has yet to be investigated. As such, this is an area of considerable interest given the significant impact fatigue has on reducing tackle technique (Davidow et al., 2020b; Gabbett, 2008) and the role of poor tackle technique in higher head impacts (Davidow et al., 2018a). Therefore, future research and policymakers should aim to discern the vital interaction of match outcomes and their role in the fatigue they create.

The second dimension of collision-related risk was bracing and blind-siding, as 'Grant' (P4) from the medical staff states that an 'out-the-back pass' is one of the most dangerous positions to be in, as you are blinded from the collision.

> 'Grant': As an outside back in particular half back and the fullback that's the ball-playing fullback that pass when you are blinded from your opposition so an out-the-back pass is one hundred per cent probably the most challenging and potentially dangerous position for a player to be in … they are blinded to when that contact will happen so their reaction time will be different if you're looking at something and you see it you can brace yourself if you don't know it's coming. (P4)

A further interview with another tactical coach, 'Tyler' (P3), reiterated this point, citing that there are some overlooked techniques for ball carriers to help reduce collisions and concussions.

> 'Tyler': It's also some techniques that we need to teach our people carrying the ball and when they're in offence that can help reduce collisions and concussions as injuries you know so there's techniques there that I think sometimes we overlook. (P3)

The last point was by another tactical coach, 'Ezra' (P8), relating to spatial awareness and how this can help players avoid collisions.

> 'Ezra': Avoiding collision is obviously another really big art so Player L … was the best avoiding collisions I've ever seen because of his spatial awareness his understanding of where people were coming from. (P8)

Chapter 4 is the only literature to acknowledge bracing for impact entering the collision in elite RL. Here, players documented their experiences of blind-sided collisions, stating that the highest-risk collisions are the ones they cannot see coming, especially for the 'adjustable' position. This experience, illustrated by players in the previous chapter, correlates with the experience described by 'Grant' (P4) as potentially the most dangerous position for a player. Nevertheless, the RFL has changed the on-field guidance regarding high tackles and dangerous contacts (Rugby Football League, 2022). The stakeholders agree that these types of collisions put players at risk and that rule changes like those already enacted by the governing body can only benefit player welfare and the game's safety. However, it is clear from a coaching perspective that some skills and techniques are potentially being overlooked regarding carrying the ball and avoiding the tackle altogether. Currently, few studies document injury risks in collision sports and the role of vision and spatial awareness. A study by Kung et al. (2020) explored the severity of head impacts and the potential role of visual performance, oculomotor behaviours and anticipation. In this instance, dynamic head stabilisation through the anticipation of contact and bracing of the head and neck is suggested to reduce the risk of concussion. Unfortunately, a plethora of current literature assessing visual performance characteristics has examined deciphering this role post-concussion (Dutta, 2023). Interestingly, a systematic review reported a significant relationship between higher neck strength and lower head accelerations in soccer (Peek et al., 2020). Unfortunately, this has not translated into a relationship between neck strength and sports-related concussions in RU (Liston et al., 2023). Nevertheless, given the opinions of stakeholders and the lack of research around vision and bracing, this area warrants further research.

The final element of collision-related risks centres around closing distances and increasing speed into the collision, as Frank (P10) from the strength and conditioning group cites below.

> 'Frank': If you've got a bigger closing distance you know and the same mass of a player coming in can they achieve a greater velocity given a bigger closing distance so obviously that the impact of that collision is going to be is going to be higher so

> maybe you could infer from that was going to have impact in terms of greater risk but equally if you want some of the most innocuous contact based injuries come from smaller closing distances especially head based ones. (P10)

Collision closing distances have been researched extensively in American football, with mixed results (Campolettano et al., 2019; Ocwieja et al., 2012). Risks associated with large collision closing distances have been attributed to the greater force exerted by the two players, increasing their speed into the collision. This relates to two of the four major variables associated with concussion, being a high-speed or accelerating player, which has previously been described in the RU literature (Estell et al., 1995). Despite the possible connection of collision closing distance to increased risk of injury, it has been proposed by Clark et al. (2017) that the greatest proportion of well-anticipated impacts were from kick-offs. The great anticipation from kick-offs may be due to the increased vision of knowing where the tackle will be made. As documented in the current chapter regarding bracing, stakeholders have stated that anticipation is crucial in allowing players to prepare for impact. However, this component was discussed by players as the most intense contact in the prior chapter, despite not being linked to increased injury risk. Therefore, this would suggest that future research should aim to test the hypothesis of greater risk or anticipation from kick-offs to help reduce tackle-associated risks in RL.

Theme 4: The Graded Exposure and Philosophical Approaches to Contact Training and Games.

The fourth theme pivoted around the coaching philosophies of contact training, exploring the benefits of coordination from tackle training as opposed to the risk of exposure. It also documents the differences in defensive coaching systems and displays how this affects the types and intensities of players' tackles. It then explores the graded exposure of tackle training and how this prepares players for match-play tackles. Finally, we examine the differences between collision and wrestle training, noting their role in grading exposure and the influence this may have on any future law changes. To start, ‘Michael’ (P17) offers some insights from a tactical coaching perspective into coaching philosophies.

> ‘Michael’: He was an offensive-based coach loved it we practice for hours and hours of attack and you know I think we practice hours and hours of set plays tap plays and very minimal defensive stuff you know we’d maybe honestly for a year and a bit under him I can't really remember doing too many contact sessions and that shows in our performances though because we used to score 30 and let in 40. (P17)

This iteration was followed by ‘John’ (P16), who provided a medical viewpoint on the role of defensive-based coaches.

> ‘John’: If you had a coach liked contact sessions you know you're going to be more exposed to it in training so therefore potentially you know collision-related injuries will be higher in training but again you could argue a coach would certainly argue you know the more you do the more we do in training though maybe better coordination technique everything like that is going to be then in match day. (P16)

This point was furthered by ‘Ezra’ from the tactical coaching group, who documented the differences in coaching systems below.

> ‘Ezra’: When you play against Club T at the minute they were a passive style defence they're not coming at you they've decided to do that so there's a different collision level in games like that there's a different stress because of the way they play an attack on the other side of the game as well it was completely different playing Club T when you are attacking them as it is to Club H or even Club F you know change their style and everything else and more aggressive. (P8)

In the initial assertions of this theme, specific stakeholders from different perspectives feel that the coach can guide the types and intensities of tackles that players make, not only in training but also in match play. Gabbett and Ryan (2009) demonstrated how tackling technique proficiency increases with the number of games played. This could establish a relationship between the number of tackles performed and competency in performing them. Therefore, this adds some validation to the concept mentioned by "Michael' (P17) and 'John' (P16) that doing more tackle training sessions may induce better timing and coordination when performing the tackle and is not something to be avoided. However, what is unclear is the optimal dose of tackles to gain the benefit of coordination and timing whilst attempting to limit injury exposure. The observation of 'Ezra' (P8) demonstrates a further standpoint of the influence of coaching systems on match play tackles. It is captivating, given the bearing of completed tackles on match outcomes (Wedding et al., 2021) and how RL literature has yet to investigate the impact of contrasting defensive systems on injury incidences and success. Future research should aim to quantify the styles and systems of defences to better understand their influence on tackles and match outcomes. Below documents the next segment of this theme from 'Phil' (P15) from the medical group, which discusses wrestle versus collision.

> 'Phil': Wrestle. I don't describe wrestle as contact really because there's no yeah it's different I think it biomechanically it's a different thing it's not a collision (P15)

This was followed by 'Dexter' (P5) from the tactical coaching group discussing contact and collision.

> 'Dexter': In the past I've used contact, collision and combat as a sort of three-ways and really the only true combat is in the game where there's a real outcome … contact is more skill-based development of technique not overly competitive and certainly not a lot of leg speed or big collision then you can progress in a collision where it's controlled environment but a bit more spice still a bit more intent or energy. (P5)

Here, 'Dexter' (P5) discusses three intensities of contact, which resonates with 'Grant' (P4) from the medical group, who discusses being able to periodise technique, pad work, and bodies in front.

> 'Grant': From a physio point of view we know that the collisions is not gonna be heavy there's no separation there's no distance between contact everything's close so it's all about technique of movement it's all about making correct contact taking place … the work that we would do with shields bodies in front taking to ground would all be based around players not leg driving for example which would aid the ability of a defender to take the player to ground without having heavy contact so it's an easier way to be able to periodize and plan contact progression without pushing the boundaries. (P4)

Above, 'Phil' (P15), 'Dexter' (P5) and 'Grant' (P4) document the differences between wrestle and collision, the different terminologies applied to the contrasting parts of the tackle, intensities of contact and their utilisation in the periodisation of training programmes. This is a novel theme in RL literature as an insight into how tackle training is performed. This also provides insight into the demands stakeholders feel the contrasting sessions may have. Previous literature has documented the variations of exercise-induced muscle damage (EIMD) markers and tackles/high-intensity running during RL match play (Oxendale et al., 2016). However, despite the progression of microtechnology in recent years, the validation of such technology to quantify the tackle has presented mixed results (Naughton et al., 2020). Therefore, subsequent research may apply the current theme and previous works, such as Mullen et al. (2015b) and Norris et al. (2016), where tackle intensities have been altered to understand the methods that may adequately quantify the tackle. This theme also demonstrates a separation in training; as such, some of the risks associated with performing the tackle may be separated into higher and lower-risk tackle training modalities. For example, as ‘Grant’ (P4) discusses, ‘technique-based’ sessions are sooner in the periodised schedule than ‘bodies in front’, which may be deemed higher risk. As of the 2024 season, load guidance for contact is set to be introduced by the RFL (Rugby Football League, 2023d). Similarly, other governing bodies, such as World Rugby, have enacted similar guidance for weekly contact loads for controlled contact sessions (40 mins) and full contact sessions (15 mins) (World Rugby, 2021c). Here, World Rugby has provided guidelines for the volume of sessions in time and differences in intensities between full contact loads and controlled contact loads. However, although the current guidance for the RFL does not state specific loads, the current theme offers insights that may influence RL-specific guidance. Given the similarities in stakeholders' perspectives of how the tackle should be trained, the exposure of drill type to each position, along with the total number of tackles in each drill, should be a focal point of any future load guidance. Moreover, research in American football has shown how drill type can influence position-specific head impacts in contact training (Kercher et al., 2020). Collectively, this theme offers a further understanding of the graded exposure of tackle training, load guidance for RL and the necessity to quantify tackle intensity.

Theme 5: Replacing Toughness with Resilience - The Impact of Game Identity.

The final theme considers how a graded exposure to the tackle can assist in mentally preparing athletes for contact, with the tackle drill type forming a central point of significance. Given that previous work had not included this area, the collision closing distance of the drill and technical execution in drill type appears crucial. A second key variable emerged in the form of emotional monitoring and the role this has on fatigue that ensues from the highs of elite sport. The final phase of this theme explores the emphasis on mental resilience, replacing mental toughness, and the advancements in mental literacy amongst ESL players, reducing modern-day stigmas. Here, the game's identity plays a vital role in understanding how to advance research. Firstly, from the medical group, ‘Grant’ (P4) discusses the mental preparation for a collision driven through physical exposure.

> ‘Grant’: I do believe that coaches physios S and C’s are becoming more and more and more aware of the importance of being mentally prepared to play … that mental preparation can be driven through physical exposure. (P4)

The graded exposure articulated by ‘Grant’ (P4) is stated to enhance mental preparation for collision. However, the emotional effect of entering a peak state for collision is unknown, as a strength and conditioning coach ‘Marcel’ (P13) discusses this below.

> ‘Marcel’: I always said they can probably needs to be a bit more research is just the emotional fatigue that comes in how much it takes you to get up for them games the nervousness before the game that type of thing so you do tend to see those well you'll spot the weeks when they're going to be quite high and the ones where they're going to be quite low. (P13)

‘Marcel’ (P13) conveys collision sports' emotional highs and lows and the subsequent fatigue that may ensue following an emotionally intense game. The essence of players being able to manage this is resilience, which was an additional part of this theme, shown by ’Kyle' (P9) of the medical group.

> ‘Kyle’: I think to be mentally tough it's probably linked to resilience … I think traditionally people would have looked at mentally tough and gone oh he’s picked up an injury here or he's got a concussion but he's mentally tough he's not gonna say something he's just gonna carry on but I think mentally tough to have the bravery and honesty to say something is not right. (P9)

‘Kyle’ (P9) demonstrated this definition, connecting mental resilience to having the bravery to be honest and communicate matters. ‘Dario’ (P19) of the strength and conditioning group reaffirmed this point when verbalising the reduction in mental health stigmas across the game.

> 'Dario': I think there was like we said a long time ago there was a stigma on it especially on male athletes about seeking psychological help and talking to someone … I think it's changing a lot now that speaking and opening up there's a lot of top athletes that are retired now that have come out and talked about mental health issues that they've had not just from collision-based injuries but just being injured in general though it's affected their mental health. (P19)

In the first instance of this theme, 'Grant' (P4) demonstrates how RL athletes are mentally prepared to tackle through gradual physical exposure. Previous research by Stokes et al. (2020) suggested a graded exposure to tackle training following a period of restricted training. Although psychological considerations were explored during the enforced modified training period, the link between the psychological graded exposure was not made. In a previous theme, 'Grant' (P4) also discussed a periodisation of contact training as part of the coaching philosophies. This section mentioned technique, pad work and bodies in front, which 'Dexter' (P5) conveyed as contact, collision, and combat. Future research should not only aim to decipher the optimal ways to prepare players for the tackle demands of a game from physical respect but, as this iteration demonstrates, from a psychological preparation standpoint. It is not within the scope of the current study to comprehend this; however, the quantification and periodisation of tackle drill type may be of interest to future work. Yet, there is a plethora of research investigating the periodisation of return-to-play protocols in other sports combining cognitive and physical loads (Taberner et al., 2022); as such, this work may highlight aspects of the control-chaos continuum that may translate to the periodisation of R tackle training.

A supplemental area mentioned above by ‘Marcel’ (P13) is the need to quantify the emotional fatigue of games, an area that has not yet been investigated in elite RL. However, most literature discussing emotions and fatigue mentions cognitive workloads, burnout, or positive and negative emotions (Bicalho & Da Costa, 2018; McCarthy, 2011; Russell et al., 2019). Given the scarcity of literature discussing the emotional highs and lows in elite RL and the apparent importance placed on this component by stakeholders, this area warrants further investigation.

Mental resilience and psychological stigmas were central in this theme's third and fourth sub-dimensions. Several studies have explored the role of mental toughness and psychological well-being in RL (Golby et al., 2003; Nicholls et al., 2020; Sheard, 2009). In this research, they noted the correlation of mental toughness with successful sports performance and the prevalence of depressive and anxiety symptoms amongst ESL players. Similarly, in RU and other collision sports, mental toughness has been viewed through the lens of developing it and its associations with successful athletes (Cowden, 2017a; Parkes & Mallett, 2011a). Being mentally resilient as opposed to mentally tough was a term preferred by many participants. Key descriptors of mental resilience by ‘Kyle’ (P9) were the ability to be honest, brave, and confident enough to voice injuries. The means to be confident enough to speak up about issues was a component that stretched across two psychological themes, with current-day stigmas being the second. Green et al. (2012b) have demonstrated the stigma around players not wanting to be perceived as needing psychological assistance and, therefore, not seeking it out. This belief was echoed by Kola-Palmer et al. (2020), who stated that fear and shame act as barriers for players seeking psychological help, but those who did have a greater mental literacy. Stakeholders feel that stigmas towards seeking psychological help are decreasing due to more athletes discussing the subject area, as ‘Dario’ (P19) exhibits.

This may be in part due to an enhanced mental literacy among the population of RL athletes, specifically in the ESL. This is of the utmost importance and should be considered key for future research as Kola-Palmer et al. (2019) found the percentage of ESL players experiencing common mental health disorders in two different surveys to be 45.4% and 38.5%, with 27.3% and 23.7% experiencing severe symptoms.

The final note of this theme recorded the viewpoints of some stakeholders who feel that the identity of RL revolves around a fundamental aspect of it as a collision sport. 'Mason' (P18) of the medical group demonstrates this below.

> 'Mason': I feel actually the sport of rugby league needs an identity I think we need to differentiate ourselves from rugby union and from other sports and one of the exciting things that I find with RL and having played RL was the collision aspect and I think the rule changes that are happening currently are I struggle to see how far we can take those rule changes before it has an impact on the identity of rugby league. (P18).

The above exemplifies a common theme discussed by stakeholders, noting the tackle aspect as key in identifying RL from other sports. A recent study by V Tonder et al. (2024) highlighted how 'rugby culture' may be perceived by RU stakeholders, describing a 'gladiator effect', 'boys' culture' and 'boys don't cry' themes with serious injuries, regularly failing to acknowledge or disclose concussions. Whilst these themes may be perceived negatively, the current theme offers a fresh perspective, examining the crucial paradox between RL needing to change certain aspects within the sport to aid the safety and spectacle of the game, whilst maintaining as much of its identity as possible. The identity in the current context aligns with previous work documenting the masculinity associated with full-contact team sports, along with the identity of working-class men in RL communities from northern England and south Wales (Spracklen, 2012). Allowing them a sense of belonging and solace through their history of unbroken working-class traditions. Therefore, considering the role of stakeholders in adopting and implementing rule changes, the current theme offers further insights into how the game's identity is viewed from a stakeholder standpoint.

5.5 Practical Applications

The findings from the current study inform future considerations specific to stakeholders in contrasting manners. The study has identified important perceptions of optimal ways to perform the tackle event in RL from a tactical coaching standpoint. This may inform coaching education programmes in RL (‘Tackle Safe’) (RFL, 2024) and lend some transferability to RU education programmes like BokSmart and Rugby Ready (Rugby, 2009a; Rugby, 2009b). Furthermore, the study has assisted in highlighting some of the highest-risk events during match play, offering viewpoints that aid in advancing injury prevention strategies (neck strength and bracing). Moreover, from a strength and conditioning and sports psychology perspective, the conclusions present worthwhile accounts of the process required to grade tackle exposure in training. A crucial element here is tackling drill type, the periodised exposure to each level of drill and creating a comprehensive fingerprint for each drill to understand risk association, aiding injury prevention and finding alternatives to high-risk drills.

5.6 Conclusions

The current study was the first of its kind, providing valuable insights into ESL stakeholders' viewpoints on the RL tackle to gain further understanding of this event. This research has contributed several key elements that have moved the literature forward. Firstly, this study has provided a foundation for future work, bridging the gap between theory and practice. It also highlights the complexity and multifaceted nature of the tackle. Overall, the stakeholders’ perspectives offered here feature themes novel to RL tackle literature, such as tackle height, match speed, fatigue, and the graded exposure of the tackle for mental and physical performance. While reiterating some themes documented in preceding work, in particular, simultaneous contact, bracing, blind-siding and collision closing distances. The final principal facet demonstrated throughout was the importance stakeholders placed on the identity of the game and culture associated with the working-class traditions of RL. This may be key when attempting to adopt and implement changes within the game to ensure they align with the identity of the sport to garner the maximum amount of support. This research identifies the consequential value of attaining collision sports stakeholders' perspectives, with the implications of this study transcending RL and informing policy and practice for other collision sports. As such, given the insightful perspectives and experiences documented in the previous chapters, future work should aim to discern if elite RU players can provide additional context to the tackle event to assess the transfer across sports of injury mechanisms, incidences and precursors.

Chapter 6

Title:

Mapping the Ecology of the Tackle Event: What Shapes How Elite Rugby Union Players Tackle?

6.1 Abstract

RU is a full contact collision sport, whereby success in the tackle event, ubiquitous within match play, is a key marker of match outcome. Moreover, the tackle is associated with the sport's most prevalent injury, concussion. To date, however, we have little insight into players' experience of the tackle. A notable knowledge gap in our understanding. Therefore, a series of online focus groups were performed with the aim of understanding elite male RU players' experiences of collision. Facilitated by a moderator, focus groups were performed with eighteen elite RU players across four teams, utilising the Microsoft team's platform. All players were competing in the Gallagher Premiership during the 2024/ 2025 season. Employing Braun and Clarkes (2019) reflexive thematic analysis, findings reveal six key themes: 1) how position and context drive tackle selection in defence, 2) strategies that shape ball speed – defensive disruption and generating attacking momentum, 3) from goal line defence to aerial battles – contextual factors that augment collision intensity and injury potential, 4) where possession is won and lost – strategic execution across the ruck, lineout and scrums, 5) philosophy vs practicality – how coaching beliefs influence contact techniques and 6) beyond the rush – balancing arousal, calmness and tactical knowledge in training and games. To assist the analysis, the ecological systems model was applied and revealed the influence of match play events and environmental contexts on the multifaceted nature of the tackle. Furthermore, the ecological systems model provides context of the interlinking systems that influence the tackle event, directly or from afar. The findings detailed here offer novel insights into the tackle event in elite men's RU and provide key areas for future research.

6.2 Introduction

RU is a worldwide invasion team sport, played in over 123 countries with 9.6 million registered players (Erskine et al., 2024). Matchplay is physically demanding, distinguished by high-intensity efforts (sprinting, change of direction, wrestling and tackles), interspersed with low-intensity efforts (walking and jogging) (Cousins et al., 2023). The tackle event carries the greatest injury risk of all match play and training actions, potentially due to the significant energy transfer between players and its chaotic nature (Martin et al., 2021). The injury incidence for premiership match-play in England is 76/1000 hours, and the most common injury, concussion, accounts for 24% of all injuries with an incidence rate of 18.4/1000 hours (RFU, 2024). This illustrates an occurrence rate of one every 1.6 matches, slightly lower than World Rugby's concussion incidences for senior men's competition (12/1000 hours), with one occurring every 2.1 matches (World Rugby, 2025a). Subsequently, some research has been undertaken to better understand concussion in RU (Tucker, Raftery, Kemp, Brown, et al., 2017), especially given its recent association with neurodegenerative diseases (Russell et al., 2022a). Governing bodies have aimed to ensure match-play is safe through policy changes, particularly focused on the tackle, whilst enhancing the spectacle of the game, although much work is to be done (Cross et al., 2019a).

Injury incidence is not the sole rationale for investigating the tackle event (Davidow et al., 2020b). The aim of RU match play is to advance the ball down the field to gain scoring opportunities (Quarrie et al., 2013). Likewise, in defence, a team's aim is to restrict territory and therefore scoring chances. As such, Colomer et al. (2020b) identified successful match performance indicators linked with the tackle event for instance, tackle percentage, tackles completed, turn overs won and tries scored. Moreover, Scott et al. (2023) reported in 96 United Rugby Competition (URC) matches, missed tackles and tackle ratios as a key differentiator between winning and losing teams. The study further highlighted at Six Nations level that line breaks and turnovers won as key features of winning teams. As a crucial component that influences match outcome, several research articles have aimed to delineate the optimal ways to perform the tackle with the purpose of limiting missed tackles and winning the tackle event (Hollander, Ponce, et al., 2021a). Key metrics such as body position, head up and face forward, contact with the shoulder, head placement on the correct side, and leg drive upon contact were noted for both injury prevention and performance. Yet, Hollander, Lambert, et al. (2021) documented the lack of association between players' knowledge of contact techniques and the ability to execute tackle techniques. Furthermore, Hendricks et al. (2017) illustrated coaches average only 16% of their total session time to coaching tackle techniques, although they rated this as an area of high importance. Taken together, given the prevalence of injuries, the potential association with neurodegeneration and importance on tackle to match success, the tackle is an area that warrants further investigation.

A considerable proportion of prior research in this domain has been performed from a quantitative stand-point (Edwards et al., 2021; Hendricks, Matthews, et al., 2014a), with only few articles in recent times, employing qualitative methods (V Tonder et al., 2024). Dane et al. (2023) highlighted the effectiveness of qualitative investigation, exhibiting the need to empower tackle coaching in the women's game, by providing bespoke training to adequately support the needs of the players. Similarly, in RL, chapter 4 has documented novel insights into optimal ways to perform the tackle, match events with higher associated risks of injury, differences in coaching philosophies and the psychology behind playing collision sports. However, no research has attempted to perform this kind of qualitative research with elite-level men's RU players. As a result, the experiences and perceptions of those involved in RU tackles remain unknown. Therefore, the aim of the current study was to perform a series of focus groups with elite-level RU players to further understand their perceptions of the tackle event, match-play events with associated risks and coaching philosophies.

6.3 Theoretical Framework: Ecological Systems Model

The tackle is a complex, multifaceted event, that is influenced by a unique environment and a multitude of factors. Models such as the Bronfenbrenner (1979) socio-ecological system model, attempt to provide insights into the impact of social environments on human development. The model was originally developed to document how the development of individuals is influenced by their innate characteristics and immediate environment (e.g., family, communities, etc.)(Bronfenbrenner, 1999). It comprises four levels; the microsystem, mesosystem, exosystem and macrosystem (see fig. 1). The microsystem is described as the ecosystems inner most level, where the immediate interactions occur (e.g., a family unit). The mesosystem outlines connections influencing the individual (e.g., schools and parents interacting). The third layer, the exosystem, was described to have a great effect on the individual without directly interacting with it (e.g., media, government policies). And the final system, the macrosystem encompasses the three other systems, which is far removed from the individual (event) but still has significance (e.g., wider cultural influences and political systems).

Whilst the model was initially developed to explore human development, it has been applied in sporting contexts. For instance, Bronfenbrenner's work has been utilised to gain insights into elite athletes' experiences (Massey et al., 2024), whilst Kerr et al. (2014) used the socio-ecological model to explore the influences upon non-disclosures of concussion. Indeed, Hendricks et al. (2023b) has previously documented how rugby athletes operate within a socio-ecological structure influenced by layers of interlinked contextual factors that change over time or through external modifications. Therefore, this framework is suitable to contextualise the elite RU players experiences of the tackle event. Accordingly, in this study the individual shall be recognised as situated in a social-ecological context and the tackle event investigated with specific attention paid to the surrounding environment.

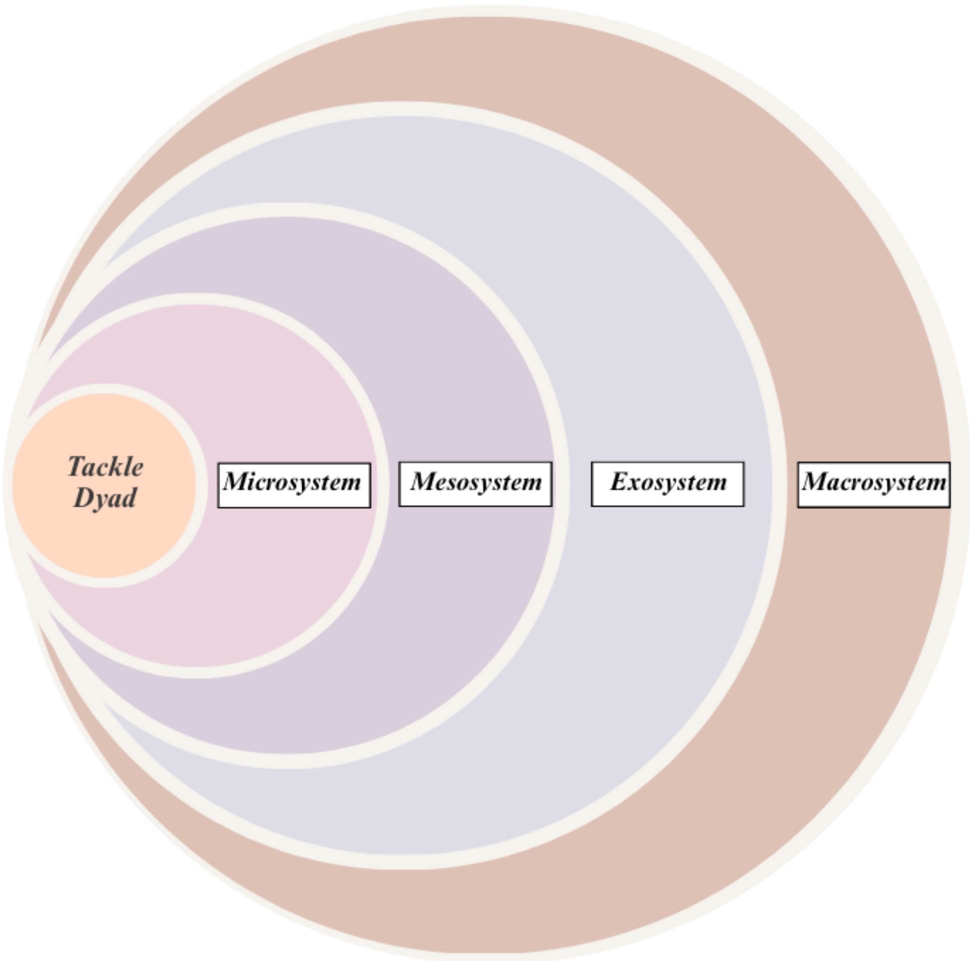

Fig 3. *Bronfenbrenner's ecological systems model.*

More recent research by Bronfenbrenner and Morris (2006) has evolved the original model to examine the interactions between the person and the context. The bioecological model in its revised concept, emphasises time, context, proximal process, and the persons (PPCT) role on human development. The person reflects components of the individual athlete, which in this study may explain direct variances within performing the tackle, (e.g., body composition, technical ability). Proximal process are the everyday regular activities resulting from performing within and across systems (e.g., training drills). The time element shifts across all systems, from individual tackles that happen in milliseconds to seasonal changes in techniques and law changes over the years. The context explores the impact of the four systems on the tackle and vice versa. These concepts provide an established and situated theoretical framework to aid understanding of players' perceptions of the tackle event, match play events with associated risks and coaching philosophies.

6.4 Methods

6.4.1 Participants

The initial findings of Chapter 4 in RL were disseminated by key stakeholders in Premiership RU, highlighting the importance of contextual factors in the applied environment shaping the tackle behaviours of players. As a result, the RFU invited a collaboration to explore a similar study in their code in conjunction with the RPA. As such, purposive sampling was employed, consistent with qualitative approaches (Sparkes & Smith, 2014), to provide comprehensive perspectives from a varied representation of Gallagher Premiership players. Eighteen participants from four Gallagher Premiership teams were recruited through gatekeepers, consisting of front row forwards (n = 5), second/ back row forwards (n = 5), halves (n = 2) and outside backs (n = 6). All premiership clubs in the league were contacted to participate, with four confirming their interest and participating. Players were competing in the Gallagher Premiership during the 2024/2025 season, with a mean ± SD age and player experience (games played) in elite RU of 25.4 ± 3.1 and 71 ± 52, respectively. Initially, gatekeepers were provided with an explanation of the study, accompanied by an information sheet, including the benefits and risks of participation. Following written consent from the gatekeepers, players were contacted, and the corresponding information was provided with consent obtained. The exclusion criteria for the study were that no player had unsuccessfully performed a head injury assessment within the previous two weeks, that had resulted in a sports related concussion or was still experiencing post-concussive symptoms, in line with the RFU medical standards.

6.4.2 Design and Data Collection

Aligning with previous research designs (Krueger, 2014), a qualitative investigation that intended to assemble participants' perspectives through the method of focus groups was employed. Focus groups strengths are in the group interaction and ability in uncovering consensus or diversity in a subject area (Morgan, 2019). To facilitate the discussion, a 'topic guide' or semi-structured interview schedule documented in Appendix Figure 6 was constructed, informed by previous research as highlighted in the table. The four groups consisted of three online sessions via the Microsoft Teams platform and one in person group, which were transcribed verbatim. Participants were assigned pseudonyms at the beginning of the transcription process, and any identifiable information was removed. Each focus group comprised 3 to 5 participants and lasted between 35 – 60 minutes in line with previous research (Barbour, 2018), with all participants represented in Appendix Figure 7.

6.4.3 Analytical Approach

To further understand players' perceptions of the tackle event, a reflexive thematic analysis was performed as set out in the general methods. The subsequent themes table is set out in Appendix Figure 7.

6.4.4 Rigour

Upon the completion of the analysis, member reflections (seen in Appendix 10) were undertaken as participants were provided with the fundamental outcomes to ensure the findings were a credible account of their experiences (Smith & McGannon, 2018).

6.5 Findings

A Reflexive Thematic Analysis revealed six themes discussed in the themes table provided in Appendix Figure 7. To help illustrate these themes Fig 4. maps the broader socio-ecological influences of tackle experience, along with the ecological systems model.

6.5.1 Ecological Systems Model and the Tackle

The findings that follow present a social ecological model to illustrate the interconnection between components of the tackle event and underpin the analysis.

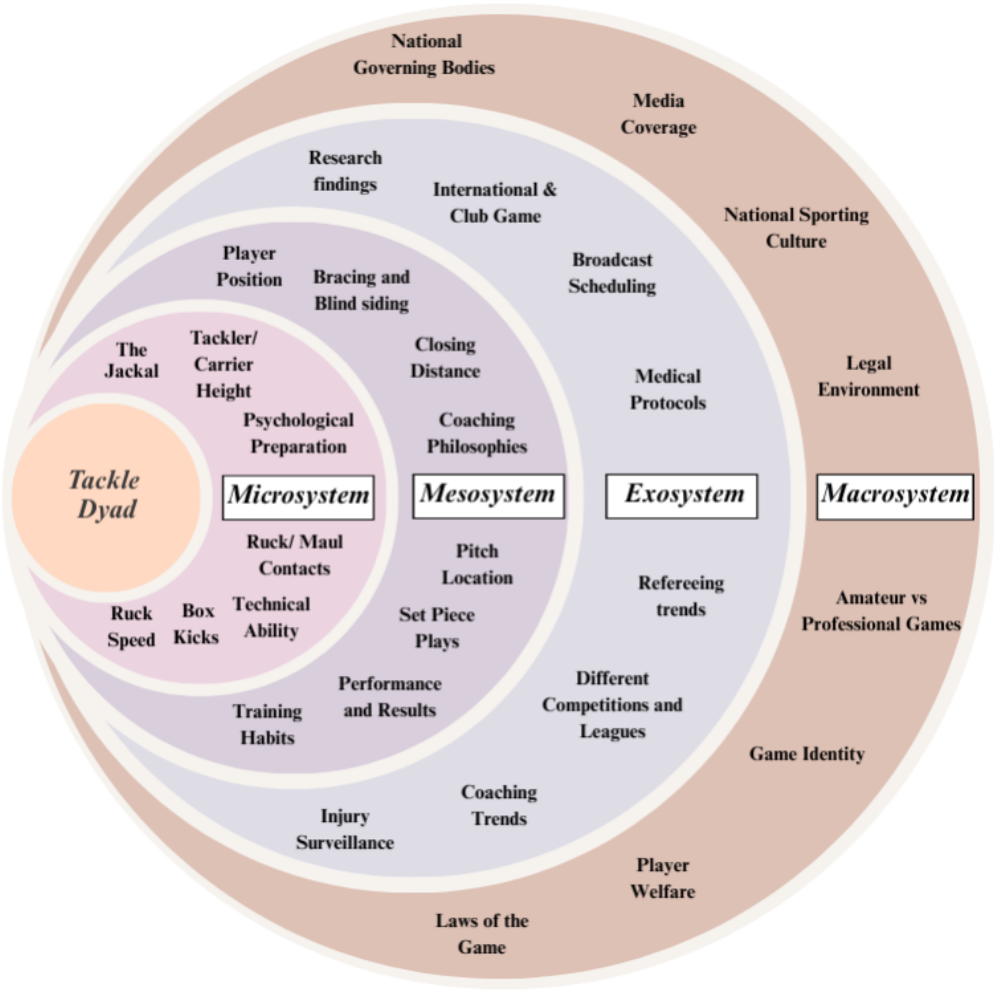

Fig 4. *An adaptation of Bronfenbrenner's ecological systems model in relation to the tackle event.*

Microsystem - People, Positions and Time Determine the Tackle.

The inner most level of the ecological system focuses on direct tackle events in match play that have an immediate interplay amongst the players and in game contacts instantly influencing the tackle event. Initial segments from themes generated in the microsystem encompass the proximal process of key proficiency metrics used by players to perform the tackle. The person is also discussed here as the nuances between those different positional groups, along with the context of match play that will influence tackle selection. This offers crucial insights into the techniques that players feel are optimal when performing the tackle, allowing comparisons to the techniques offered by the literature.

Principally, players discussed how footwork and tracking the opponent as process components. G3Participant2 illustrates this component below and was echoed by G3Participant1, G2Particpant5 and G3Participant4 throughout the focus groups:

> G3Participant2: 'If you can step in close, your first step after that collision, as well, is also gonna be, like, one of the strongest, but if you've lunged that in, and you've got straight legs, like, you're not gonna get any sort of leg drive.'

The above suggests the placement of the final step to be significant in enabling leg drive in contact is crucial. Timing within the tackle is crucial here as a player has seconds to react when entering contact to decide where to place the final step.

A key element of the tackle proficiency techniques is the requirement to win the contact. Time is highlighted as key in slowing the ball to ground and allowing the defensive line to set and as a process to ensure a connection for the subsequent play as G3Participant2 and G3Participant2 illustrates below:

> G3Participant2: 'Its all just outcome based really. We look at the same outcome every time, which is you want to slow their ball down and take away space from them, however you go about that isn't really. We show highlight reels most weeks of the game before and you'll have tackles that look really messy, really grabby, but that would be an effective tackle or something that we would praise because we would slow their ball down and hit them behind the gain line. Even if it doesn't look like perfect technique, like it looks really high, really messy, that's still an effective tackle.

G3Participant2: Yeah, especially in rugby union, that's what you're trying to do because the more you slow the ball down, the more time you've got for your defensive line to get set, whereas if you're, like I said about chop tackles, if the boys are on the floor straight away, that ball's available to play. You might only have one or two seconds for everyone to get set and off the line, whereas if you've got them for a higher shot and you've slowed that ball right down, you might give boys three, four, five seconds to set that line. That means that you've got better spacing, you're more connected, you're going to get off the line with more pace, so you're going to be more, effective.'

The weekly feedback, given to players relating to their contact outcomes, sits within this system and has a specific time component. This weekly feedback, which comprised a video review, illustrates the influence of feedback on tackle proficiency and how, throughout a season and over the course of seasons, a player's tackle technique may alter.

Contrastingly with defence, in attack, players emphasise that being able to manipulate the defence by the process of 'using the ball' and 'carrying to the weak shoulders of defenders'. Furthermore, players spoke of a context specific to RU as players latch onto each other, which adds more mass to the contact, as G2Participant2 and G2Participant5 document:

G2Participant2: 'I'll start off, I'd imagine me, G2Participant1 and G2Participant3 pretty similar as a forward quite a lot, If you're carrying off nine, you're running into pretty much a brick wall. You try and manipulate the defence a bit, but by using the ball, but most of the time you're sort of carrying into probably two forwards as well. Your carrying position's probably pretty similar to your tackle position. Well for us we look to carry quite low to obviously create quick ball.

G2Participant5: The only other thing I'd add is like sometimes you can get it where cause players are like to a certain extent allows to like latch on to each other. So basically there's two you're trying to tackle two people at the same time, like the mass of two people. You obviously go for the guy with the ball, but that's pretty, maybe a nuance of our game that you might not get elsewhere is people, there's sometimes more than one guy you're trying to bring down or dominate to win the collision, which can make the collisions a lot higher.'

In sum, this element demonstrates a further time component as players' focus on slowing the ruck in defence and attempting to speed it up in attack. The benefits are shown as being able to perform easier carries in attack, gaining momentum and getting the defensive line set and connected in defence. Yet, defenders demonstrate how contacting the ball carrier higher slows down the ruck and allows better defensive lines. Gaining insights into this area allows further understanding of the performance indicators at the elite level.

Performance indicators aren't the only component discussed by players relating to the ruck. Players perceived contact in the ruck as a contextual part of match play that is difficult to officiate because there are head contacts that are challenging to see due to the number of players.

G2Participant2: 'You actually have sort of made me think like in when I'm in a ruck, if I'm getting cleared out, I feel like around the pitch if someone gets hit in the head in a tackle in a carry, it's pretty obvious you'll get looked at. Where I reckon in that rucks is actually where maybe that doesn't get seen as much. I'd say in a ruck, if I get cleaned out. Like there's and you get hit on the head, nothing will happen and it's like it's quite hard to actually for the technique because your head can be low anyway. But I feel like stuff like that, I reckon probably 10 times in a game someone gets hit in the head in a ruck, right with a shoulder or like head on head and it's sort of well, it's not really looked at because it's quite hard to officiate because if your head's basically by the ground and they're clearing out low, like, that's where you can see like shoulders to head, head on heads, which maybe aren't picked up by the TMO, but they do happen … I'm not saying that if you get hit on the head in a breakdown, it should be a penalty because it’s, I almost feel like you can't avoid it sometimes It's just one of those. Like, it's one of those things.′

Ruck contacts sit within the microsystem with their inherent effect on in game contact experienced by players. In contrast, edge breakdowns were seen as a much lower collision. In this section of the field, a crucial focus was placed on the race to the ruck and then holding position, as G1Participant1 shows below:

G1Participant1: ‘Again, for it’s different, for backs than for you guys, if you're thinking about like an edge breakdown so often for us it's more about, like a race to get into a position and then these guys are thinking about hitting people off the ball. We're actually thinking about just staying over the ball rather than taking someone out of it. So, for like an edge breakdown, often there's not that much of a collision there. It's like just getting get into a good position and then just hold on rather than like actually hit someone and take them off their feet, definitely less of a collision now.’

People related interposition differences between forwards and backs have been a common trend throughout the themes that is prevalent again here. The context of contacts in wider rucks located towards the touchline is a vital element noted by players.

Mesosystem - Where Coaching Meets the Process of Tackle Variation

The mesosystem involves interactions between the microsystems for the tackle event, such as set-piece plays, pitch location and defensive philosophies. Every area of the mesosystem is interconnected and impacts the types and intensities of contacts that players will make. The backs' positional group highlights a person component within this system, feeling there was a variety in reaction times to their tackles, as G2Participant5 shows here:

> G2Participant5: 'There's a lot more variety in my tackle maybe compared to these guys (forwards) like. There's a variety in reaction time that I have. There's some of them really quick. Some of them I've got to sort of track a guy down for a long time and I'm expecting to make a tackle, but it takes me a bit longer to get there. Like mostly I'd say I'm quite a low tackler so like it never really ends up being high and it can be sort of a lot of different angles, a lot of stretching.'

G2Participant4 further illustrated agreement with the above statement, citing match play tackles for backs as 'situational', with differences in times to track the attacker. This theme shows the potential differences between the proximal process of contrasting people within the match play.

A crucial area associated with risk for forwards was the change in defensive system near the goal line, as players note the context of the field location requires players to operate lower when tackling to match the height of the ball carrier. The will to regain possession was noted to be key as the defence cannot hold the attack out for a significant amount of time. G3Participant4 outlines below.

> G3Participant4: 'I think it depends it depends where you are on the pitch as well, so we were talking if you're defending your own try line like if you look at the game from the weekend you've got lads like heads going to people's shins just like diving straight down um compared to outfield you'd never have that technique because you're just trying to keep them out.'

G2Participant5: ‘And also like we, we're trying to get the ball back at that point because there's only so long that we can hold teams out. So we've got to try and do something to get it back.’

Here, players speak of a different type of tackle technique, which means the process involved in tackling is altered by the context of pitch location.

Further notable sections relate to the backs’ positional group and the process of the coaching method used to coach goal line defence. The context of tackle technique changes near the goal line, being attributed to defending small spaces, is also elucidated.

G3Participant1: ‘But again, it depends on the area of the pitch, because here, defending the goal line, I don't think we get coached really the technique that well, especially when we've been coached on, as backs, how to defend in there.’

G3Participant3: It's completely different tackle. It's because you're defending inches, isn't it? You don't want to give away an inch, whereas outfield, that doesn't matter so much, so you can often give half a meter or whatever, but when you're on your goal line, you can't do that, so you've got to literally just be as low. you can they can't because they're trying to be as low as they can as well so you it's just a battle.’

Expanding on the previous section on goal line defence, G3Participant1 adds a new element, citing that the coaching of defensive processes taught to backs near the goal line is not as optimal as forwards. Potentially illustrating the requirement for further context to be added to training situations for this group.

Set pieces played a prominent role in players’ experiences, as players cited key differences in context between pressure based scrummage contacts in comparison to a collision-based tackle. The final element of this section discussed the process of setting up the maul from a lineout and how giving go forward from the second rows is quite problematic due to the head positioning of the flanker. This element is situated on the border of the microsystem and mesosystem, and set-piece plays are within the mesosystem, yet the maul is in the microsystem. G1Particiapnt3 documents this below.

> G1Participant3: 'I think so when you look at that plus one like the guy going to get the ball off the people jumping, that's horrible because you're like, it's almost like you're carrying into your own people, but it's with your head. Because you think about three people lift in the middle, two sorry jump in the middle, sorry two lifters either side you're hitting into that jumper. There's nowhere for you head to go. So that can feel like a big impact, especially in trying to give go forward to the maul. The rest of it not so much like when you're in there. Once you're in there, but obviously when you hit, that does feel hard. But once you're in there, I think it's the same. It's kind of like a breakdown. It's niggly like if it collapses, people landing on you. So the biggest point I don't know about you G1Participant2, but in training, training feels completely different to a game. So, like you think about like, what I spoke about having a collision, the first collision of the game. Usually, the maul was never the first collision of a game, whereas in training, so training to do mauls, that is usually the first collision that you have within training. And so, the opposition you play against obviously knows that what you're doing, because on the same team, you know, the same calls for me, that's probably the hard training wise. That's probably the hardest collision you get.'

Lineouts are a distinct match play event, unique to the context of RU match play and training. However, highlighted here are the difficulties in the process of training this movement and the head placement of the people whose role goes from aiding the jumper to setting up and giving go forward to the maul as there is a lack of space, specifically for the head. Coaching philosophies should centre around coaching optimal techniques and removing the problematic contacts arising in this positional group during the lineout training and match play.

Coaching philosophies were further discussed in this system by players as the differences in coaching trends were noted over time for the chop tackle, which enabled the jackal, versus higher up contacts, which aimed to slow the ruck. G3Participant4 shows the initial discussion below of contrasting coaching philosophies and their influence on the proximal process of the tackle:

> G3Participant4: 'Yeah, so I've had two clubs where it's all been about timing the tackle, get two people in there, try and hold them up, change the momentum, get our defensive line set, and that was very much like, that's what they'd review every week, and then I've had two clubs where we've had real good jacklers in the side, so it's been like, right, chop, chop and roll, because obviously once you've made the tackle, in order for our jackler, because we had a few real good jacklers, to be able to get over the ball, the tackler who made the tackle had to roll out of the way, because otherwise it would give the penalty away. So that philosophy was very much like, right, chop, tackle, roll, chop, tackle, roll. Yeah, and just the way they go about it, for example here, one of the other clubs, it was like, all the drills would do would be very much like two men in the tackle, change momentum. Whereas the other clubs I was at was like, right, chop and roll, chop and roll, you've got to operate low, you've got to live low.'

Here players document differing processes influenced by club coaches' philosophies and how the context of match play contacts alters in relation to the perceptions and aims of coaches.

Exosystem - Tackle Contexts to Inform Refereeing Trends

The exosystem impacts the development of the tackle, but it is not an environment where the tackle is directly performed. Areas such as broadcasting schedule, medical protocols, injury surveillance and research findings all impact the tackle event from a distance. In a similar fashion, the differences between club and international games are documented alongside the contrasting trends of play between leagues and refereeing.

In the principal section of this system, players discussed coaching trends developed over time from an attacking point of view. Suggesting through a process of protecting the ball, coaches will coach a lower carry.

> G4Participant3: 'I think there's a difficulty between. It's like a bit of a balance, right, because the rules have been changed to drop the tackle height to promote safety. But then at the same time, on the other side of the ball, part of like attack coaches and like coaching people to carry lower in order to stop like what you're saying, like the ball being ripped and ball being put in danger. So, like, I suppose the question is like, how, how does the game make it safer for everyone if we can't just keep bringing the height down. You've got to tackle lower because people are carrying lower and you got to tackle lower, you know.'

The dropping tackle height for the attack was a prevalent perception in the current study. NGB's have aimed to alter match play to aid the safety of the game over time, however, highlighting a contextual insight for referees is in that near the goal line, tacklers will also be lower. As such, ensuring ball carriers are not dipping into contact in this pitch location is paramount. Furthermore, players also discussed tackle height being effected by altering law interpretations of the jackal in subsequent seasons as G3Participant4 and G3Participants1 discuss below:

G3Participant4: ‘It's when they changed the law. The club I was at, we had a couple of really good jackals, and it was around Covid time, and they changed the laws around the jackal. Whereas if the jackal can get his hands on the ball, he's literally going to blow for a penalty straight away. So our whole thing was like, right, chop, jackal on it, chop, jackal on it. We got so many penalties that worked really well for us. Then as they reviewed that law and changed it a bit, that's when we moved away from that.’

G3Participant1: ‘I actually think that's increased the height at which people tackle has gone up since then. Which is probably more dangerous. They're obviously trying to go away from that but because there's not as much benefit for the jackal because they're obviously going to speed the ball up, the tackle heights gone up because the only way you can do it is have time and tackle and be up there around the ball.’

Players outline a time component of tackle technique altering in ensuing seasons as the process of refereeing changes. This element of the theme highlights some potential unintended consequences of rule changes and the importance of including stakeholders in the decision-making process.

Macrosystem - Laws of the Game Driving Tackle Experiences.

The final system relates to the contributions of broader society and cultural forces upon the tackle event. For instance, the inability for players to brace as a catcher during box kicks was highlighted as a component within this system associated with increased risk of injury. Although this event sits within the microsystem (closing distance/ blind-siding), player’s perceptions were that new rule changes had made this event more difficult due to the lack of ‘shepherding’. It was perceived that this gave the attacker a free run to the catcher, and therefore rules modified the context of the event. This sits within the macrosystem as the laws of the game influence this component of the tackle. Below G4Participant5 shows.

> G4Participant5: 'I think as well because it's such a major rule change this that they've bought this year around the no cradle, there's still sort of an area of uncertainty around. With some of the calls refs have made. But yeah, I think there is definitely a lot, a lot of the guys who are in those position are going up to catch the ball. There probably is a little bit more fear that you are going to, it's to encourage that one-on-one contest in the air. But that fear that you probably are going to get taken out in the air. It's definitely crossing a lot a lot more boys' minds. Whereas with the cradle, it's something which has happened. They're pretty hard to try and avoid that but yeah, that's something's certainly something that's crossed my mind.'
>
> G3Participant1: 'That's one for me is that when box kicks go up, I'm up for a box kick landing and someone's well-timed hitting you. That's the worst one. Because you don't really know where they are because you're focusing on the ball.'

Notwithstanding the person specific element of this section to back field players during the box kick, the precedent for contacts that do not allow the player to brace remains a key point. In this case, players' perceptions in this study suggest that rule changes over time have increased the one-on-one contest in the air, which could potentially be problematic. There is also a process influence at play here. Specifically, it was reported that defensive philosophies are a difficult area to train due to the increased risk associated with performing the event in training.

More broadly, in training, players discussed contact being in a level 2 zone intensity in line with contact load guidelines (Starling et al., 2023). This means they operate high but with low intensity to control the contact. However, training habits potentially translate into the game where they need to lower their contact levels. There is an interjection of the macrosystem in this section as the laws of the game and rules that NGB's are putting in place to aid player safety alter training contacts over time. Players felt that operating at a higher level in training can result in poor process habits translating to a game, as G1Particant2 discusses below.

> G1Participant2: 'Well, when I had those two cards back-to-back in Year X, I blame that solely on training habits, completely on training habits. Where because we train that way all the time, and we'd have a, it wasn't a big Level 2, but it was a kind of like a grab level 2. So you never change your body height, and then you go into the game and you've been doing that for 12 weeks of preseason plus the six weeks is 20 weeks from practising this kind of like high grab and then you go into a game where you get to, I've got two, Player S got two cards, Player U got two cards, Player Z got two cards.'

G1Participant2 shows that performing contact for 12 weeks at a higher level may influence the ability process of players' technique in match play. Illustrating some of the key interactions of rule changes over time, altering the process of coaching the contact, which results in different match contact contexts.

The final component of the macrosystem describes the evolution of the game's identity. A balancing act between arousal and calmness was noted, citing a time element whereby players now value being calm over the adrenaline rush valued by previous generations. Moreover, players also discussed how knowing the game plan is as crucial as the emotional side of the game when preparing for a match. There seems to be a key interplay between the process of feeling prepared for match play contact and being in an emotional state that isn't overtly aroused for match play. Although psychological preparation is in the microsystem due to its direct influence on contact, G2Participant5 highlights the benefits of feeling calm, whilst G1Participant2 illustrates the evolution of match psychology.

> G2Participant5: 'I'll say, like most of the time, I feel quite calm. Like the more the more amped up I get. I think that's where errors come into my game, so I just I try and stay calm and normally it's sort of like muscle memory kicks in and you end up doing the things that you that you want to do.'
>
> G1Participant2: 'I also think like bigger picture stuff on the game at the minute is that emotional side of the game is getting less and less and less. So if you wind back the changing rooms to 12 years ago or 14 years ago when I started you, that's where you had boys headbutted walls still. And you have boys slap on each other, screaming, shouting. They're spraying water in their face, but then 14 years ago, just throw a punch, maybe a penalty. So now you throw a punch it's a red card and a six week ban. So the game physicality is the style of physicality has changed. I believe it's a way more physical game now. As in the collisions are bigger and harder, but they're less aggressive as in there's less punching there's less, it's more controlled. There's much more controlled aggression rather than just raw aggression.'
>
> G2Participant3: Everyone's different, I'd say, cause for me, obviously I've gotta get myself like for me. I'll probably say look forwards, wise as well. It's totally different for backs. So I've got to get myself amped up because I feel like I'm like, I'm going to go to war type of thing.

Feeling calm and the increased development of match officiating show a transformation of the sport to more controlled efforts of physicality and aggression in more recent times. However, iterations were highlighted of different psychologies between forwards and backs, as some forwards still mentioned the feeling of going to 'war'. Additionally, knowing the game plan was also discussed as crucial from a process perspective.

G1Participant2: ‘I think there's two parts to it. I don't know how you break it up psychologically, but there's one about the game plan and your role and you knowing, and having like you really knowing it, so you’re not thinking about it, you know where you’re going you know where your job is. And then the other part of it is like that emotional get up for the game. The way I play and where I am, the second one, I've never had an issue with I've never gone into a game thinking oh, I don't know if I fancy this today, you know, I've never had that feeling. Whereas I have had that feeling where I go into the game or like I'm not 100% sure if he calls a 7-man line out shift one where that ball is going so. For me, having both of those things concrete as I know exactly what I'm doing and where I should be, and then I'm then I'm sweet, but then that the first one says, well, can perhaps impact the second one because emotionally, if I'm thinking I'm not thinking, let's go. Let's go. Let's go. Which is where I am in a good place.’

In this theme, players illustrate that knowing the game plan whilst remaining in a state of calmness is key for performance, denoting the metamorphosis of team cultures over time. A further element related to the game's identity was players’ desire to maintain the essence of the game, whilst making it as safe as possible. Reflecting a person related component, as the individuals who participate in the sport collectively determine the culture and identity through their shared traditions and perceptions of long-term health implications from injuries, as G4Participant2 shows.

G4Participant2: It’s like a jackal, nobody jackals, but nobody gets cleared out anyway. If you're Jackal in training no one's going to go and clear you out, I think those are the areas where like you actually either do see or will see like the more nasty ones is actually because like other areas where we like, we do have a lot of hours to train like two man tackles and stuff. So you don't see people like getting nasty head knocks off. Those is the, it's the ones where you can't get loads of reps in the week because they're a bit dangerous. That's where the decision making isn't great, and that's where probably like people, the players them like the most at their most vulnerable.

G4Participant2: I don't know you can practice certain things, but like you said it, there's only so much you can do until you have to just actually do it 100%. But then I think I don't know. I don't think you guys are saying this, but like, that's what makes it like that's what's rugby is, isn't it? Like we've all made like, we get paid to do the job. It's like F1 drivers like I'm sure, when they're like going around …

G4Participant3: They don't say, oh, we won't wear a helmet then. Yeah, they still take all precautions they can.

G4Participant2: Yeah.

G4Participant3: I'm sorry. I know we're.

G4Participant2: I know well, I think we're agreeing, but I think it's just like

G4Participant1: I think we all know the risks.

This section shows players discussing the injury risk associated with playing a collision sport like rugby and the dichotomy between the identity of the sport and mitigating against risk as much as possible. This section relates to the people playing the sport and their perceptions of its identity, along with the transformation of the sport over time to ensure that match play and training are as safe as possible.

6.6 Discussion

The current study explored elite RU players' experiences of the tackle event through a series of focus groups. The findings of the study illustrate a plethora of novel insights from an elite population, not previously noted in the literature. Participants described key tackle proficiency techniques for the tackler, reflecting personal position differences perceived to be associated with greater tackle success and the immediate context of the tackle. Moreover, players highlighted the central importance of ruck speed and how tackles, regardless of context, are outcome-based, which dictates the contact zone of the tackler. The jackal had a significant influence on contact zones and whether players were aiming to recoup possession through performing a lower contact in the preceding tackle by way of a chop tackle. Players also discussed head contacts from two distinct perspectives, initially in the ruck as this is a difficult place to officiate for referees and separately in the back row position in the process of setting up a maul from a successful line out due to the lack of space for the head. Recent rules and officiating changes have placed a prominent focus on box kicks, with players perceiving an inherent risk with this kind of contact due to a lack of bracing for the collision. Lastly, elements of the game's identity were documented as players alluded to some transformational parts of rugby culture, such as a focus on calmness, albeit with a deep rooted feeling of going to 'war'.

Tackle proficiency metrics have been a focal point of research to understand the patterns in contact techniques linked with injury and tackle success (Davidow et al., 2018b; Hendricks, van Niekerk, et al., 2018). Of the key techniques highlighted by players, identifying the ball carrier onto the shoulder, shortening steps, and leg drive upon contact all correlated with previous research associated with performance and injury prevention (Hollander, Ponce, et al., 2021b). As a reciprocal interaction between players adapting to their environment, the proximal process of the defender aiming to plant the lead foot as close to the attacker as possible was a crucial element discussed. Driven by coaches' feedback from the resultant outcome-based approach, tackle techniques contrasted from the 'chop' tackle to enable a teammate to 'jackal', or a higher up contact to control the ruck and get the defensive line set. Training habits were also underscored as shaping behaviour through the repetitive nature of practice. Starling et al. (2023) has shown how contact guidelines have recently been introduced to track and monitor contact loads. However, players cited that the repetition of performing contacts in zone 2 means a higher up contact is performed more often in training. The interaction between repetition of zone 2 contacts and match play, when contact zones must be lower, is potentially problematic for players due to the habitual nature of tackle technique, especially with increased fatigue.

Head contacts were a component noted by players in specific elements of the lineout and subsequent maul relating to the individual characteristics of the person playing the position. Players elucidated how 'adding' into a successful lineout whilst setting up a maul can be an intense collision due to the lack of space for head placement, especially for the flanker position. It was also described as one of the most difficult contacts in training due to the augmentation of the opposition knowing the play, as such, correlating with the proximal process of training habits. Research investigating lineouts illustrated lower performing teams lost more lineouts and higher performing teams won more of their opposition's lineouts (Colomer et al., 2020a). Yet, there is little research delineating the individual positional roles within the lineout and the collision exposure that occurs during training and matches. Given that winning lineouts are a key performance indicator shown in research, this is a significant area to train. Other excerpts from the current study showed players' perceptions of being at the head of the maul from a successful line out as lower risk. Therefore, the individual exposure to each person within the lineout may contrast and as such, warrants further inquiry. Positional role further shaped interactions at edge breakdowns and contacts near the goal line for backs. Backs discussed how the breakdown on an edge is a race to position, in contrast to middle breakdowns, which are a competition amongst forwards. Similarly, backs felt there was a lot more variety in their tackle in comparison to forwards, however, the coaching of goal line defence is not as proficient as that of forwards. Given the individual roles ascribed to each position, the person feature of this element highlights the distinction between playing groups and their experience of the tackle.

Time was discussed by players relating to tackle type, if the tackle creates a 'slow ruck', this is positive, and if it creates a 'fast ruck', it is deemed negative. Players highlighted coaches' focus on slowing down the ruck to set the defensive line, a transformative tactic, since recent rule changes to post-contact components of the ruck. In March 2020, World Rugby altered the enforcement of ruck infringements at the breakdown, bringing increased scrutiny to the jackal, and shifting its officiating over time (World Rugby, 2020a). More emphasis was placed on which player wins the race to possession before the ruck is formed and ensuring the jackler supports their body weight without going to ground. To further player safety, World Rugby (2020b) reduced additional problematic elements of the jackal, such as the 'crocodile roll', to reduce the risk of knee injuries during match play (West et al., 2024). This was a significant change given the association the jackal has with turnover possession in central pitch areas (Colomer et al., 2020b). Related to the jackal, players in this study perceived coaching philosophies to originate from two divisions, a chop tackle for a teammate to perform the jackal, or a higher up contact aimed at slowing the ruck down. These philosophies manifest in the interplay of coaches coaching the tackle, and players changing over time via weekly feedback in the microsystem to alter players' technique. They also refer to the change in refereeing trends over time, situated in the exosystem, prompted by law changes by governing bodies in the macrosystem. Given the increased scrutiny on the jackal, the likelihood of players performing the chop tackle to enable this event decreases. Consequently, players report contacting the body of the attacker higher up to control the carrier to the floor and allow time for the defensive line to set and get connected as more beneficial. Tackle height is, however, a continual discussion in rugby due to higher up contacts having an increased likelihood of HIA's (Tierney et al., 2018b) and concussions (Tucker, Hester, et al., 2017). In an effort to reduce concussions, governing bodies have rolled out trials to alter behaviour change in the tackle (Stokes et al., 2021b), along with tackle technique programs to modify tackle technique to more frequently select a lower contact zone (RFU tackle technique program). However, it appears players in the current study feel contacting the ball carrier in a higher zone may increase the ability to slow the ruck down and therefore provide a greater tactical advantage.

A box kick is a short-range contestable kick that aims to put the opposition under pressure, gain territory or regain possession (World Rugby, 2021a). The deployment of the box kick has substantially increased over recent years. Strydom et al. (2025) showed an increase of 6% of all kicks in the 2003 world cup to 23% in the 2019 rugby world cup. The box kick alters the environmental conditions in which the tackle occurs and, therefore, is context dependant. Recent rule changes are aimed at penalising teams that 'escort' or slow down the chaser en route to the catcher, to provide an even contest in the air (World Rugby, 2024a), transforming the context of the event. However, players cited a lack of ability to perform this type of contact in training, which potentially leads to poorer decision making in match play. This may not help players' abilities to brace when catching from a box kick, which is often difficult anyway due to their focus on the ball and the association of tackler speed and accelerating tackler with a concussion (Cross et al., 2019b). Finding ways to train the box kick safely is of paramount importance to aid players' coordination. Further contextual factors unique to RU are the ruck maul, lineouts, and contested scrums (Quarrie & Hopkins, 2007). Clearing out the ruck and contacts in the maul were a prevalent point documented by players. Players spoke of head contacts in the ruck that do not get seen by officials, illustrating the difficulty in officiating the ruck. However, a recent study by Roe, Sawczuk, Owen, Tooby, Starling, Gilthorpe, Falvey, Hendricks, Rasmussen, and Readhead (2024) showed the probability of maximum magnitude head acceleration event (peak linear acceleration and peak angular acceleration) was higher for tackles and ball carries than rucks. Yet, certain ruck events had a significantly higher magnitude, such as 'got cleared out' and 'failed clear out in attacking rucks' or 'turnover won in defensive rucks'. Whereas almost 75% of all rucks comprised 'secured' or 'attended', which were associated with the lowest magnitudes. England Rugby (2021) have employed the real-time video review system Hawkeye, since 2016/2017 premiership season to support the pitch side reviewing of HIA's. Although a comprehensive system, it appears there are practicalities with viewing some head contacts in the ruck in specific contexts, which may support the application of in game alerts from mouthguards.

6.7 Conclusions

Through a series of online focus groups, this study aimed to explore the subjective experiences of elite RU players playing in the Premiership in England. Using Braun and Clarke (2019) reflexive thematic analysis, the four focus groups were analysed producing six themes consisting of : 1) how position and context drive tackle selection in defence, 2) strategies that shape ball speed – defensive disruption and generating attacking momentum, 3) from goal line defence to aerial battles – contextual factors that augment collision intensity and injury potential, 4) where possession is won and lost – strategic execution across the ruck, lineout and scrums, 5) philosophy vs practicality – how coaching beliefs influence contact techniques and preparation**,** 6) beyond the rush – balancing arousal, calmness and tactical knowledge in training and games. To provide further context to the tackle event, a theoretical model was included to provide context of several interlinking systems and their role in the tackle event. This research moves the existing research forward by providing previously unheard subjective experiences of players and mapping the environment of the tackle in elite RU. Future research should aim to assess the applicability of the findings and assess how tackle mechanics are altered by contrasting conditions, such as fatigue, blind-sided contacts and in pitch areas like the goal line. Gaining further insights into such areas will provide a greater understanding of at risk scenarios for players.

Chapter 7

Title:

The Effect of Match Speed and Contact Volume on Tackle Proficiency of Highly Trained Rugby League Players.

7.1 Abstract

Background: RL is an intermittent full-contact collision sport, where the tackle event is a crucial element of match play associated with team success and injury. An increased tackle proficiency reduces the likelihood of the sport's most prevalent injury, the concussion. The aim of this study was to assess the effect of match speed and tackle load on tackle proficiency in highly trained RL players using a simulated RL match.

Methods: Thirteen highly trained ESL reserve players took part in two conditions: a reduced match speed increased collision load condition (slow) and an increased match speed reduced collision load (fast) condition. Players performed a standardised warm-up for both conditions and were habituated to the protocol before participation. After a baseline tackle on each shoulder, players completed the fatiguing conditions for ~20 minutes, replicating an average of the match-specific ball-in-play periods reported for each condition for a hit-up forward.

Results: A greater total distance, mean speed, high speed running, average heart rate and RPE were observed in the faster condition (all $p < 0.05$), while peak sprint speed was greater in the slow condition ($p < 0.05$). Despite observations of player fatigue, there was no difference in tackle proficiency between low-speed running and peak heart rate between trials ($p > 0.05$).

Conclusion: This study demonstrates, in a match simulation protocol with increased mean speed and a lower contact load, that a greater mean HR and RPE, along with reduced peak sprint distance and sprint distance occur, compared to a slower condition with more contacts. The study also highlights the difficulty in assessing tackle proficiency through a standardised one-on-one testing protocol, attributed to the subjectivity of the coach's rating.

7.2 Introduction

A common theme throughout all chapters is the role of tackle proficiency and the contrasting factors influencing this aspect in match play and training. Elite RL stakeholders discussed different levels of contact training, such as contact, collision and contact, whereas RU players denoted different kinds of tackle types in match play. Nevertheless, tackle technique proficiency is associated with performance and injury prevention outcomes for the tackler (i.e., body position dipping, back straight, head up and face forward, shortened steps, contact with the shoulder, contact the centre of gravity, head placement on the correct side, shoulder drive upon contact, leg drive, punch arms and wrap) and the ball carrier (i.e., body position upright to low, fend into contact, explosive on contact, leg drive upon contact) in both RL and RU players (Hollander, Ponce, et al. (2021b). Davidow et al. (2018b) reported the role of contact proficiency in RU, as both ball carriers and tacklers had lower contact technique scores in head-impacted tackles. This finding is despite the tackler being 1.7 times more likely to experience a head injury assessment (HIA) than the ball carrier (Gardner et al., 2021c). Four key variables increase the risk of concussion, such as tackle impact location on the ball carrier, the number of players in the tackle, the ball carrier's use of the leading arm and the ball carrier-tackler body position (Owen et al., 2025). Thus, tackle technique and body position in contact for both the tackler and ball carrier have been a focal point of contemporary research in both codes (Tucker, Hester, et al., 2017). Tackling technique is also positively influenced by greater playing experience in RL players, with poorer technique observed in players with <150 games compared to those players with >150 games in the NRL (Gabbett and Ryan (2009). These observations suggest that tackling is a skill that can be mastered with practice and is a key performance indicator of match-play success.

Fatigue has been identified as a contributing factor that affects an individual's tackle technique in both rugby codes (Davidow et al., 2020a; Gabbett, 2008). Chapter 4 identified through online focus groups that elite RL players perceived tackle technique to be impaired as fatigue increased in matches. Fatigue generated by recent increases in ball-in-play duration and match speed has also been highlighted as a factor for increased injury risk in Chapters 4, 5, and 6 by players and stakeholders. In Chapter 5, coaches believed that the recent rule changes aimed at removing stagnant time in match play had increased the demands for players beyond their physical capacities. These findings are accompanied by work by Rennie et al. (2021) who established an increase in ball-in-play duration for the English Super League that resulted in a decreased match speed (m/min) and an increase in total match play collisions, specifically in forward positions. Understanding the role of match speed on player fatigue and tackle performance would therefore be useful to help inform player development and training practices. Moreover, given the aim of both codes to increase ball-in-play (World Rugby, 2024a), it is imperative that the potential unintended consequences are delineated before enacting change to reduce the potential risk of injury to players.

The relationship between fatigue and changes in tackle technique has previously been examined using intermittent conditioning drills to replicate match-related fatigue (Gabbett, 2016). However, the ecological validity of conditioning drills to reproduce fatigue induced in match play is a potential limitation of the previous work. The repeated high intensity effort (RHIE) protocol utilised was based on the most intense cycle of RL match play, comprising a 10 m sprint, 3 full contact tackles and a 30 m recovery jog. This cycle was performed on a rolling 40 s clock with four efforts performed, totalling 160 s. The rationale for the number of bouts and tackles completed was not given, as the time-motion analysis cited in the study from the previous work described the maximum number of RHIE bouts per game as 13

(Gabbett et al., 2012). Studies using more ecologically valid replications of match movement demands are needed to offer insight to the influence of fatigue on tackle proficiency in rugby players.

The rugby league match simulation protocol for interchange players (RLMSP-i; (Waldron, Highton, & Twist, 2013) is reliable (Norris et al., 2019) and has been used successfully to assess the effect of nutrition (Clarke et al., 2019) and tackle manipulation (Mullen et al., 2015a; Mullen et al., 2021) on match movement characteristics and player fatiguability. Given the utility of this simulation and that the forward group are the foremost player group affected by the recent ball-in-play changes, this might offer a more ecologically appropriate approach to systematically study the effect of fatigue on player performance and tackle proficiency. Therefore, the aim of the current study was to replicate the potential influence of rule changes that enabled the examination of two different match play speeds (95 m·min^{-1} vs. 102 m·min^{-1} and contact loads (22 tackles vs. 17 tackles) on the movement characteristics, internal load and tackling technique of professional male RL players.

7.3 Methods

7.3.1 Design

Thirteen highly trained (McKay et al. (2022) male RL players currently playing for European Super League (ESL) reserves teams were recruited to take part in the study. The study sample size was estimated a *priori* to reliably detect a meaningful difference in tackle proficiency between the fast and slow trials using an independent sample *t*-test, and ensure high statistical power (0.9)(Abt et al., 2025). Type 1 (a) and Type 2 (b) error rates were chosen at 0.05 and 0.20, respectively, in line with the conventional thresholds of prior literature (Akobeng, 2016). The calculation was performed using G*Power (version 3.1.9.7), and the smallest effect size of interest in tackle proficiency (f = 0.25) was informed by effect sizes reported in a comparable study (Gabbett, 2008). The analysis estimated the sample size to identify the statistical power between groups was 12, and to account for experimental mortality, 13 participants were selected. Testing took place during the 2024 season. Participants were required to have been competing in the ESL reserve competition in the previous season or were due to compete in the upcoming season, and were injury-free at the time of testing. Purposive sampling was used to recruit hit up, middle playing forwards because of their distinct movement and fatigue characteristics compared to their positional counterparts (i.e., wide running forwards, backs and adjustables) (Austin & Kelly, 2013). Moreover, forwards perform more collisions than other position groups during match-play (Glassbrook et al., 2019), and are the foremost affected position by the recent increased ball-in-play and contact loads due to rule changes (Rennie et al., 2021). The present study used a randomised cross-over design to investigate the influence of match speed and contact load on tackling proficiency, internal and external load. Players completed two trials: a reduced match speed increased collision load (slow) trial and an increased match speed reduced collision load (fast) trial. Players performed a standardised warm-up for both trials and were habituated to the protocol before participation. After a baseline tackle on each shoulder using a standardised one-on-one drill, players completed the trial (fast or slow for ~20 minutes, replicating an average of the match-specific ball-in-play periods as shown in Rennie et al. (2021) for a hit-up forward. Each trial was separated by a minimum of 72 hours, allowing recovery for the subsequent bout. All players were provided with a participant information sheet with a full explanation of the protocol and provided consent to participate in the study. Liverpool John Moores University granted institutional ethics approval for this study (23/SPS/067).

7.3.2 Match Movement Simulation

A forward-specific rugby league simulation protocol for interchange players (RLMSP-i), designed to replicate the movement characteristics of interchange players, was used for the fast and slow trials (Waldron, Highton, & Twist, 2013). The simulation protocol has demonstrated sufficient reliability to enable the detection of moderate changes in various performance measurements (Waldron et al., 2013). The match-specific simulation has been through several iterations to adapt to contrasting investigations (Mullen et al., 2015a), as such, the mean speed was adapted. The movement protocol (see Figure 1) required players to sprint from the yellow cone to the blue cone, decelerate to the white cone, and then walk to the contact zone, intermittently performing contacts using a one-on-one tackle drill (Gabbett et al., 2016; see below). After performing a contact or rest period, players would walk back into the running zone and continue with the condition, returning to the yellow cone. The fast rial replicated the locomotor and contact match characteristics from the 2020 pre-COVID-19 period with a mean speed of 102 $m \cdot min^{-1}$ and 17 tackles (Rennie et al., 2021). The slow trial replicated locomotor and contact match characteristics from the post-COVID-19 period with a mean speed of 95 $m \cdot min^{-1}$ and 22 tackles (Rennie et al., 2021). To record the movement characteristics during the simulation, a portable 10 Hz Global Navigation Satellite System (GNSS) device (Catapult, Optimeye S5, Catapult Innovations, Melbourne, Australia) was fitted in an appropriately sized vest situated between the scapulae. Heart rate (HR) was collected using a chest-fitted HR monitor (Polar Electro, Oy, Kempele, Finland) synchronised to the GNSS device. Catapult OpenField 1.21.0 (Catapult, Innovations, Melbourne, Australia) was used to download and analyse movement and HR data for both trials. A digital watch, synchronised with Greenwich Mean Time, was used to record the start and finish time of the trial, and later used to truncate the raw GNSS files into four different quartiles. Data were then analysed per quarter of each trial of the RLMSP-i, recording mean speed ($m \cdot min^{-1}$), low speed running (<14 km·h^{-1}), high speed running (>14 km·h^{-1}) and sprinting (>19 km·h^{-1}). Peak heart rate (%HRpeak, i.e., the highest heart rate achieved in both trials) was also used to calculate the mean percentage of each participant's heart rate attained in each trial.

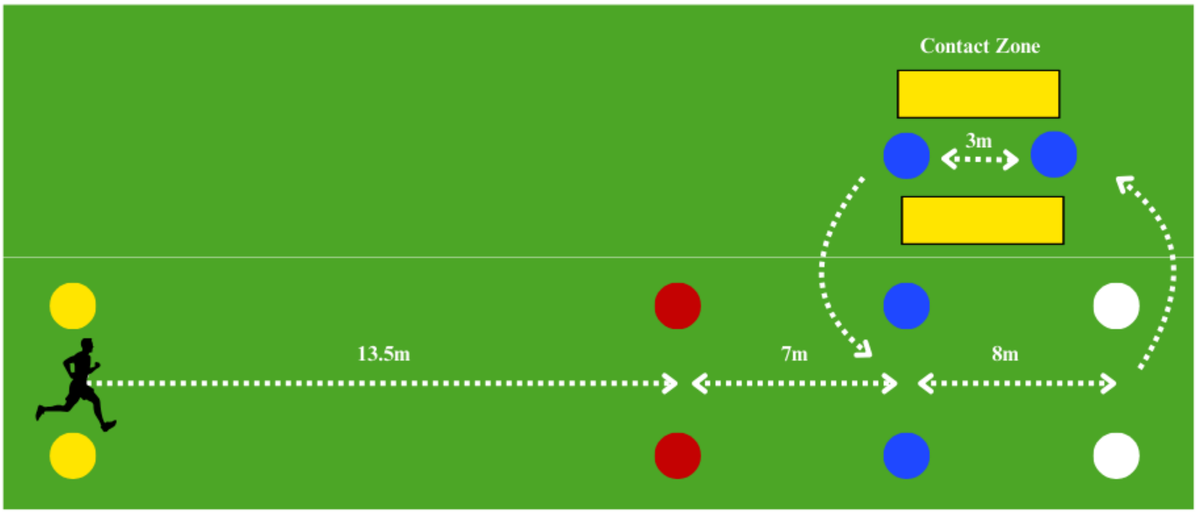

Fig 5. RLMSP-i adaptation with a 3 m contact zone to simulate a game marker tackle.

7.3.3 Perceptual Measures of Exercise Intensity

Perceptual measures of exercise intensity were recorded for both conditions of the RLMSP-i using rate of perceived exertion (RPE), taken every quartile (5 minutes) during the simulation and differential rate of perceived exertion (dRPE) recorded upon the completion of each bout (20 minutes). Measures of RPE have been utilised in RL as a non-invasive 'global measure' of internal load (Lovell et al., 2013). RPE was taken using a category ratio scale of 0 – 10, in line with previous research highlighting a strong correlation with the Borg-RPE (6 – 20) scale (Arney et al., 2019). Although RPE provides a global measure, dRPE has been used to discern differences of internal load between breathlessness (dRPE-B), upper/ lower body muscle exertion (dRPE-U/L), and cognitive demands (dRPE-T) (McLaren et al., 2017). As such, the CR100 scale (0-100) was utilised to provide a greater sensitivity of scores, as shown by McLaren et al. (2018), with the internal load markers adapted to breathlessness (dRPE-B), cognitive demands (dRPE-T) and muscular peripheral fatigue (dRPE-P).

7.3.4 One-on-One Tackle Proficiency Drill

Using the work of Gabbett (2016), the standardised one-on-one tackle proficiency drill comprised players completing alternating front-on shoulder tackles in a 3 m grid. The ball carrier, accompanied by a tackle shield, alternated shoulder order by stepping towards the opposing shoulder of the defender. The distance between the attacker and defender aimed to adequately reflect the approximate distance of a tackle from the marker (Gabbett, 2016). Video footage was taken from the side during the standardised one-on-one tackling drill using a video camera (Sony Panasonic HC-V75OEB-K Full HD Camcorder), mounted to a tripod set to 1.6 m. To objectively assess the tackling technique, a technical tackling criteria culminating from previous research was used (Gabbett, 2008; Hollander et al., 2021). The technical criteria assessed three different phases of the tackle, comprising: i) pre-contact phase, ii) contact phase and iii) post-contact phase. The technical criteria in each phase were, *pre-contact:* a) accelerate towards the ball carrier b) identify the ball-carrier onto the shoulder, c) shorten steps with head up, d) body position upright; *contact* e) contact target with opposite shoulder to the leading leg, f) contacting centre of mass, g) head in the correct position to the side, h) arms wrap around ball carrier; *post- contact* i) shoulder and leg drive. To assess the tackles, two qualified coaches (Level 3 RL Coaching Qualification, UK) were chosen due to the requirement of the Level 3 to be either an ESL head coach or performance pathway coach (Rugby Football League, 2023b). The coaches were habituated with the tackle proficiency techniques and marking of the tackles, with examples of scored tackles provided. Participants were rated out of 10 tackle proficiency markers associated with performance and injury reduction in previous research (Gabbett, 2016; Hollander, Ponce, et al., 2021b), with 1 point awarded for each occasion a technique was achieved, and 0 awarded when it was not. All tackles were completed to ground onto a crash mat that was placed on either side of the contact zone.

7.3.5 Reliability

To test intra- and inter-rater reliability, tests were conducted assessing the subjective rating by coaches. A two-way mixed model intraclass correlation coefficient (ICC) and the typical error of measurement (TEM) were used to determine inter-rater and intra-rater reliability for absolute tackle ratings (0-10). Interrater agreement between Coach A and Coach B was poor: ICC (two-way mixed, absolute agreement, single measures) = 0.263, 95% CI [0.18, 0.343], indicating low absolute agreement in 0 – 10 tackle ratings. Averaging both raters improved reliability but remained poor: ICC (average measures) = 0.417. Coach A scored on average 0.682 points lower than Coach B. The typical error of measurement equated to 1.575 points. To determine intra-rater reliability, 56 tackles (11%) were selected by a computer-generated random sample (https://www.random.org/) and scored on a separate occasion, separated by at least one week, with coaches blinded to their prior scores (Beare & Stone, 2019). Both coaches indicated a poor absolute agreement of 0 – 10 tackle ratings, as Coach A, ICC (two-way mixed, absolute agreement, single measures) = 0.343, 95% CI [0.04, 0.58], F (55, 55) = 2.51, $p < .001$ and Coach B ICC (two-way mixed, absolute agreement, single measures) = 0.368, 95% CI [0.13, 0.57], F (55,55) = 2.21, $p = .002$. The averaging of the two ratings improved reliability but remained moderate for Coach A, ICC (average measures) = 0.511 (95% CI [-0.09, 0.73]) and Coach B, ICC (average measures) = 0.539 (95% CI [0.22, 0.73]), respectively. To establish an average rating for scores with large discrepancies, a third qualified coach (Level 3 RL Coaching Qualification, UK) assessed tackles with a difference of 4 or more between the initial two raters. The average of this score was added to the final analysis. To ascertain inter-reliability measures on an item-by-item basis, Cohen's Kappa were computed, see Table 1.

Table 1: Inter-Rater Reliability for Tackle Proficiency Scores

Tackle Technique Criterion (0 = No, 1 = Yes)	**Cohen's K**	**Interpretation**
Accelerating into the contact zone	0.72	Substantial
Identify the ball carrier on the shoulder	0.98	Almost Perfect
Shorten steps with head up	0.64	Substantial
Spin in neutral (not slumped)	0.79	Substantial
Contact target w/ same shoulder & leg	0.75	Substantial
Contact centre of mass	0.70	Substantial
Head in the correct position	0.90	Almost Perfect
Place lead foot in close	0.66	Substantial
Arms wrap around carrier	0.69	Substantial
Leg drive	0.67	Substantial
K_{total}	**0.75**	Substantial

7.3.6 Statistical Analysis

Changes in movement characteristics, tackle proficiency, heart rate and RPE during the simulation were analysed using separate two-way fully repeated analyses of variance (ANOVA) to compare the trial (fast vs. slow) by match quartile (Q1, Q2, Q3, and Q4). Assumptions of sphericity were assessed using the Mauchly test of sphericity, with any violations adjusted by use of the Greenhouse-Geisser correction. When significant interaction effects were observed, a paired-samples *t*-test with a Bonferroni adjustment was used to determine the location of the differences between match quartiles for each trial. Differences in differential RPE between trials were assessed using paired *t*-tests. In all instances, alpha was set as $P<0.05$. All data were analysed using SPSS v 27.0 (IBM, Chicago, Illinois, USA).

7.4 Results

The overall movement and heart rate demands of the fast and slow trials are shown in Table 1. Paired *t*-tests revealed differences for distance, mean speed, low-speed distance, and high-speed distance for the fast trial in comparison to the slow trial (distance ($t = 8.97$, $p < 0.001$), mean speed ($t = 8.32$, $p < 0.001$), low speed ($t = 2.70$, $p = 0.019$) and high speed ($t = 5.13$, $p < 0.001$). Sprint distance did not differ between conditions ($t = 1.74$, $p = 0.106$), whereas peak sprint speed was higher in the slow trial ($t = 5.29$, $p < 0.001$). Mean heart rate was greater in the fast trial ($t = 3.58$, $p = 0.004$), although there was no difference between trials for peak heart rate ($t = 2.03$, $p = 0.066$). Finally, mean RPE was greater in the fast condition in comparison to the slow ($t = 2.73$, $p = 0.018$).

Table 2: Movement Characteristics Profile

	Fast trial	**Slow Trial**
Distance (m)	*2103.7 ± 88.9**	*1942.4 ± 83.4*
Mean speed ($m \cdot min^{-1}$)	*102.5 ± 4.3**	*95.22 ± 4.1*
Low speed activity (m)	*1489.5 ± 115.0*	*1434.7 ± 97.9*
High speed running (m)	*509.6 ± 146.3**	*370.26 ± 94.1*
Sprint distance (m)	*104.0 ± 72.2*	*136.8 ± 81.8*
Peak sprint speed ($m \cdot s^{-1}$)	*6.3 ± 0.5**	*6.6 ± 0.5*
Mean heart rate ($b \cdot min^{-1}$)	*160 ± 9**	*152 ± 13*
Mean heart rate (%)	*80 ± 4**	*76 ± 6*
Peak heart rate ($b \cdot min^{-1}$)	*202 ± 9*	*195 ± 10*
Rate of Perceived Exertion	*5.8 ± 1.5**	*5.2 ± 1.4*

Changes in movement characteristics during fast and slow interchange bouts

There was a main effect of trial ($F = 69.16$, $p < 0.001$), time (F = 87.5, $p < 0.001$) and trial by time interaction (F = 53.84, $p < 0.001$) on mean speed. For the fast trial, *post hoc* analysis revealed reductions in mean speed from Q1 (107.9 ± 3.8 m·min-1) at Q2 (99.2 ± 5.1 m·min-1, $p < 0.001$) and Q4 (97.3 ± 4.6 m·min-1, $p < 0.001$) but not Q3 (105.4 ± 4.8 m·min-1, p = 0.019). For the slow trial, reductions in mean speed from Q1 (98.7 ± 4.3 m·min-1) occurred at Q2 (96.2 ± 4.8 m·min-1, $p = 0.002$), Q3 (94.2 ± 3.7 m·min-1, p <0.001) and Q4 (91.8 ± 4.3 m·min-1, $p < 0.001$). There was also a main effect of trial (F = 135.94, $p < 0.001$), time (F = 76.28, $p < 0.001$) and trial by time (F = 41.66, $p < 0.001$) for total distance. *Post hoc* analysis revealed that for the fast trial reductions from Q1 (553.4 ± 19.9 m) to Q2 (509.6 ± 26.0 m, p < 0.001) and Q4 (499.4 ± 23.8 m, $p < 0.001$), but not Q3 (541.2 ± 24.5 m, $p = 0.20$). In the slow trial, total distance reductions were revealed from Q1 (503.2 ± 21.8 m) to Q2 (490.7 ±

24.4 m, $p = 0.002$), Q3 (480.4 ± 19.1 m, $p < 0.001$) and Q4 (468.1 ± 21.7 m, $p < 0.001$). There was a main effect of trial (F = 5.34, $p = 0.004$), with low-speed activity greater during the fast trial. However, there was no main effect of time (F = 2.10, $p = 0.173$) and no trial by time interaction (F = 1.41, $p = 0.256$). High-speed activity showed a main effect for trial (F = 29.54, $p < 0.001$), time (F = 29.54, p = < 0.001), and trial by time ($F = 5.16$, $p < 0.001$). *Post hoc* analysis illustrated no difference from Q1 (130.8 ± 34.9 m) to Q2 (119.3 ± 41.8 m, p = 0.049), or from Q3 (143.7 ± 43.4 m, $p = 0.047$) and Q4 (115.9 ± 34.1 m, $p = 0.052$) during the fast trial for high-speed running. In the slow trial, there was a significant difference between Q1 (101.8 ± 21.2 m) and Q4 (82.5 ± 21.7 m, $p < 0.001$) but not Q2 (95.6 ± 26.5 m, p = 0.049) or Q3 (90.4 ± 28.9 m, $p = 0.047$). Sprint distance illustrated a main effect for time (F = 4.39, $p = 0.026$), trial (F = 35.53, $p < 0.001$) and time by trial (F = 6.44, $p = 0.001$). For the fast trial, *post hoc* analysis highlighted a difference between Q1 (41.5 ± 8.1 m, Q2 (20.6 ± 15.8 m, $p < 0.001$), and Q4 (14.6 ± 14.8 m, $p < 0.001$), but not Q3 (27.4 ± 19.8 m, $p = 0.039$). In contrast, the slow trial had no differences between Q1 (39.0 ± 24.0 m), Q2 (37.3 ± 23.4 m, $p = 0.533$), Q3 (31.6 ± 18.4 m, $p = 0.054$), and Q4 (28.9 ± 19.4 m, $p = 0.022$). There was a main effect for peak sprint speed (m/s) on trial (F = 23.43, $p < 0.001$), time (F = 6.16, p = 0.002), and trial by time interaction (F = 3.78, $p = 0.019$). *Post hoc* analysis revealed differences from Q1 (6.6 ± 0.6 m·s-1) to Q2 (6.3 ± 0.4 m·s-1, $p < 0.001$), Q3 (6.3 ± 0.4 m·s-1, $p = 0.004$) and Q4 (6.1 ± 0.5 m·s-1, $p < 0.001$) for the fast condition. However, there were no differences between quarters during the slow condition in Q1 (6.7 ± 0.6 m·s-1), Q2 (6.6 ± 0.5 m·s-1, $p = 0.134$), Q3 (6.5 ± 0.5 m·s-1, $p = 0.134$) or Q4 (6.6 ± 0.5 m·s-1, $p = 0.122$). Data are shown in Figure 6.

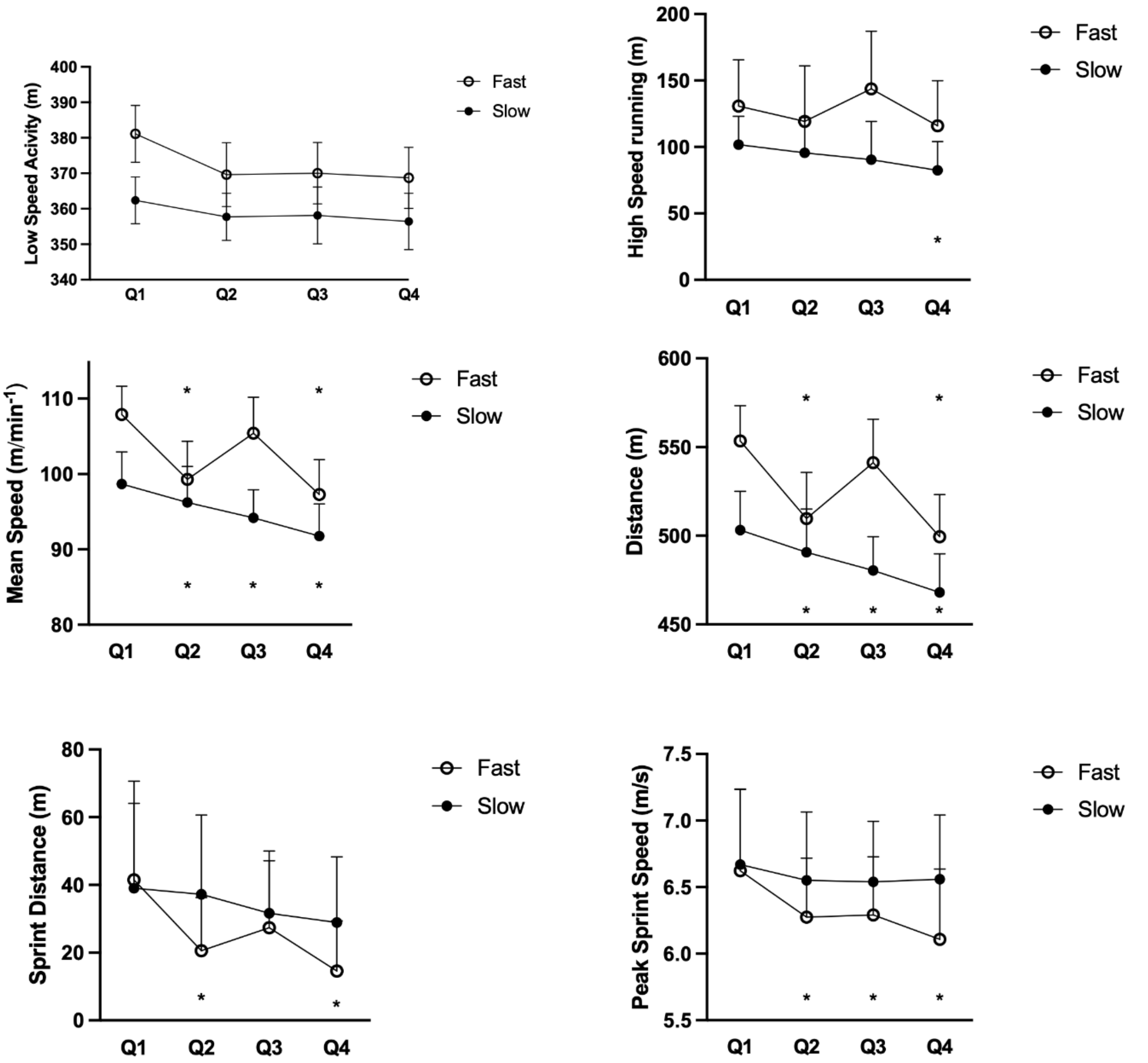

Fig 6. Changes in low-speed activity (top left), high-speed running (top right), mean speed (middle left), distance (middle right), sprint distance (bottom left) and peak sprint speed (bottom right) during the fast and slow interchange trials. * indicates significantly different to Q1 (p <0.008).

Heart Rate and Subjective Ratings

There was a main effect for RPE across time (F = 60.8, p < 0.001) and trial (F = 7.46, p = 0.018) but no effect for trial by time (F = 0.68, p = 0.495). There was a main effect for mean heart rate on trial (F = 6.36, p = 0.018) and time (F = 13.03, p = 0.005), but there was no effect for trial by time (0.682, $p = 0.570$). For peak heart rate, there was a main effect for time ($F = 10.17$, $p < 0.001$), however, there was no main effect for trial ($F = 2.96$, $p = 0.116$) or trial by time ($F = 0.611$, $p = 0.613$). For differential RPE (CR100), paired *t*-tests showed no difference between trials for breathlessness in the fast (57.9 ± 16 AU) or slow (50.4 ± 14.9 AU; $t = 1.974$ $p = 0.072$) trials, for peripheral in the fast (59.5 ± 17.6 AU) or slow (45.3 ± 21.4 AU; $t = 1.887$ $p = 0.084$) condition, or in cognitive fatigue for the fast (47.3 ± 18.1 AU) or slow (41.5 ± 23.4 AU; $t = 1.100$, p = 0.293) condition. Data are shown in Figure 7.

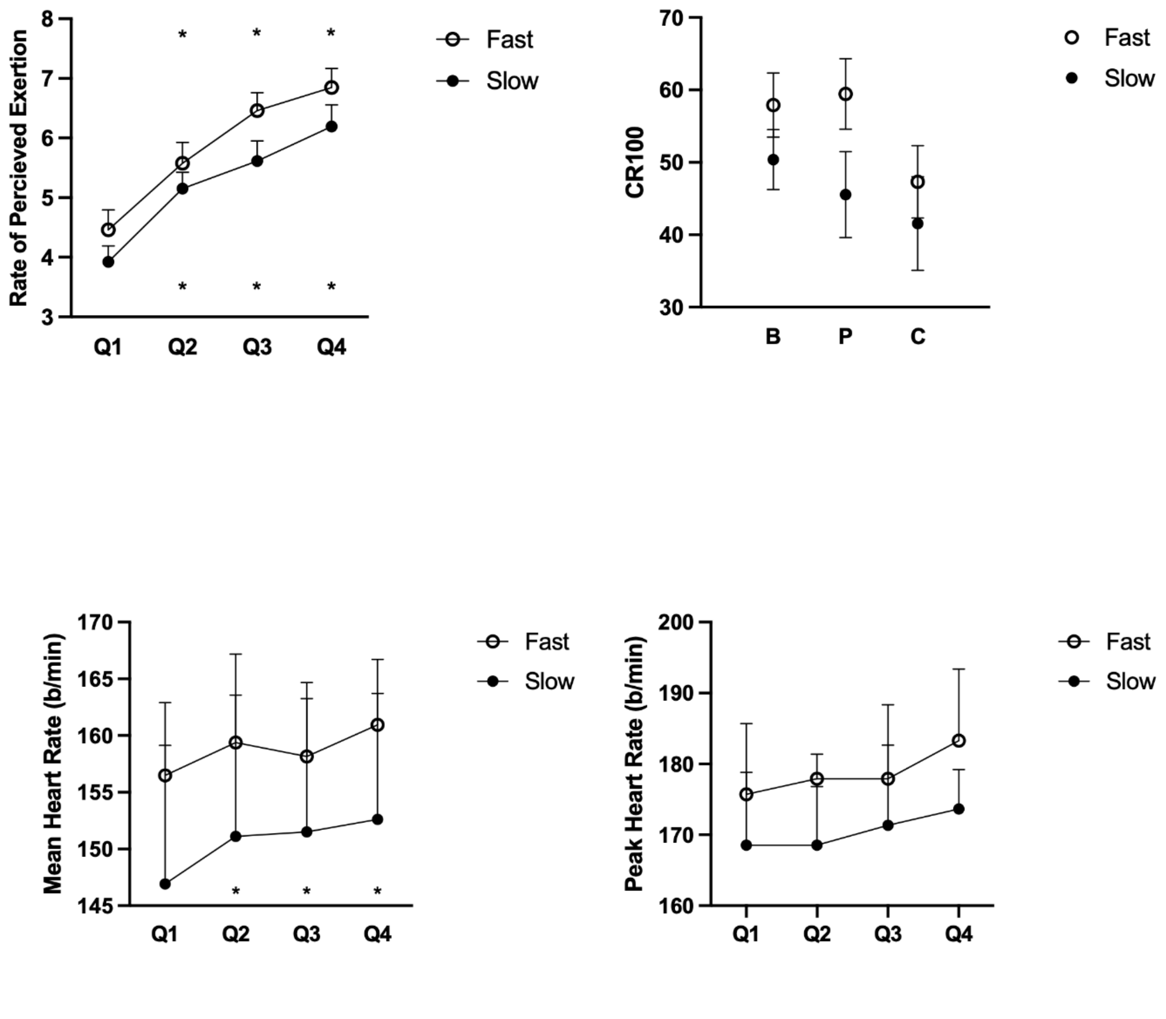

Fig 7. Changes in rate of perceived exertion (top left), CR100 (top right), mean heart rate (bottom left) and maximum heart rate (bottom right) during the fast and slow interchange trials. * indicates significantly different to Q1 ($p < 0.008$).

Tackle Proficiency

Analysis revealed no main effects of trial (F = 1.64, p = 0.23), time (F = 1.43, p = 0.25) or trial by time interaction (F = 2.22, p = 0.11) for tackle proficiency. Data are shown in Figure 8.

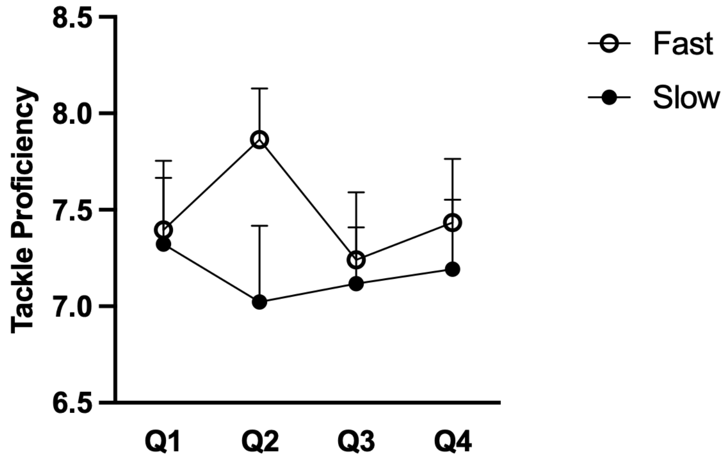

Fig 8. Changes in tackle proficiency across each quarter, demonstrating scores across all time points.

7.5 Discussion

The aim of the current study was to utilise the RLMSP-i to examine the effect of contrasting match speeds and tackle loads incurred from rule changes on the movement characteristics and tackle proficiency of highly trained RL players. In the first study of its kind, we showed contrasting movement characteristics and internal loads for some metrics between the fast trial and the slow trial, but no difference in perceived load (dRPE) or tackle proficiency between trials. Specifically, the fast trial elicited a higher mean heart rate, mean speed, high-speed running, total distance and RPE than the slower trial. Whereas peak sprint speed and sprint distance were higher in the slow trial than in the fast trial. Changes in movement characteristics were observed during trials, with greater reductions in sprint performance during the fast compared to the slow trial, whereas high-speed running was only reduced towards the end of the slow trial. The quartile analysis revealed a rebound effect from Q1 to Q3 for mean sprint speed in the fast trial, contrasting the slow trial, which gradually decreased across quarters.

Fatigue has been suggested as a possible cause of injury in highly trained rugby players (Fitzpatrick et al., 2018) and was highlighted in earlier chapters of this thesis as stakeholders and players emphasising the increasing demands of games because of rule changes. Fatigue is a complex phenomenon which has been defined in rugby as a reduction in performance-related task ability which is underpinned by time-dependent negative homeostatic changes within and between cognitive (e.g., tiredness, lethargy), neuromuscular (e.g. force, power), perceptual (e.g. perceived exertion), physiological (e.g. cardio-autonomic, muscle damage), emotional (e.g. motivation), and technical/tactical (e.g. positioning, skill execution) domains (Naughton et al. (2023). As such, several potential mechanisms are likely to influence an individual's fatigue response during the high-intensity intermittent activity that is rugby. Acknowledging the complexity and task dependency of the individual fatigue response, what follows below is an attempt to interpret the changes in external and internal measures during the fast and slow match simulations and to what extent these might reflect player fatigue and its implications for performance and injury risk.

The mean movement speed for the fast trial was 102.5 ± 4.3 m·min-1 in comparison to the slow condition of 95.2 ± 4.1 m·min-1. However, mean speeds within the fast trial varied from the first and third quarter, 107.9 ± 3.8 m·min-1 and 105.4 ± 4.8 m·min-1, in comparison to the second and fourth quarters, 99.2 ± 5.1 m·min-1and 97.3 ± 4.6 m·min-1, respectively. Similarly, high-speed running increased in the third quarter, 143.7 ± 43.4 m during the fast condition from quarter one, 130.8 ± 34.9 m and the second quarter, 119.3 ± 41.8 m, whilst decreasing again in the fourth quarter, 115.9 ± 34.1 m. These findings contrast with the slow condition, where mean speed gradually reduced over the quarters from quarter one, 98.7 ± 4.3 m/min^{-1} to quarter two, 96.2 ± 4.8 m·min-1, quarter three, 94.2 ± 3.7 m·min-1 and finally the fourth quarter, 91.8 ± 4.3 m·min-1. Comparably, high speed running reduced over quarters from the first quarter, 101.8 ± 21.2 m, to the second quarter, 95.6 ± 26.5 m, third quarter, 90.4 ± 28.9 m, with a significant reduction in quarter four, 82.5 ± 21.7 m. While reductions in mean speed are consistent with fatigue caused by reduced substrate availability (Bradley et al., 2010), fluctuations in movement speeds during the fast trial are evidence of players adopting pacing strategies as reported previously (Highton et al., 2017; Waldron & Highton, 2014b). A central metabolic control system enables players to consciously determine their movement during simulated match play, which is modified using afferent signals from the various physiological systems and in response to environmental cues (Waldron & Highton, 2014a). This was particularly notable in the fast condition, where a higher mean speed and a higher internal load (i.e., RPE and HR) compared to the slower trial might have caused players to self-regulate their activity (i.e., pace themselves) to sustain mechanical output. Similar observations have been reported in match play where highly trained interchange RL players performed high initial intensity activity followed by a severe decline (Waldron, Highton, Daniels, et al. (2013). In the faster condition, players may therefore have adopted more game-like pacing strategies to minimise the influence of fatigue.

Peak sprint speed and sprint distance were higher in the slow compared to the fast trial. In the first quarter, the sprint distances during fast and trial slow trials were comparable at 41.5 ± 8.1 m and 39.0 ± 24.0 m, respectively. However, by the fourth quarter, the fast trial (14.6 ± 14.8 m) was almost half the distance of the slow trial (28.9 ± 19.4 m). This was in combination with peak sprint speed, as the fast trial had differences from quarter one (6.6 ± 0.6 $m \cdot s^{-1}$), gradually decreasing to quarter four (6.1 ± 0.5 $m \cdot s^{-1}$). Whereas in the slow trial, there were no differences across quarters. Reductions in sprint performance during team sport match play are consistent with increased fatiguability that might be explained by a combination of changes in substrate availability, disruption to muscle homeostasis, and a player's training status (Mohr et al. (2003). For example, reductions in muscle glycogen and high speed running have been reported in trained RL players during match play ((Bradley et al., 2016), while decrease in muscle creatine phosphate after intense activity during match play have been associated with impaired sprint performance in soccer players (Krustrup et al., 2006). Mohr et al. (2003) have also showed top-class soccer players with a greater Yo-Yo intermittent recovery test score demonstrate greater resistance to fatigue, completing more high-speed running during match play. Despite no comparable studies of R players, the present findings reinforce the association of decreased sprint performance as an indirect measure of fatigue and that a faster game speed is likely to incur more fatigue than one played at a slower mean speed. Considering the desire by lead bodies to increase game speed for entertainment, players should therefore be adequately prepared to meet these increased demands.

Tackle proficiency was a key element of the study that did not change over time but was different between trials. Consequently, the findings of the current study do not support previous research showing significant reductions in tackle proficiency with fatigue (Davidow et al., 2020a; Gabbett, 2016). Key differences between the two studies and the current study are how fatigue was induced, the contact performed by the players and the population of the players. Gabbett (2016) followed a repeated high-intensity effort protocol (RHIE), comprising 1 x 10 m sprint, 3 x full contact one-on-one tackling last 4 s and a 30 m recovery jog completed four times within 40 s. Culminating in 12 contacts within the four-minute period, which is substantially higher than the number of contacts performed in both conditions of the current study and does not replicate match activity. An increased number of contacts in a short period of time is likely to result in greater fatigue than experienced by players during match play. Davidow et al. (2020a) did not perform contact within the conditioning element of the trial, instead using a prolonged high-intensity running ability test. The test involved 8 x 12 s maximal effort shuttles (sprinting forward 20 m, turning 180° and sprinting 10 m, turning 180° and sprinting 20 m) performed on a 48 s cycle for a total of 8 minutes. The population studied was amateur RU players, and as such, the tackle proficiency reductions reported could be a consequence of inferior fitness in comparison to the highly trained players used in the current study.

Both codes of rugby are aiming to increase ball-in-play time, which has been suggested to increase the speed of match play and induce more fatigue in players compared to slower matches with less ball-in-play (Rennie et al., 2021; World Rugby, 2024a). Despite trying to replicate the effects of rule changes on match play speed and observing greater decrements in sprint speed during faster matches, the current study does not support the notion of increased match speed reducing tackle proficiency in highly trained players during the first interchange bout. Our data support the work of Scantlebury et al. (2024) who reported fewer injuries in the first quarter of a match (0-20 minutes) when players are least fatigued. The severity of injuries was greatest in the second and fourth quarters, suggesting more severe injuries occur when players are experiencing the greatest fatigue at the end of each half (Scantlebury et al. (2024). Unfortunately, the design of this study did not use longer match play periods and prevented the study of accumulated fatigue on tackle proficiency. Consequently, if the governing bodies are aiming to increase ball-in-play and alter match speed, it is likely that more fatigue could be induced, which means players could potentially be at an increased risk of injury. Further work is needed to explore the associations between fatigue and tackle proficiency in highly trained rugby players, particularly in the latter stages of match play, where fatigue would be more pronounced.

7.6 Limitations

The current study built upon subsequent research, whereby the tackler either contacted a tackle bag attached to a sling pulley system accelerated towards the player (Davidow et al., 2020b), or a chest pad on a ball carrier (Gabbett, 2016), without taking to ground. This study employed a carrier holding a tackle pad going to ground on two crash mats after several pilot studies to discern the greatest match-specific contact. Although this is a closer replication of match-based tackling, this tackle type lacks a static wrestle component. Furthermore, match play tackles are often performed with a teammate, as shown in Chapters 4 and 5, where players perceived the optimal way to perform a tackle through simultaneous contact. This is an inherent criticism of performing a simulation, however, analysing the tackle during live match play can be problematic due to the chaotic nature of the game. A further limitation of this protocol is the subjectivity of coaches' ratings of tackles. Two Level three coaches were used to rate the tackles, with a third rater (Level 3) rating tackles with greater disagreements by four points. However, the lack of agreement between coaches potentially shows the lack of association of tackle proficiency with fatigue. Although prior research did not encounter this limitation, the level and number of coaches were not detailed (Davidow et al., 2020a; Gabbett, 2016). Future work should aim to document the number and level of coaches' ratings of tackles.

7.7 Practical Implications

The data shown here highlights a faster protocol to induce more fatigue, interpreted as a higher mean heart rate, RPE and greater reduction in sprint distance and peak sprint speed. The outcomes have several implications for practitioners and policymakers in the training of players and directions of the game. The main implication would be that the requirement for rule changes to be practically trialled before being adopted by the competition to allow the discovery of any unintended consequences. The current study also revealed a lack of heterogeneity amongst coaches on what constitutes optimal tackling techniques. Given that the three coaches who rated tackles in the study were all Level 3, establishing their viewpoints on what makes an optimal tackle is warranted. Two components of the techniques in the rating scale that had an almost perfect reliability were identifying the ball carrier onto the shoulder and head position in the correct place. However, ten techniques were noted in the current study as Hollander, Ponce, et al. (2021b) noted several more. Coaches should aim to utilise the techniques that have the highest association with tackle success. Finally, sprint distance and peak sprint speed were reduced in the fast protocol, illustrating that players fatigued more during the faster protocol than in the reduced match speed protocol. As such, conditioning coaches should aim to produce conditioning practices that help to develop fatigue resilience with the aim of minimising losses in sprint distance and peak sprint speed during an interchange bout and a match. Examples might include shuttles that hit the required distance thresholds for mean sprint speed whilst including components of static wrestle contact. Moreover, designing games conditioning sessions that replicate mean sprint speeds and include relevant static components of wrestle are warranted.

7.8 Conclusion

In conclusion, this study illustrates that an increased match speed simulation protocol increases mean heart rate and RPE, whilst impairing sprint distance and peak sprint speed to a greater extent in comparison to a slower condition and thereby inducing greater fatigue. This study provides insights for policymakers, potentially highlighting the unintended consequences of increasing the speed of matches. This study also highlights the subjective nature of rating tackles and the differences between coaches' opinions of the tackle. Therefore, there is a requirement for further investigation into the technical assessment of the tackle. Finally, this study informs practitioners of the different responses to contrasting match speeds, aiding in the preparation of rugby athletes for match play.

Chapter 8

Thesis Synthesis

8.1 Realisation of Aims

8.1.1 Aim 1 – To identify the technical and physical characteristics of optimal methods for players to perform contacts in training and match-play.

This aim was addressed in Chapters 4 and 5, highlighting simultaneous contact with the third man tackling the legs as the most efficient, safe, and optimal technique in RL. Stakeholders spoke of the aim of match play being to control the ruck, which the simultaneous tackle type increases this possibility. However, players did not describe tackle technique proficiency metrics associated with the tackle. Similarly, in RU, players discussed in Chapter 6 the desire to create a slow ruck through numbers in the tackle and higher up contacts due to recent rule changes. Tackle proficiency metrics, such as a planted foot prior to contact, were deemed crucial in generating/ reversing momentum into the contact. However, an emphasis was placed on tackle type in comparison to specific metrics. Nevertheless, key tackle proficiency metrics associated with controlling the momentum of the tackle illustrate metrics coveted by players and coaches to control contact.

8.1.2 Aim 2 – To identify components of the tackle in match play and training associated with elevated levels of risk.

This aim was addressed in Chapters 4, 5 and 6. Initial at-risk events were cited by players as contacts that did not allow for adequate time for the ball carrier to brace for the tackle. RU players discussed this element relating to the box kick, where the catcher could not see the defender arriving. In this component, recent rule changes have facilitated the chaser competing with the catcher for the ball, as the catcher focuses on retrieving the ball. RL players highlighted the half-back position as key, as they would often not see a defender arriving whilst attempting to create space for their teammates. A further component of considerable risk identified by players as contacts with large closing distances between the attacker and defender. RL Players cited the kick off and drop out as the highest intensity contacts, although they did not associate this event with the game's most prevalent contact injury, the concussion. Fatigue was further discussed by RL players relating to the tackler and the effect this has on the timing and coordination of the tackle. Stakeholders advanced this component, perceiving match play to have increased in speed due to unintended consequences of rule changes such as the 'six again'. Contrastingly, head impacts were discussed by RU players, specifically relating to the lineout. Players' perceptions centred around players who initially aid the jumper, once successful in the lineout, have little room to place their head, and as such, can be problematic. Additional perspectives discussed the training of this event and the risk of head impacts. Taken together, these data have highlighted potential different perspectives and interpretations of rule changes which may have unintentional consequences and highlight the importance of player perceptions in informing the direction of rule changes and addressing at risk areas.

8.1.3 Aim 3 – To conceptualise coaching methodologies and philosophies behind the techniques used to succeed in contact.

This aim was addressed in Chapters 4,5, and 6 from a tactical perspective. Primarily across both codes, coaches' philosophies are derived from the techniques available to control the ruck or win possession in RU. The theoretical model of Bronfenbrenner highlighted the influence of law changes on coaching trends and philosophies, which culminated in the tackle. Recent rule changes in RU affecting the ‘jackal’ have meant that coaches’ focus has shifted towards higher up contacts to set the defensive line, whereas previously, the chop tackle would have been favoured in teams with proficient jacklers to regain possession. Moreover, RU players spoke of feedback from coaches in weekly review meetings, highlighting messy tackles that slow the ruck. Illustrating coaches’ philosophies to centre around slowing the ruck in RU. In RL, both stakeholders and players discussed the optimal way to perform the tackle event due to its ability to stop the momentum of the tackler and slow the ruck. Both codes’ philosophies formed around controlling the ruck and slowing down attacking possession for the defensive team. Highlighting coaching philosophies gives insights into the methods coaches are utilising to increase their performance. However, the specifics of game models and overarching team philosophies were not elucidated. As such, understanding the aims of coaches and players can inform future policymakers to understand which components of the game can be changed and which elements are crucial to the identity of the sport.

8.1.4 Aim 4 – To explore the psychological underpinnings of performing the tackle and the strategies that players use to cope with participating in a contact sport.

This aim was discussed throughout Chapters 4, 5 and 6. In Chapter 4, RL players discussed the lack of adrenaline associated with contacts in training and, therefore, a greater reluctance to perform training contacts. Whereas in Chapter 5, stakeholders highlighted the requirement to build confidence in performing contact through a gradual exposure to contact training for players in RL. Lastly, in RU, players discussed the value of calmness when going into a game, with some forwards still citing the feeling of going to war, but overall, players did not want to get overtly aroused for match play. Moreover, knowing the game plan was key to attaining confidence in contact for RU players, potentially owing to the increased strategy in RU match play. Significant attention in the research has been placed on the psychological demands of match play. However, it appears that RU players have managed to find positive ways to self-regulate for games. The psychology of performing contact was discussed in the attritional going to war sense by RU. Yet, building confidence in their tackling ability was a component discussed by stakeholders. As such, a greater understanding of the way in which players' confidence is built through the gradual exposure to contact is warranted.

8.1.5 Aim – 5 To investigate the physical match demands of rugby and their relationship with tackle proficiency.

This aim was addressed in Chapter 7 through the analysis of tackle proficiency and its relationship with match speed. Two conditions of contrasting match speeds and contact loads were performed by highly trained RL players to assess the influence on tackle proficiency. The analysis illustrated that a faster protocol induced a greater fatigue through a higher mean heart rate and RPE, along with reduced total sprint distance and peak sprint speed. However, there was no significant difference in tackle proficiency across trials, potentially owing to the subjective nature of coaches' ratings of tackle technique. This study did highlight the requirement to assess tackle proficiency in match play to understand the unintended consequences of rule changes, as seen in the research.

8.2 General Discussion

Prior to undertaking this research, there was a paucity of research documenting the tackle event from a qualitative perspective, utilising elite rugby players, and performing investigative research to assess match speed. Of the studies undertaken, several remarkable insights have been reported, illustrating the interplay between the tackle event and contrasting elements of match play and/ or training that influence its execution.

The four studies documented in this thesis have provided novel insights into rugby literature. Consequently, there are several original findings that have been highlighted, particularly relating to the optimal ways to perform contact in match play, contact associated risk, the philosophies coaches employ to enable players to succeed in contact, the psychological underpinnings that players use to cope with contact demands and the physical demands of rugby and tackle proficiency. Moreover, this is the first thesis to include Bronfenbrenner's socio-ecological system model in relation to the tackle to fully elucidate the systems influencing the development and evolution of this match play component. Through the application of the model, elements of the macrosystem highlight the strands of influence through the exosystem and mesosystem to the micro level, affecting match play. Below are outlined some key components of the model, along with significant sections from further chapters. The main findings of the thesis are represented in a schematic, as seen in Figure 9.

8.2.1 Optimal Contact and Controlling the Ruck – Aim 1

Controlling the ruck played a prevalent role across all qualitative studies, documenting the preferred tackle technique that optimally provides the greatest defensive control. Previous research by Hollander, Ponce, et al. (2021b) has illustrated key tackle proficiency metrics associated with tackle success and injury prevention. However, no research up until now has outlined a common coaching philosophy across both codes with the aim of slowing the ruck in defence and speeding it up whilst in attack. Although previous research has focused on tackle proficiency metrics, it appears throughout both codes that players and coaches are focused on tackle types. Moreover, amongst the alterations to rule changes surrounding contact techniques such as the 'jackal' in RU, players highlighted the move away from 'chop' tackles to contacts targeting the upper body due to the increased officiating of this area. Recent research in RU has shown the problematic nature of contacts targeting zones where players share head space (Cross et al., 2019a). Contrastingly, in RL, Owen et al. (2025) showed no differences in concussion between contacts made by tacklers bent at the waist or in the upright position. Therefore, contacts that aim to control the ruck in RL may be less problematic than the same contact in RU. One reason for this may be the technical proficiency of the players in this technique, as RU players could potentially be more proficient in lower contact techniques like the 'chop' tackle due to their increased previous popularity. However, it is clear that tackle types are the way players and coaches discuss the tackle across both codes in the applied environment. At the elite level, tackle proficiency may be assumed as a given for this population. Therefore, the key metrics associated with this tackle type need further investigation to understand the precursors to performing it.

8.2.2 Match Speed, Ball-in-Play, and Fatigue – Aim 2 & Aim 5

Stakeholder perceptions across both codes were that the governing bodies are aiming to speed up match play and/ or increase ball in play to augment the spectacle of the game. However, recent research in RL has shown that match play speed has decreased with ball-in-play increasing and overall match play contacts increasing (Rennie et al., 2021). Increasing the ball-in-play time does increase the exposure to contact through time in play, with the overall contact load in this period increasing from 36 to 42 on average for the forward playing position. Chapter 7 highlights the relationship between match speed during a game simulation and indicators of physical fatigue, including increased mean heart rate and RPE, and reduced peak sprint speed and total sprint distance during a faster condition. Whilst on an acute level, this may not seem a significant increase of 6 contacts per game, the effect over the course of a season warrants further investigation. Stakeholders in Chapter 5 highlighted the desire to reduce overall exposure by reducing the number of games. However, if the ball-in-play times increase, and therefore contact load along with this, additional risk is being added to players. Given that recent research has highlighted a higher cumulative head impact association with neurodegenerative disease (Graham et al., 2025), and not solely concussion, future research should monitor the increased risk of exposure through ball-in-play or additional matches before enacting change. Recent policies have included the implementation of match limit restrictions over a season, yet the impact of this may be reduced with additional exposure from ball-in-play. Whilst Chapter 7 utilised the match simulation to isolate tackle proficiency and elucidate the role of fatigue, it inevitably could not capture the full complexity and unpredictability of live match-play tackles. However, the controlled design did elucidate the relationship between match speed, contact load and fatigue, highlighting the requirement for further investigation in this area.

8.2.3 Training Contact and the Tackle – Aim 3

Optimal tackle techniques, as discussed in Chapters 4, 5, and 6, focused on key tackle types in contrast to the specific tackle proficiency metrics. RU players noted the final foot plant as a key component of the tackle in dictating the momentum of the play. However, knowledge of key tackle proficiency techniques has not always translated to performance (den Hollander et al., 2021). Furthermore, Hendricks et al. (2017) has shown that coaches dedicate minimal time (16%) to coaching tackle technique, even though it is deemed highly important. In Chapter 6, outside backs highlighted the lack of coaching for contacts made near the goal line in this positional group. Yet coaching the tackle event in the elite environment has not been fully elucidated in previous research. As such, the current thesis examines the utilisation of tackle techniques discussed in the literature by coaches in comparison to the tackle types discussed by stakeholders. A factor shown in Chapter 7 is the lack of agreement among coaches in their subjective rating of tackle technique, illustrating contrasting perspectives on optimal techniques of performing the tackle. This makes identifying key proficiency markers particularly challenging. A potential factor for this may be that elite-level coaches assume players' tackle technique is already mastered, and as such, the tackle type is the focus. Therefore, the specific drills coaches are using to elicit tackle types are of key interest. More specifically, the coaching cues utilised to teach the tackle. The reason for this is two-fold: initially, to understand if the coaching cues utilised are congruent with the literature proficiency metrics. Secondly, to conceptualise the use of gradual exposure to contact used by coaches. Stakeholders in Chapter 5 discussed this element from a physical and psychological standpoint. To fully understand the most appropriate ways to return players to contact, further research is warranted.

The final element of training contact relates to contacts in set-pieces in RU. Specific to RU is the lineout, and as such, this is not problematic for RL. Chapter 6 highlights a specific potential area of concern for RU, which involves the players setting up a maul following a successful lineout after aiding the jumper. It was reported that these players are at risk, given a lack of space for their head, a problem that may be compounded in training due to the opposition understanding the play call. This lack of space for the head was reported to result in multiple heads competing for the same space, augmenting the head contact in this area. A key consideration should be the ability to safely train high-risk match events to increase players' coordination and technique in this situation. However, given the lack of head space, this is an area that warrants further investigation to aid the safety of the players by potentially limiting exposure to this event.

8.2.4 Identity of the Contact Sports – Aim 2 & Aim 4

The identity of the game was a prevalent theme across both codes, as discussed by stakeholders in Chapter 5 and RU players in Chapter 6. Stakeholders discussed the identity of RL, with the collision aspect of the sport defining it. Similarly, in RU, players discussed the inherent risks of the game, debating what level of risk is acceptable. Both codes have made significant changes recently to the tackle event to improve player safety (Rugby Football League, 2023c; World Rugby, 2023). Nevertheless, with changes emerge inevitable resistance as tactical coaches discussed the effect on the fabric of the game from changing the tackle height from below the neck to below the armpit in Chapter 5. Regardless, given the long-term health implications for players, changes are necessitated; however, the level of change is a key point of contention.

Nonetheless, large distances between the tackler and ball carrier (closing distances) were a key component discussed by both focus groups relating to the increased risk of injury. RL players discussed the significance of the kick-off and drop-out contacts due to the increased speed into contact. In RU, increased risk was associated with aerial contacts due to the considerable distance the chaser has pre-contact to gain speed into the tackle, combined with recent rule changes removing protection from the ball catcher. Therefore, contacts at increased distances could pose a greater injury potential due to the lack of proficiency at greater speeds or an increased force in contact. Cross et al. (2019b) has illustrated a players speed when entering contact and an accelerating player into contact as a key predictor of concussion in RU players. Therefore, the rules around protecting players catching aerial balls should be altered with caution. Moreover, the ability of players to brace in this position is crucial. RU and RL players highlighted the requirement of being able to brace for contact to reduce the risk of injury. The RFL has altered guidance to reduce the likelihood of players being contacted when in a compromised position (Rugby Football League, 2022). Yet, it appears crucial that both codes gain insights from the players to understand which positions represent significant danger. The Bronfenbrenner ecological system model denotes to several key distinctions of the national governing body and laws of the game relationship with coaching and refereeing trends on closing distances and bracing/ blind siding, culminating with box kicks. This is a key distinction as once we understand the interrelationships of the match play event we can understand how to influence the on pitch behaviours from either a law or technical teaching point of view.

8.2.5 The Psychological Demands of Rugby – Aim 4

The interplay between psychology and tackle proficiency was discussed, as RL players highlighted the lack of readiness for contact in training and a shift from mental toughness to mental resilience was noted by stakeholders. In contrast, RU discussed the requirement to focus on calmness during match play. The differences in viewpoints could be two-fold. Initially, that RL and RU match play is quite contrasting, with far more set pieces (contested scrums and lineouts) in RU than in RL, and therefore, a greater calmness is required to fulfil the cognitive requirements of match play. Moreover, RL match play has a greater mean speed, as highlighted in section 2.2 of the literature review, denoting a free-flowing game with fewer stoppages in play to strategically contemplate tactics. Highlighting an emphasis during training to oscillate between high arousal states of games in training, to lower states, practising set pieces. Therefore, the greater emotional regulation documented by RU players could be a trainable aspect of the game in which RL players may see performance benefits. Conversely, due to the increased number of tackles during RL match play as opposed to RU, RL players could take longer to recover from match soreness and lack readiness for training contact in the subsequent weeks training. Highlighting a potential need for increased focus on recovery post-match. This component seems unlikely, as although overall match tackles are less in RU, match play contacts are increased through contested set pieces and contacts in the ruck. Nevertheless, both codes are shifting away from problematic elements of the traditional identity of 'rugby culture' of 'boys don't cry' in acknowledging the significance of focusing on mental resilience and emotional regulation. Yet, there are potential elements of RU preparation around contact in training that could aid RL players.

8.3 Thesis Limitations

The qualitative approach to this study used focus groups and semi-structured interviews to gain insights into stakeholders' experiences of the tackle event across both codes for the first time in elite populations. Qualitative research aims to bridge the gap between academic research and the applied world. The research reflects the views of those who took part, yet it will not have captured all stakeholders' viewpoints. Subsequently, a potential limitation could be viewed as the lack of transferability of the findings due to the number of stakeholders that participated. However, the study did provide an equal representation of stakeholders across the groups, achieving data saturation through the exploration of diverse perspectives Therefore, there is confidence in the sample size to provide thorough insights gathered through our rigorous methodological approach Moreover, it is not claimed that the perceptions and experiences provided are generalizable to all involved in elite rugby, as the research will not have captured all the views within the ESL and Premiership. Instead, the research reported offers a rich, in-depth, and credible account of elite stakeholders' experience of collision. As is commonplace in qualitative research, readers can use the transparent information provided to consider the transferability of findings to their context.(Smith, 2018) To enhance the transferability of the current research, future qualitative research could embrace a variety of methods such as surveys and Delphi polls. Nevertheless, the insights documented here offer in-depth and rich accounts of a difficult to access population and their experiences of a contemporary match play event, the tackle. Therefore, readers can use the transparent and credible information provided to consider the applicability of the conclusions adapted to their context, as is commonplace in qualitative research.

8.4 Future Directions

The findings of this thesis pose several implications for future work to gain greater insights into the tackle event. Initial research should aim to delineate the propensity of simultaneous within both codes. Once match demands have been understood the influence of this contact type needs to be investigated in relation to team success. Highlighting if this tackle type either a) allows teams to win the ruck and therefore limit scoring opportunities to their opposition due to defensive players being in the correct position or b) allows teams to limit field position to their opposition, reducing scoring opportunities or c) both. If this contact type is found to be more prevalent in match play and with more successful teams, the influence of this tackle type on match speed should then be explored. Similarly, in RU a key component of note here is the influence of the jackler in RU on the prevalence of simultaneous contact and the height of the tackler. This has implications for the tackler, as head to head contacts have been shown by Cross et al. (2019b) as a key mechanism of concussion in RU. Therefore, understanding the incidences of concussions in teams that have a greater amount of chop tacklers to elicit the jackal versus upright contacts to slow the ruck down is crucial to understand injury mechanisms.

Bracing and blind-sided contacts played a prominent role in themes through the qualitative research studies. Instances during match play where this action is exacerbated need careful consideration. In RL, the out the back pass, where the attacker is blinded from the contact, was highlighted as a key area, along with the aerial duel in RU, where the catcher cannot see the tackler coming. Future research has two key options when traversing this area. Firstly, an aim of future work should be to find the components of match play where contacts like this exist and investigate how to limit players' exposure to them through rule changes without altering match play. Secondly, areas in which players feel blind sided should aim to be trained in a way that enhances safety and the coordination of the athlete. Moreover, exploration into contact techniques and visual training could elucidate whether players can enhance their peripheral vision to avoid contact or protect themselves when in vulnerable positions. Research by Kung et al. (2020) has focused on the role of visual performance and anticipation on head impacts. Yet, research into rugby athletes and vision is limited.

Collision closing distances is a further area associated with risk highlighted by players. The proclivity for contacts with larger closing distances is greater in RL due to defensive lines retreating 10m and the kick-off and drop-out tackle contest distance than in RU. However, restarting match play with a kick-off or drop-out that has a large closing distance between contact is a part of game play unique to RL and one other sport, American football. Recently, the NFL has changed their kick-off rules, significantly reducing the distance between defenders and the attacker by having them line up inside the 40-yard line, waiting for the catcher to receive possession in the landing zone (0-20 yards) until they can move. The new ruling reduced average player speeds during the kick-off and reduced concussions by 43% (National Football League, 2025). The RU kick-off does not provide the same run-up to contact as RL. The kick-off target zone in RU tends to travel a shorter distance with a catcher receiving the ball and teammates supporting (World Rugby, 2025b). Therefore, policymakers in RL may look to alter the kick-off and dropouts to reduce the speed into contact. The process of achieving this outcome can be disparate, following the NFL with a landing zone or, conversely, emulating RU with a high catch for the ball, potentially contested in RL due to the lack of lifting players. Yet, the gravity of the change needs to be assessed and whether the elimination of the traditional kick-off alters the identity of the sport.

Further findings from this thesis document the philosophies and coaching methods to elicit optimal tackle technique in both codes. Future research should aim to establish elite coaches' perspectives on specific contact techniques to better understand technical cues and drills coveted to alter technique and demonstrate key techniques that are common amongst coaches. The role of technical cues and drills used in the applied environment will provide more insights into how elite coaches aim to alter tackle techniques. Once this is understood, the research can focus on investigating to what extent the drills and cues alter technique and the transfer to match play. Moreover, the influence of defensive coaching philosophies on player contacts is also an area for further consideration due to the impact this may have on tackle drill type and head acceleration events for players in non-tackle type contacts like the maul and lineout. Lastly, traditional training considerations of conditioning and the influence on energy system development for rugby athletes have a substantial portion of research dedicated to the effects of fatigue on tackle technique (Davidow et al., 2020b; Tierney et al., 2018a). Yet, the means to develop the energy system adequately, specific to the demands of the game needs further investigation to fully elucidate the optimal methods to build fatigue resistance.

The final area for future directions focuses on the psychological component of the sport whereby the physical graded exposure to contact drills can influence the contact psychology of players. Grading the collision closing distance is crucial here to understand the role of anticipation in concussive events, but also the optimal ways to grade exposure to prepare players for contact in match play. Collision closing distance will play a focal point within this as highlighted by stakeholders in starting with close distances and opening the space as confidence increases. However, the mechanisms and time points at which this happens need further investigation. Furthermore, RL players highlighted the lack of psychological readiness to perform contacts in training. However, RU players denoted to the ability to remain calm in match play. The emotional regulation of collision sports athletes requires further exploration to fully understand why RU athletes focus on emotional regulation in comparison to RL athletes. Understanding why there are differences and garnering the ability to emotionally regulate could see performance benefits in RL players. This section shows the relationship between the game identity, competition and leagues, training habits and psychological preparation. Demonstrating the functionality of the socio-ecological model in exploring the tackle. Future work should aim to build on this approach to fully recognise which components influence the tackle and how.

8.5 Conclusions and Practical Implications

This thesis explored the tackle event in elite male rugby, discerning the perspectives of players and stakeholders. The premier novel feature of this study was the population accessed by the researcher. Through using personal-professional connections, the author gained insights from a sample whose voice has never previously been captured. A summary of the studies, research methods, key findings and practical takeaways can be seen in Figure 9.

The significant findings produced by the current work should be considered by policymakers to ensure stakeholders' perceptions are continually updated as the game evolves. Optimal contact techniques, contacts associated with injuries (in particular concussions), and the psychology behind contact sport athletes are paramount areas for future work. More specifically, the interplay between tackle technique drill types on tackle proficiency and the process of technique alteration through tackle practice. Along with the manipulation of match play through rule changes. Stakeholders across both sports perceive match play speed to be increasing, potentially due to an increase in ball-in-play time, which has key implications for the fatigue and contact exposure induced during games. The increases in speed in RU match play have not been elucidated as ball in play have been documented in RL (Rennie et al., 2021). This work also recognises some of the similarities between the rugby codes whilst highlighting key differences in physical and psychological aspects of training and match play.

The most significant implications from this thesis are:

1. Adopting a systems based approach to tackle technique training. Highlighted in Chapter 6 are the socio-ecological influences that affect the tackle. Practice structures, law changes and coaching philosophies are some of the common elements that shape tackle behaviours, and as such, coaches, governing bodies, and referees should fully understand the implications of changes in the system.

2. Simultaneous contact is the optimal way to perform the tackle in RL, whilst RU players are aiming for higher up contacts with both codes, aiming to control the ruck. Previously in RU, players were performing chop tackles to allow their teammate to perform a jackal, however, with recent rule changes, coaching trends have aimed to increase the height of the tackler to slow the ruck. Policymakers should ensure to understand the identity of collision sports before aiming to alter match play to aid safety.

3. The applied and research environments appear misaligned regarding optimal technique, as stakeholders did not discuss proficiency metrics throughout any chapters. As

such, in the applied environment, the focus should not be solely on tackle types with proficient technique assumed. Practitioners should recognise that while specific tackle types were discussed, there is limited empirical evidence on which training drills effectively alter tackle technique.

4. High risk associated areas, such as contact with long closing distances, blind-sided contacts and head contacts, warrant careful consideration by coaches in how they are trained. Policymakers should look to these events to understand how to limit exposure and injury risk to events like the box kick and mauls from successful lineouts.

5. A key interplay between mean match speed, ball in play and contact load is documented. Given the potential implications of concussion and HAE on potential neurodegeneration, the way rule changes alter collision exposure needs careful consideration by governing bodies and policymakers.

6. Psychological differences in emotional regulation were evident across the codes, likely reflecting the differences in match play strategy or average speed. However, grading contact exposure through closing distances appears crucial in training contact from a psychological standpoint in both codes. Practitioners should aim to explore the methods grading contact exposure and developing emotional regulation for collision sport athletes.

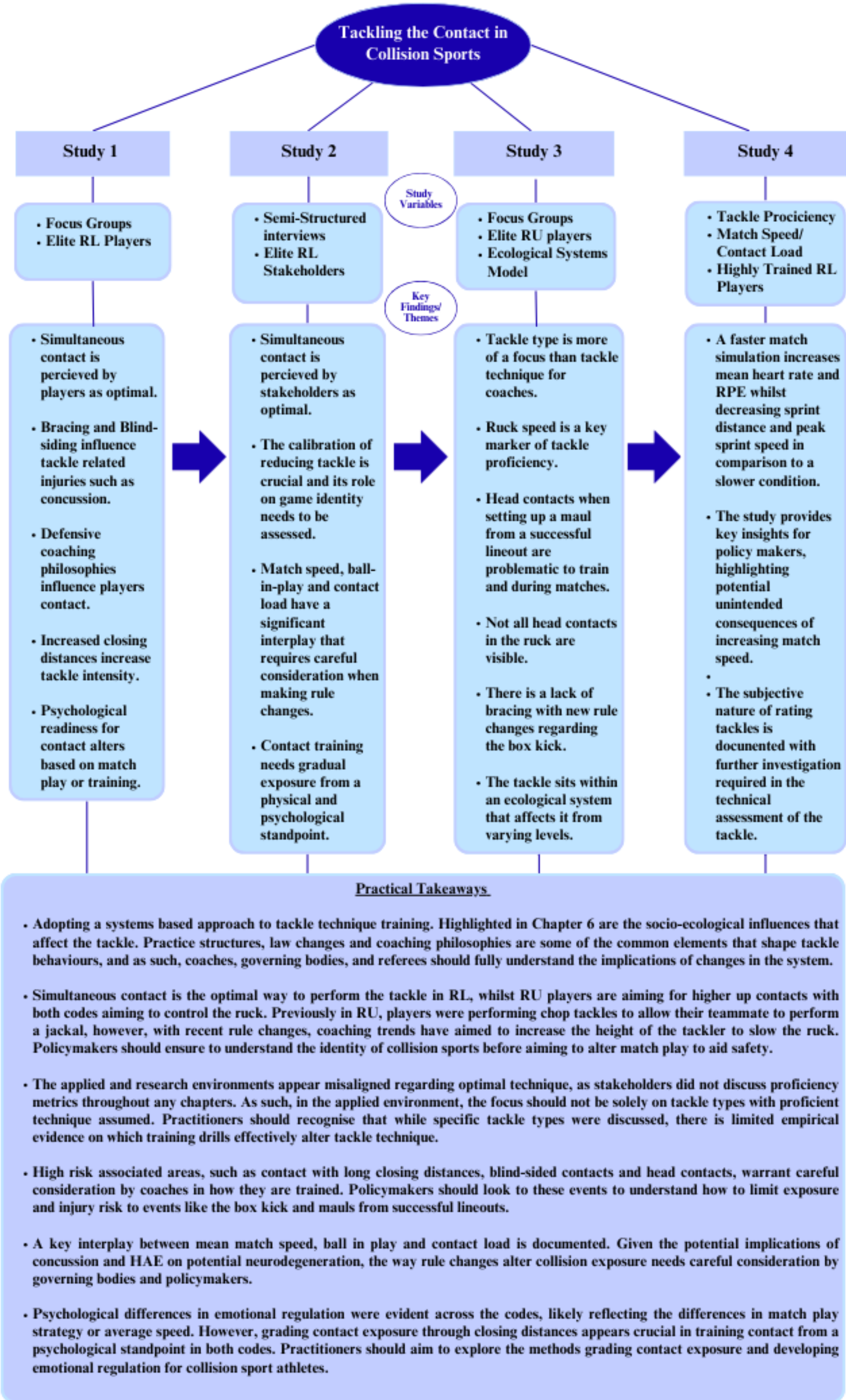

Figure 9. Practical applications and the body of work of the current study.

Chapter 9

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Chapter 10

List of Appendices

Appendix Figure 1. Topic guide for Elite RL Players

Offensive and Defensive Collisions

1. Can you tell me about the collisions you experience whilst defending during a rugby league match?
2. Can you tell me about the different types of contact when defending?
3. Can you tell me what you would describe as the optimal tackling technique?
4. Can you tell me about the collisions you experience whilst attacking during a rugby league match?

Collision Monitoring

1. Can you tell me about your experiences of how collisions are monitored?
2. Are there any determinants that may make a defensive collision more intense than another one?
3. Can you tell me about your experiences of collisions in training versus collisions in a game?
4. Can you tell me about the variables that may affect how intense a ball carry is?

Defensive Coaching Philosophies

1. Can you tell me about the philosophies of coaches coaching defence?
2. Can you tell me about the techniques used to coach collisions?
3. Can you tell me which role in the tackle is the most important in determining the success of it?
4. Can you tell me about the defensive systems in place to nullify the attack?

Psychology

1. Can you tell me about the influence of psychology on performing collisions?
2. Can you tell me about the feelings associated with being psychologically ready for collision?
3. Can you tell me whether your psychological readiness for collision is ever altered?
4. Can you tell me about the differences in psychology for collision in a training session versus a game?

Appendix 2. Elite RL Players Experiences of the Tackle Event Themes Table

Raw Data	1st Order Theme	2nd Order Theme	General Dimension
P2G4Jordan: Yeah so the perfect tackle would be (.) simultaneous contact two of ya (.) um::m stop him in his tracks and then the third man just coming in	Simultaneous contact and the third man.	Strategies to win collision through simultaneous contact and a third man.	The three-man tackle - the perceived optimal defensive strategy
P3G2Carlo: yeah gen generally you want to do a simultaneous tackle … um::m two men up top (.) the the person that has got the ball carrying arm .hh will wrap the ball up the other person will just (.) get his body in front and then we hope we're looking for a third man then (.) to come around the legs and um:m take his legs away and then um (.) whilst you're doing that you're trying to get levers the people up top to (.) to control the tackle (.)	Simultaneous tackle. Two men up top and third take the legs away.		
P3G3Ricky: Um:m the best (.) the best is to be two man contact so:o you wanna hit together with your teammate next to you .hh um down their end especially and well as often as you can really um (.) good defences does that it's just um:m I say if someone is carrying on my right shoulder I hope my teammate it's his left shoulder so he can	Two men contact so the force is doubled.	Two men stopping the momentum of	

.hh so you both can put forces together (.) into the tackle (.) and um:m (0.3) onto just one one guy so the force is (.) just times two really		the attacker with contact.	
Moderator: = are there any other determinants of where a collision might be more intense (.) than another one. Carlo: Kick off carries Derek: [Yup]	Kick-offs and dropouts are intense carries.	Matchplay events with large closing distance and collision intensity.	Not all collisions are the same; Matchplay events change the collision intensity.
Carlo: = or or wingers returning the ball when they've got a twenty thirty metre run up so it's (.) the time time to pick up full speed isn't it	Wingers returning the ball.		
P1G3Lennox: kick offs drop outs .h and probably kick returns for backs are probably the most um high intensity	Kick returns high intensity.		
P3G3Ricky: for the carries and the tackles the heaviest they are is when like (.) long metres in front of you (.) so::o kick off and (.) and taps even taps like when you find touch get a penalty	Long metres in front of you.	Carries with long closing	

		distances are intense.	
P1G4Ross: Yeah well Phil briefly touched on it didn't he (.) so I had the luxury of testing out the (.) the middle this week so::o .hh and as bad as bad as that sounded (.) I actually found it easier carrying the ball in the middle because I knew I was gonna carry the ball (.) so I was set for being whacked (.) … I honestly think twenty times I've been concussed where I've gone to the line (.) irrelevant on whether I've thrown it o::r (.) or um::m (.) or dummied and been whacked in the side um:m (0.4) below below below the the the jaw (.) and it's knocked me out and nothings touched me head	Set for being whacked in the middle. Adjustable position creating space and been whacked.		Bracing and blindsiding – two factors that influence experiences of collision and concussion.
P2G3Gary: the blind side the one where you get blind-sided are again the ones where you're not expecting it (.) so you're not bracing (.) generally when you're tackling (.) you know that the contacts coming (.) so you brace for it and you prepare for it (.) whereas the contacts when you're not expecting it are the worst ones P3G3Ricky: for me as Gary said like (.) for us it's more like the blind-sided one um who gets heavy	Blind-sided carries and bracing. Heavy blind-sided carries.	Positional differences in bracing.	

Tim: Well it the ball carrier knows where he's going doesn't he (.) but as a defender you don't know where the collision is going to be so::o (.) all (.) you(.) all you're doing is (.) you're accelerating into collision but (.) the point of collision could change at last second (0.3) so::o (.) that's the most (.) like we were saying before (.) the more fatigue comes in (.) the harder it is to react and the more likely you're gonna get your head in the wrong place (.) as a defender.	Collision point could change as defender. Reaction and fatigue.	Inability to brace on blind-sided carries.	
James: Yeah it's so unpredictable as a defender isn't it		Reacting to brace when defending.	
P3G1Allan: = our coach as an example at the minute like Coach A was like ((*Hand motions forward*)) kill kill kill and it was all about .hh hard collision hit um as hard as you can .hh whereas like Coach B has come in and it's a bit more .hh hit the ball (.) wrestle	Different coaching philosophies.		Coaching philosophies and orientations.
P2G3Gary: Like I said sometimes people would rather have team of (0.3) cuddlers and make it slow play the ball		Fatigue's role in bracing.	
P3G3Ricky: when the new coach but it might be a .hh he wants us to tackle a bit differently but then (0.3) at the end of the day it's (.) it's what suits you best really you	Wrestlers to slow the ruck.	Wrestling or collision	

P1G4Ross: = um::m (0.2) you get irrational coaches who are (0.2) desperate to keep their jobs or desperate to win (.) and they think (0.2) more physicality is the way forward (.) or .hh they wanna punish you for being soft ((*Inverted commas*)) and missing a tackle an::d (0.2) I've never seen it really work (.) and I've seen it over and over and over again wher::e (.) they say right get in the pit o::r (.) get your gumshields on it's gonna be a tough defensive session um::m and more often than not (.) it's a technical side of thing or a lack of effort because people's minds ar:e (.) are not fully behind it an::d um::m and you end up with a few more injuries and it slowly starts to spiral downhill um::m .hh so yeah I think a lot of it's reactionary stuff not not not I don't see the best coaches	Players know their own technique. More physicality isn't the way forward when losing. Technical or psychological element.	orientations of coaches. Individuality of players techniques. The best coaches focus on the technical/ psychological side of collision when losing.	Contrasting coach's philosophies and orientations.
Allan: = that's down to what coache::s some coaches don't do any any any whack like you hear X Club and that (.) I mean I wasn't there but (.) Coach H I believe and that weren't <u>massive</u> on whacking each other all the time Tim: [Yeah] Allan: What do you think with that David (.) it wasn't like that was it	The best coaches don't do this. Different coach's philosophies.		

David: No no not at all um::m just more technique (.) um::m (.) he he wouldn't have let us chop legs or anything in training (.) um::m and if anyone did go overboard he he would pull em out um::m similar (.) Coach Y was a bit like that if you remember (.)	Technique and no third man in training.	Contrasting coach's philosophies to training collision.	Psychological readiness for collision
P2G2Terry: I always feel th:e the contact in training hurts more tha:n (.) the game (.) because obviously that that boils down to the psychological side of it because obviously in training it's not competitive you don't really wanna be doing it	Contact hurts more in training.		
P2G3Gary: you've just not got the same chemicals in your body (.) and adrenaline to deal with them big contacts	Different chemicals in your body.	Reduction in psychological readiness for collision in training.	
P3G3Ricky: yeah adrenaline just (0.2) get you out of (.) like pain really you don't feel the	Adrenaline.		
P2G2Terry: = so that reflects on your line speed on your intensity .hh how much whack you're gonna put into the contacts and that tends to have a better affect where .hh you know them games where you know things (0.2) things in your prep hasn't been the best you've got a few niggles you know you're playing at not necessarily the top			

P5G2Brian: Club B (H) P2G2Terry: ((*Laughing*)) Yeah and you go you go there and and you haven’t got the intensity you haven’t got the aggression (.) contacts not as good you’re on the back foot and it it it’s a (0.2) carries on spirals on the back of that (.) all because your psychological preparation wasn’t as good as it (.) as it as it can be	Preparation hasn’t been the best and you’re not playing the top club. You go to lower clubs and don’t have the intensity or the aggression.	Psychology of collision versus lower teams can influence preparation. Lower intensity and aggression.	Psychological readiness for collision

Appendix Figure 3. Semi-Structured Interview Topic guide for Elite RL Stakeholders

Specific Question	Theme	Literature Background
1. Can you tell me what you think defines a collision?	**Icebreaker**	N/A
a. Can you tell me how collisions influence your role as a rugby league coach/ medical practitioner/ strength coach?		N/A
2. Can you tell me about your thoughts on the optimal ways for players to perform collisions?	**Offensive & Defensive Collisions**	Hollander, Ponce, et al. (2021b)
b. Can you tell me your experiences of optimal ways for players to make collisions whilst attacking?		Wheeler et al. (2011)
c. Can you tell me your experiences of optimal ways for players to make collisions whilst defending?		Hollander, Ponce, et al. (2021b)
d. Can you tell me about the role of simultaneous contact in a collision?		Dixon et al. (2024)
e. Can you tell me about the role of tackle height in collisions?		Cross et al. (2019a)
3. Can you tell me about your experiences of factors influencing collision intensity in rugby league?	**Collision Monitoring and Associated Risks**	Naughton et al. (2020)
a. Can you tell me about the role of fatigue in collisions?		Gabbett (2008)

b. Can you tell me about your experiences of collision closing distances and their role in collisions?		Dixon et al. (2024)
c. Can you tell me about the role of bracing into contact and blind-sided in collisions that players don't see coming?		Kung et al. (2020)
d. Can you tell me about the role of law changes and their influences on collisions?		Rennie et al. (2021)
4. Can you tell me about your experiences with the kinds of collisions players will make with different defensive coaching philosophies?	**Coaching Philosophies**	Bennie and O'Connor (2010)
a. Can you tell me about your experiences of attack versus defensive coaches' influence on collisions?		Dixon et al. (2024)
b. Can you tell me about the design and prescription of collision sessions?		Asken et al. (2019)
5. Can you tell me about your experiences of psychologically preparing players for collisions?	**The Psychology Behind Collisions**	Dixon et al. (2024)
a. Can you tell me about your experiences of players' psychological readiness for collisions in training versus games?		Dixon et al. (2024)

b. Can you tell me about your experiences with the influence of opposition on players' psychological readiness to perform collisions?		Dixon et al. (2024)
c. Can you tell me about your experiences of the term mentally tough in rugby league?		(Golby et al., 2003); Sheard (2009)
d. Can you tell me about your experiences of stigmas towards psychology?		Kola-Palmer et al. (2020)
6. Is there anything else you would like to add that you feel has not been covered and is important when discussing your experiences of collision in rugby league?	**Final Thoughts**	N/A

Appendix Figure 4. Definition of Terms

Term	Definition
Bracing for the tackle	The ability of the athlete to scan the field of play for opponents, anticipating the tackle and bracing into it.
Blindsiding in the tackle	The inability of the athlete to scan the field of play for opponents and not being able to anticipate the tackle coming, therefore not bracing.
Collision closing distance	The distance between two opposing players on the field before the tackle.
‘Out the back pass’	An attacking player, passing the ball in a backwards motion with their visual field compromised, not allowing them to brace for tackle.
Average match speed	The average speed of the game and is measured in metres per minute.

Ball in play duration	The average duration that the ball is in play per game.
Average match tackle events	The average number of offensive and defensive tackles per game.
‘Win the ruck’	A term used to describe the attacking player playing the ball before either one of or both of the defensive lines or markers are in their set position for the next play.

Appendix Figure 5. Elite RL Stakeholders' Experiences of the Tackle Event Themes Table.

<u>Offensive and Defensive Collisions</u>

Raw Data	1st Order Theme	2nd Order Theme	General Dimension
'Barry': So perfect tackle as people call it now which you know is a simultaneous contact you know full left shoulder from the right shoulder from the opposite side simultaneous hips together close any space down third man joining in effectively … they're just they are more effective and efficient tackles at times to control the ruck. (P8)	Simultaneous contact is the perfect collision. Efficient.	Efficient Simultaneous contact.	Simultaneous contact in the three-man tackle – optimal ways to win collision.
'Matt': The difference between our sport and rugby union in rugby union you're wanting to go to ground as soon as you possibly can with the attacker because then it becomes a jackal on the floor and it becomes a fifty-fifty opportunity to get the ball back whereas in league you almost want to keep him in the air as long as you can before you go to ground … a bog standard it's a sim hit so simultaneously hitting two defenders in between two defenders the attacker comes between two defenders and then	Difference between RU and RL, holding players in the air. Simultaneous contact as part of a three-man tackle.	Differences in codes, wanting to create time standing in the contact.	

that third man assist looking to take away the legs of the attacker or any leg drive or momentum. (P2)	When executed correctly is safe and effective.	The advantages of simultaneous contact as part of the three-man tackle in controlling the ruck.	Simultaneous contact in the three-man tackle – optimal ways to win collision.
'Grant': We would call that dual contact and from a medical perspective what I feel about that is where it's well coached and when players execute it correctly I think it's an extremely safe method of being able to elicit a tackle with the most control considering the chaotic nature of our sport. (P4)			
'Merlin': I think when you've got people running upright with the ball and they're going in between two players it seems to be relatively controlled tackle because you've got two bodies that are relatively close together you've got someone coming up and their control tackles third man comes in and they take it down. (P11)	Controlled tackle when running into two people.		
'Chris': there's a lot of catching technique in tackles nowadays there's advantages in two people tackling high catching somebody holding them up and then somebody come in and takes their legs from under him and there's			

an advantage in that in terms of rugby league tactics I’m not a fan of it for the sake of the sport but I’m also not a fan of it for the sake of preventing injuries and concussions and accidents in collision cause what I’ve learned in recent times from other studies on concussions a lot of our concussions in our sport in rugby union in contact sports are head-to-head injuries… I’m more traditional rugby league tackle bend over and crouch and bend your knees bend your hips and use your shoulder. (P3)	Negative influence of catching techniques on risk of injury.	The negative influences of catching techniques and the risks of simultaneous contact through numbers.	Simultaneous contact in the three-man tackle – optimal ways to win collision.
‘Ralph’: I think I think it’s simultaneous contacts what they try to achieve in rugby league when they do most hits of in the in training and in games it’s always gonna have increased risk potentially than a one on one … I think the more bodies that you’ve got in the frame the more increased risk. (P6)	Head-to-head injuries from catching.		
‘Ralph’: I think that tackle height needs to be addressed I think they are addressing it and I think it’s improving but the problem is that the sports there’s a lot of moving parts that have to be addressed within that rule	Increased risk of simultaneous contact with numbers in the tackle.		

change so the coaches need to understand how to teach it the players need to understand what it looks like and then the refs need to know how to ref it and the match review needs to know how to judge what it is and what it isn’t. (P6)

‘John’: I think there still a big risk of getting head injuries or significant collisions when you are tackling below the waist because you know your heads going to be near their feet and knees hips so from my perspective I think those kinds of rules they sound they sound good but whether they reduce head injury rates I'm not sure … I think that's protecting the attacker because you know your kind of you're steering away from the shoulders and the head and chest but I think it puts the defender at risk. (P16)

‘Brian’: I know other sports going down the line of tackling under the armpit or under the belly button or whatever it is and you know I think that’s got huge risks attached to it from a health and safety point of view as well as the you know the whole fabric of their game. (P15)

Tackle height needs addressing.

A lot of moving parts.

Still a risk of head injuries tackling lower.

The defender is more at risk when going low.

Tackle height needs addressing but there are a lot of moving parts.

The biggest risk it to the defender even when going low.

Tackle Height – Calibration is critical.

‘Michael’: I think we practise now a lot of tackles around the ball and very rarely do we practise a low tackle because that gives the opposition momentum they fall over play the ball quick and it's hard to get that back … there still the odd instance where somebody hits under the ball and drives and everybody applauds and everybody loves a tackle like that but a low tackle as well where somebody falls over the top of you and plays a ball quick is probably the worst tackle that you can you can have as a coach. (P17)	The risks of tackling under the armpit for the fabric of the game. Low tackles give the opposition momentum. Some low tackles are deemed negative from coaches.	The mixed feelings of tackle height and the momentum it may give the attacking team.	Tackle Height – calibration is critical.
‘Grant’: When you see that collision this you know potentially of a kick-off carry for example can be up to like twenty-five metres like you thinking shine a light like that’s gotta be unbelievably impactful but if you see players that have been injured as a result of that first carry it’s not normally the players that come up tall and tackle high it’s normally the players that try to tackle low and they catch your knee or they catch a hip and it’s more of a loss of technique than it is somebody tackling higher in the tackle. (P4)	Kick off carries. Going low and catching a hip.		

Collision Monitoring and Associated Risks

Raw Data	1st Order Theme	2nd Order Theme	General Dimension
'Grant': if I'm being really truthful I would love to see less games I would love to see a super league with the thing that increases risk is obviously a game and that's the greatest risk a player will be exposed … I think ultimately if we're looking at a competition which helps player welfare and also assist the product of the sport less games is more of those two things. (P4)	Less games in super league to reduce exposure.	Two different perspectives of the influence of fatigue	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
'Barry': We're speeding everything up in the game and giving the players less time we're decreasing the time for drop outs and scrums or we brought those rules in there's a shot clock now for how many seconds you can use this for that now there's a stoppage of 5 minutes from the end of the half the game has quickened up a set to such an extent for me that it is getting on the point of breaking the players … there's a breaking point for the players so I don't necessarily feel that it's just the collisions that are causing or	Breaking point for the players due to speed of the game.		

potentially causing trouble it's the fatigue in the game the general fatigue in the game now. (P8)			
‘Frank’: I think in terms of something that in terms of collision-based injuries that I probably would highlight myself more of a factor would be tiredness so I think I said in training a lot of the time actually rather than match play would be guys getting poor technically with their contact technique when their when they're tired. (P10)	Getting poor technically when you’re tired.	Lack of tackle technique when fatigued.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
‘Chris’: Fatigue is one of the big ones you know reasons why and when you haven’t mentioned it during their too much fatigue is when a lot of collision accidents happen too that they’re tired you know and so maybe you know we still need to look at how substitutions and interchanges works and get the ideal there because I’m it's when people get tired that they usually succumb to but poor technique or not being able to react quickly I think there’s enough evidence that to probably suppose it so I think there’s a lot that we can go at as a sport. (P3)	Succumbing to poor technique from fatigue. Substitution rule may need future research.	Law changes influence on	

'Grant': The other thing as well is let's look at the law changes that we've had that increases fatigue like the games quicker than it's ever been you know we've got more collisions because we haven't had scrummages we've had six again laws fantastic to speed the game up but induce more fatigue more fatigue we know his from 2017 research from Fitzpatrick that went through match data so injuries happened at the second part of the first half and the second part of the second half why because they're knackered because you you're tired you know and you're put at risk and you make decisions based on wanting to be the best that you can be but when fatigue is in your in your body there's only certain capacity that you can take yourself and that's when errors start to happen. (P4)	Law changes increasing fatigue. At risk when tired of poor technique.	fatigue and match speed. Lack of tackle technique when fatigued.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
'Grant': As an outside back in particular half back and the fullback that's the ball-playing fullback that pass when you are blinded from your opposition so an out-the-back pass is one hundred per cent probably the most challenging and potentially dangerous position for a player to be in … they are blinded to when that contact will happen so their reaction time will	Out-the-back pass is the riskiest position.		

be different if you’re looking at something and you see it you can brace yourself if you don’t know it’s coming. (P4)			
‘Frank’: Yeah I think that's one element so you know if it's a blindside contact especially if you look at something which you can’t pre brace too if you're looking at you know a concussion or whiplash-based injury you see a lot of the time with half-backs you know what the things they're trying to clamp down at in rugby league is that late shot and half who's just got into the teeth of the line. (P10)	No brace for impact.	Lack of pre-bracing on blind-sided collisions especially out-the-back pass.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
‘Jim’: The spatial awareness and visual and field I mean that's what sets professional players apart from you know those who are just keen amateurs … I think it's absolutely critical to have that awareness of what is happening around you and then to have that visual signal that contact is about to happen and then brace yourself for that as a result. (P14)	Can’t pre-brace for the blind-sided collisions.		

‘Kyle’: We've actually had a case where that's probably worked in the opposite direction with one of our players where one of our players has rushed out to charge the kicker down been anticipating him taking a kick and then thought I don't wanna do it late hate on this kicker I need to just sort of be there enough as a distraction and be there for as someone who's going to tackle this player knowing full well this players going to kick the ball where in that action the player sort of dummy the kick and tried to step our player and sort of collide straight into them because our player wasn't anticipating contact he sort of went into that challenge sloppy in a way of in the sense of teams because he was being quite passive in his movement and he ended up actually picking up an injury from that collision. (P9)	Visual signal is important for bracing. Lack of anticipation of collision resulting in injury.	Vision for contact is key to brace.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
‘Chris’: It’s also some techniques that we need to teach our people carrying the ball and when they’re in offence that can help reduce collisions and concussions as injuries you know so there’s techniques there that I think sometimes we overlook. (P3)	Overlooked protective techniques.	Protective techniques overlooked in coaching.	

‘Chris’: I was taught as a young half back ((passing motion with arm in front and head tucked)) how to go into the line and feel safe you know feel like I’ve got my body protected turn my body a little bit as well so when I got hit ((smacks hip)) I was getting hit and shoved in the way that the ball was travelling rather than you know a collision where I’m gonna get smacked on the back and my head hit the ground. (P3)	Protective techniques.	Overlooked protective techniques and ways to avoid collisions.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
P17G17Michael: I think it's really important we practise a lot of offensively being able to see what's coming at you and use footwork if somebody wants to come out of the line you've got the ability to be able to use your footwork find the pass hit in spin so ride the collision a little bit so there's all different ways that you coach to try and sort of gain advantage from collision. (P17)	Footwork to avoid collisions.		
‘Barry’: To practise to perform a collision is one thing but avoiding collision is obviously another really big art so Player L you know Player L from probably playing against him moderator but he was the best-avoiding			

collisions I've ever seen because of his spatial awareness his understanding of where people were coming from so a lot of his spatial awareness stuff there is makes people avoid contacts in the best way. (P8)	Spatial awareness in avoiding collisions.	Avoiding contact is a key skill.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
‘Frank’: If you've got a bigger closing distance you know and the same mass of a player coming in can they achieve a greater velocity given a bigger closing distance so obviously that the impact of that collision is going to be is going to be higher so maybe you could infer from that was going to have impact in terms of greater risk but equally if you want some of the most innocuous contact based injuries come from smaller closing distances especially head based ones. (P10)	Bigger closing distance means a greater velocity into contact.	Mixed opinions on closing distances and injury.	
‘Michael’: You see so I'm a bit I'm a bit torn on this one I've seen you know I think years ago they had the old five metre rule where obviously the attacker basically hasn't got enough time but then obviously would have less time to ramp up on the ball but then defensively that gives you more time to get up and catch him when he's not probably not expecting it so I	Not all collision-based		

don't I'm not sure don't think we've got it bad if I'm honest I think we've got it all right at the minute I think we've got the 10 metres away by the time you've carried the ball and they've move forward so you probably get 6 metres worth of you know sort of what's the word I'm looking for 6 metres worth before impact 3 with a runner three with a defender maybe something like that so I think we're all right. (P17)	injuries are from large distances. Closing distances in the current game are appropriate.	Bigger closing distance means greater velocity, but other variables (fatigue) may be more significant in injury risk.	Collision related risks – the influence of fatigue, bracing and blind-siding and collision closing distances.
'Ralph': I think yeah obviously if there's someone got a ten metre run up and they're running into each other that does create a bigger collision cause you've got force acceleration you all those things that that come into play but I think it's also the second tackle so if you look at a lot of injuries that occur they've made they've made a tackle and then they're trying to make that second tackle and that's when they're fatigued or even a third tackle. (P6)	Fatigue may be more important than closing distances.		

Coaching Philosophies

Raw Data	1st Order Theme	2nd Order Theme	General Dimension
'Michael': He was an offensive-based coach loved it we practice for hours and hours of attack and you know I think we practice hours and hours of set plays tap plays and very minimal defensive stuff you know we'd maybe honestly for a year and a bit under him I can't really remember doing too many contact sessions and that shows in our performances though because we used to score 30 and let in 40. (P17)	Offensive based coach. Not as many collision sessions.	Less contact sessions with an offensive based coach.	Coaching Philosophies – the graded exposure and philosophical approaches to collision training and games.
'John': If you had a coach liked contact sessions you know you're going to be more exposed to it in training so therefore potentially you know collision-related injuries will be higher in training but again you could argue a coach would certainly argue you know the more you do the more we do in training though maybe better coordination technique everything like that is going to be then in match day. (P16)	Higher exposure but better coordination. .	. Trade of between exposure and coordination.	

'Barry': When you play against Club T at the minute they were a passive style defence they're not coming at you they've decided to do that so there's a different collision level in games like that there's a different stress because of the way they play an attack on the other side of the game as well it was completely different playing Club T when you are attacking them as it is to Club H or even Club F you know change their style and everything else and more aggressive. (P8)	. Different collisions in different systems.	Contrasting philosophies influencing the types, intensities and ways in which players perform collisions.	Coaching Philosophies – the graded exposure and philosophical approaches to collision training and games.
'Phil': I think there's I think that's more to do with the mindset of the coach that depends who you coach is so club A it's kind of a given you've got your tackling skill so sort of you sets and sort of thing you about learning it's almost like learning your dance a dance like learning a dance move if you know what I mean and everybody getting used to where everybody is rather than the sheer it's not full whack if you know what I mean tackling sessions are you tackling but you are tackling but you're not going out to bloody kill someone you know you're not going I'm gonna bloody end him here which is what you got in the game whereas with nation	Low volume high intensity coaching versus high volume low intensity.		

A he wants to see you doing that he wants his sessions short so you've got probably about two maybe 3 to six minutes sessions that are whack but they are proper whack you know their proper game intensity so you either you're either winning because you've got low volume and you're not actually having to make many tackles or you've got a session which is lower intensity.. (P15)			
'Phil': Wrestle I don't describe wrestle as contact really because there's no yeah it's different I think it biomechanically it's a different thing it's not a collision (P15)	Wrestle and contact are different.	Wrestle and collision are different biomechanically.	Coaching Philosophies – the graded exposure and philosophical approaches to collision training and games.
'Frank': contact versus a wrestle is you know is a collision sorry you know wrestle situation where there's a pre-established contact between people and there's now a focus on a manipulation of each other it's that is that a collision I wouldn't really categorise that as a collision so I would say the impact is the important word for me. (P10)	Pre-established contact is not collision.		

'Brian': In the past I've used contact collision and combat as a sort of three-ways and really the only true combat is in the game where there's a real outcome … contact is more skill-based development of technique not overly competitive and certainly not a lot of leg speed or big collision then you can progress in a collision where it's controlled environment but a bit more spice still a bit more intent or energy. (P5) 'Grant': From a point of view physio we know that the collisions is not gonna be heavy there's no separation there's no distance between contact everything's close so it's all about technique of movement it's all about making correct contact taking place … the work that we would do with shields bodies in front taking to ground would all be based around players not leg driving for example which would aid the ability of a defender to take the player to ground without having heavy contact so it's an easier way to be able to periodize and plan contact progression without pushing the boundaries. (P4)	Contact, collision, and combat as levels of collision. Technique, shields, bodies in front and take to	Grading levels of collision to periodise the levels of impact for training.	Coaching Philosophies – the graded exposure and philosophical approaches to collision training and games.

'Michael': Yeah 100% we if we're after a session of you know we're probably grade like we're looking sort of 50 to 60% collisions here we're not looking for 100% we're working on some technique based things were going to work a little bit more on the floor so will take)you know at some point you can take the impact out of the session so basically the defender will maybe run from a metre or two metres away taking the impact out of it but then still looking for all the other processes that are involved in a tackle so take down. (P17)	ground as levels of collision.	Contacts as a percentage in grading collision load.	Coaching Philosophies – the graded exposure and philosophical approaches to collision training and games.
'Kyle': It's probably done as a collective in terms of the coaches would set out what they wanted to achieve from a session … and then it would be probably working with the S&C coaches and the medical staff especially early on in the preseason or with specific players about the best way of prescribing that how much volume of collisions in terms of time but also the intensity of it. (P9)	Grading collision as a percentage.		
'Alex': I think in an ideal world it's multidisciplinary I think in practice it's probably not so much I think that the tactical and skill element of that			

has to come from a coaching perspective I think that you should probably from a medical standpoint and I guess from a sport science and s and c perspective you're probably just trying to put some guidelines. (P7)	Designed as a collective (MDT).		
'Merlin': So I guess as medical staff we probably have input at the last minute we sort of got an idea and I suppose what's good I guess across the league but particularly our club we've had some relatively recently retired coaching staff ex-players so we're all of a similar understanding narrative where the games changed from you know medical was just there to pick up the broken pieces whereas now there sort of an integral as part of that sort of holistic or MDT approach to planning sessions and you know (.) being able to modify sessions. (P11)	MDT is ideal. In practice coaches design the tactical and skill and other staff create guidelines.	MDT approach is best when designing and prescribing collision sessions.	Coaching Philosophies – the graded exposure and philosophical approaches to collision training and games.
	Ex-players understanding the MDT approach.		

Psychology behind Collisions

Raw Data	1st Order Theme	2nd Order Theme	General Dimension
'Grant': I do believe that coaches physios S and Cs are becoming more and more and more aware of the importance of being mentally prepared to play … that mental preparation can be driven through physical exposure. (P4)	Mental preparation driven through physical exposure.	Psychological preparation and confidence can be driven through gradual physical exposure.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.
'Frank': I think for me you've got to treat it like any other facets of the game in terms of mentally preparing them for that you got to expose them to a certain level to make them feel comfortable (.) and physically and mentally prepared. (P10)	Mentally preparing players through physical exposure.		
'Ralph': If they're not very good at two on one tackles and the psychology is that the player doesn't feel confident whose fault is that is that not something that the coaching staff should have taught the player to be able to be more confident with so yes the player is gonna be signed up to	Preparing players through physical exposure		

make the tackle but actually can we psychologically prepare someone by giving them the exposure that they require to feel more confident going into it into a tackle situation. (P6)	to gain confidence.	Emotional fatigue is important and currently has no way of monitoring.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.
‘Marcel’: I always said they can probably needs to be a bit more research is just the emotional fatigue that comes in how much it takes you to get up for them games the nervousness before the game that type of thing so you do tend to see those well you'll spot the weeks when they're going to be quite high and the ones where they're going to be quite low. (P13)	Emotional fatigue monitoring.		
‘Matt’: I think from a you know we obviously look after the wellness of every player after every training session and you know it’s a common one that’s thrown at me from the S and C is you know he’s nearly run three games this week during the week in preseason and I think that’s great but what you know the emotional energy and what it takes out of you emotionally during the game I don’t think you can there’s no monitor for			

that or we haven’t found one yet anywhere and I think yeah definitely is the answer to that. (P2)	Emotional output of games.	High emotion games require a monitor.	
‘Michael’: I think the biggest one is winning and losing as well I think there's the different sort of what's the word I'm looking for here the way they carry themselves on Monday morning after a win on a Friday night compared to the loss is a huge and even into practice that sometimes. (P17)	No emotional monitor.		
‘Kyle’: I think to be mentally tough it's probably linked to resilience … I think traditionally people would have looked at mentally tough and gone oh he’s picked up an injury here or he's got a concussion but he's mentally tough he's not gonna say something he's just gonna carry on but I think mentally tough to have the bravery and honesty to say something is not right. (P9)	The psychological difference between winning and losing. Resilience being preferred to toughness.	The psychology of match play, resilience and being open.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.
‘Grant’: I think the terminology mentally tough mentally tough I think is not something I feel comfortable using but I’ll try and give you an example	Players needing to be honest.		

of what the traditional way of looking at that would so somebody who can handle a great degree of challenge and stress and still thrive someone who can handle or who can be exposed to a large amount of physical and mental challenge and thrive grow and develop but I do feel that every individual who plays this sport is tough … I mean it's a contact sport there are different levels there are different people on the spectrum and we can help people that aren't as robust as others and we can help them through finding out why is it a technical problem can we have a look at the video of them tackling can we have a look at them video in in contact and ball carrying is it a conditioning problem are they fit enough or is it they aren't strong enough or is it a psychological problem where maybe they've not gone through the graduated exposure where they feel comfortable and confident to be able to deal with the challenges. (P4) 'Nicholas': I think there was like we said a long time ago there was a stigma on it especially on male athletes about seeking psychological help and talking to someone … I think it's changing a lot now that speaking and	Not comfortable with using toughness. Someone who can handle a great degree of stress. Gaining resilience through exposure.	Resilience is preferred to toughness and can be gained through gradual exposure.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.

opening up there's a lot of top athletes that are retired now that have come out and talked about mental health issues that they've had not just from collision-based injuries but just being injured in general though it's affected their mental health. (P19)	Stigmas are becoming less.	Stigmas are reducing driven by previous athletes opening up on experiences with mental health.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.
'Steve': I think the landscape is definitely changing when I think back sort of ten years even there was a lot of stigma around that and that showing weakness was never an option or that's what it was perceived as showing weakness whereas obviously in society things have changed dramatically and being able to open up and share issues and be able to confide in people is now a lot more sort of socially acceptable. (P1)	Driven by top athletes opening up.		
	The landscape has changed.		
'Mason': I feel actually the sport of rugby league needs an identity I think we need to differentiate ourselves from rugby union and from other sports and one of the exciting things that I find with rugby league and having played rugby league was the collision aspect and I think the rule changes	Society has changed.		

that are happening currently are I struggle to see how far we can take those rule changes before it has an impact on the identity of rugby league. (P18) 'Steve': Again with that comes our identity as a sport so that the ultimately the aim of players on the field it to creates space so I think the variables that we've got now are for example you mentioned we've got the scrum is basically a load of blokes stand together to create space for others to try and execute a play in space so there are a number of variables that are sort of part and parcel and been the bread and butter of the game for a long time. (P1)	Rugby league needs an identity. Struggling to see how far the changes can go. Identity as a sport.	Identity of rugby league and how changes may affect it.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.
'Grant': I think my biggest thing is the future of the sport depends upon the product being something that's still the gladiatorial sport it should be and it and you've got to have contact you've got to have collision you've got to have situations where players are gonna be exposed to risk that that's unavoidable if the sports going to maintain its identity. (P4)	Creating space for players to execute plays.	Identity of match play variables.	

'Michael': Listen we're in the entertainment business as well if we bring the defence up closer it's going to affect the attack there's no getting away from that and you know the TV broadcaster put our games on a Friday night for people to be entertained and to see the people throw the ball about in the team chance their arm and have time on the ball we want to watch the exciting players with the ball and then they give if we kind of change that we'd lose a little bit of that a little bit and you know we may save on the odd collision here and there but I think overall it wouldn't be beneficial to the game in my opinion . (P17)	Gladiatorial sport. Identity. Entertainment business. Calibration is key to changes.	Galditorial sport with an aim to entertain. Calibration of the change is vital.	Replacing toughness with resilience – the psychology of collision, associated stigmas and game identity.

Appendix Figure 6. Topic guide for Elite RU Players

Specific Question	Theme	Literature Background
1. Can you tell me about your experiences whilst defending in a rugby union match?	**Offensive & Defensive Collisions**	(Roe, Sawczuk, Owen, Tooby, Starling, Gilthorpe, Falvey, Hendricks, Rasmussen, & Readhead, 2024)
a. Can you tell me your experiences whilst attacking in a rugby union match?		(Roe, Sawczuk, Owen, Tooby, Starling, Gilthorpe, Falvey, Hendricks, Rasmussen, & Readhead, 2024)
b. Can you tell me about the differences in collisions in a tackle versus collisions in the clean-out (or scrummaging)?		(Quarrie et al., 2013)
c. Can you tell me your experiences of optimal ways for players to make collisions whilst defending?		(Hollander, Ponce, et al., 2021b)
d. Can you tell me about the role of tackle height in collisions?		(Hendricks et al., 2025)
2. Can you tell me about your experiences of factors influencing collision intensity in rugby union?	**Collision Monitoring and Associated Risks**	(Paul et al., 2022)

a. Can you tell me about your experiences of fatigue when making contact in rugby union?		(Davidow et al., 2020b)
b. Can you tell me about your experiences of collisions during training versus games?		(World Rugby, 2021b)
c. Are there any variables that may affect how intense a ball carry is?		(Colomer et al., 2020b)
d. Are there any determinants that make one collision more intense than another one in defence?		(Colomer et al., 2020b)
3. Can you tell me about your experiences with the different defensive coaching philosophies and how this may influence the collision you make?	**Coaching Philosophies**	(Bennie & O'Connor, 2010)
a. Can you tell me about your experiences of attack versus defensive coaches' influence on collisions?		(Hendricks et al., 2013)
b. Can you tell me about the techniques used to coach collisions?		(Smith et al., 2024)
c. Can you tell me which role in the tackle is the most important in		(Hendricks et al., 2015)

determining the success of it?		
4. Can you tell me about the influence of psychology on performing collisions?	**Psychology behind Collisions**	(Robazza et al., 2025)
a. Can you tell me about the feelings associated with being psychologically ready for collisions?		(Robazza et al., 2025)
b. Can you tell me about your experiences of players' psychological readiness for collisions in training versus games?		(Dixon et al., 2024)
c. Can you tell me whether your psychological readiness for match play collisions has ever altered?		(Campo, Champely, et al., 2019)
5. Is there anything else you would like to add that you feel has not been covered and is important when discussing your experiences of collision in rugby union?	**Final Thoughts**	N/A

Appendix Figure 7. Elite RU Players Experiences of the Tackle Event Themes Table

Offensive and Defensive Collisions

Raw Data	1st Order Theme	2nd Order Theme	General Dimension
G2Participant5 I say from my perspective, like there's a lot more variety and tackle maybe compared to these guys (forwards) like. There's a variety in reaction time that I have. There's some of them really quick. Some of them I've got to sort of track a guy down for a long time and I'm expecting to make a tackle, but it takes me a bit longer to get there. Like mostly I'd say I'm quite a low tackler so like it never really ends up being high and it can be sort of a lot of different angles, a lot of stretching. It's more sort of reactive to the attacker rather than maybe me sort of controlling the collision	Variety in backs tackles. Tracking down the opponent. Different angles.	Variety in tracking and angles of the tackle for backs.	How Position and Context Drive Tackle Selection in Defence.
G3Participant1 Yeah, that's what I was gonna say about footwork, is that, for me, operating in bigger spaces, the biggest thing that will give you a good collision is your footwork. Because if you can get one foot in close, then you know you're gonna get a good shoulder contact.	Footwork is key in bigger spaces.	Closing the space with footwork is key.	
G3Participant2 Yeah, and then you've got that further, like, if you can step in close, your first step after that collision, as well, is also gonna be, like, one of the			

strongest, but if you've lunged that in, and you've got straight legs, like, you're not gonna get any sort of leg drive.

G2Participant5

Yeah, I'd say like on the whole, my like general process for tackling would be like shortening my feet, the closer I get to it to the attacker, I'd like try and stay as tall as I can for as long as I can so that I've got sort of got movement and then I change my height as low as I can as fast as I can punch my arms through and wrap around the back and then try and continue my foot my feet through the collision like post initial contact to win the collision and then obviously then you get them on the floor of the back of that. So that's kind of my process and I find on the whole, there's variance to it depending on sort of your situation, but that's there probably that that's the process I follow for pretty much 90% of my tackles.

G2Participant2

Yeah, and on you're quite like you said in terms of like choice of tackle, I'd say, like if you can see a player isolated as from a forward's point of view, if they're running you and they're isolated, it looks like they haven't got support either side, for me If I can chop them as quick as I can and someone like that someone in our team like Player X or actually G2Participant5 G2Participant5s is a good jackler can get over it, then it gives them an opportunity to get over it. So I'd say that's where, like, obviously, a choice of tackle effects whether you can get the ball back or

Lunging lacks leg drive.

Footwork, staying tall, dropping height and leg drive.

Variance depending on the situation.

Isolated ball carrier.

90% of tackles follow optimal cues although there is some variance.

Tackle selection affected by teammates.

How Position and Context Drive Tackle Selection in Defence.

not, because if you, if you go high and like hold them up, then obviously the attack time to come in and recycle the ball.

G1Participant1

I think you're right on the shape of the ball carrier as well because if you imagine, like, you've got someone that's carrying, like for you guys, you're defending up an out for a carry and someone's gone really low like for to set up an eagle or something like that. Like just going to probably have to go relatively low on that because otherwise you're looking at hitting heads where if you've got someone running really upright and they're all like this and they're showing you like their chest. That's an opportunity that to go low

G1Participant2

That's sort of the type of carry. You know on like an exit carry off nine that they want a box kick. You know, they don't really want to break the 22.

G1Participant1

Yeah. Yeah.

G1Participant2

So then they're waiting for you to come and hit them so almost sometimes you try and pull them rather than hit them. To make them cross that line and they can't kick it straight out. And then it's probably the same on the goal line as well that we don't, we don't do this, but

Chop tackles to aid the jackler.

The shape of the ball carrier is key.

Upright versus low carries.

The area of the pitch can influence the tackle.

Tackle selection based on carrier.

The pitch area influencing height.

How Position and Context Drive Tackle Selection in Defence.

sometimes deliberately absorb tackles and then deliberately land under the ball or over the try line so that there's that drop out rather than they keep tapping. So I think the tackle selection is massively dependent on the ball carrier shape and the style of carry.

Dependant on the ball carrier.

The height of the carrier.

G3Participant2

It's all just outcome based really. We look at the same outcome every time, which is you want to slow their ball down and take away space from them, however you go about that isn't really. We show highlight reels most weeks of the game before and you'll have tackles that look really, really messy, really grabby, but that would be an effective tackle or something that we would praise because we would slow their ball down and hit them behind the gain line. Even if it doesn't look like perfect technique, like it looks really high, really messy, that's still an effective tackle.

Outcome based, is the ball slow.

Messy tackles can still be effective.

Outcome based tackles are the focus.

Strategies That Shape Ball Speed – Defensive Disruption and Generating Attacking Momentum.

Moderator

So the key thing you talked about there is slowing the ball coming out when they've got it, when you're defending?

G3Participant2

Yeah, especially in rugby union, that's what you're trying to do because the more you slow the ball down, the more time you've got for your defensive line to get set, whereas if you're, like I said about chop tackles, if the boys are on the floor straight away, that ball's available to play. You

Slowing the ball down to get the defensive line set.

might only have one or two seconds for everyone to get set and off the line, whereas if you've got them for a higher shot and you've slowed that ball right down, you might give boys three, four, five seconds to set that line. That means that you've got better spacing, you're more connected, you're going to get off the line with more pace, so you're going to be more, effective.

G2Participant2

I’ll start off, I'd imagine me, G2Participant1 and G2Participant3 pretty similar as a forward quite a lot, If you're carrying off nine, you're running into pretty much a brick wall. You try and manipulate the defence a bit, but by using the ball, but most of the time you're sort of carrying into probably two forwards as well. I think they're like you're trying to. You're probably your carrying position's probably pretty similar to your tackle position. Well for us we look to carry quite low to obviously create quick ball.

G2Participant5

The only other thing I'd add is like sometimes you can get it where cause players are like to a certain extent allows to like latch on to each other. So basically there's two you're trying to tackle two people at the same time, like the mass of two people. You obviously go for the guy with the ball, but that's pretty maybe a nuance of our game that you might not get

A higher tackle equals slower ball. Influencing spacing and connection.

Manipulating the defence by using the ball. Carrying position similar to the tackle position.

Creating quick ball.

Players are allowed to latch onto one another.

Slowing the ball through higher contacts to influence spacing and connection in defence.

Using tactical elements to create quick ruck speed.

Strategies That Shape Ball Speed – Defensive Disruption and Generating Attacking Momentum.

elsewhere is people. There's sometimes more than one guy you're trying to bring down or dominate to win the collision, which can make the collisions a lot higher.

G2Participant3

With that, though, I'd probably say when you're saying about the double, it's more likely in in what in the 22, but I'll say with that, yeah..

G2Participant5

I think the biggest thing for me is who if I've got the ball, is like, who's in front of me? Is it a big guy? Is it a small guy? Is it a fast guy? Is it a slow guy? Like, if it's, if it's a faster guy, I'm probably more likely to run at them because I'm not the fastest. So like, I'm not going to take them on. It's a slow guy, probably run away from them if it's a big guy, I'll probably try and use a bit of footwork and create a softer collision. If it's a small guy like, I'll probably try and take him on directly and bump him off and try and carry on. So. I'd say that who the defender is, or who the guy opposite you is depends on the style of collision.

G2Participant2

Oh yeah, it's just for like the attack. Obviously, if we get held up as forwards it obviously it gives the attack more time, the defence more time

Adding numbers into the tackle.

A double is more likely in the twenty-two.

Opposition strengths when carrying.

Who the defender is depends on the style of the collision.

Latching on to the carrier to win the ruck potentially creates more force.

Opposition influence on carries

Strategies That Shape Ball Speed – Defensive Disruption and Generating Attacking Momentum.

to fold round. So with us if it generates quick ball and then players like G2Participant2 and G2Participant4 (backs) can then have more space out wide because they haven't been enough defenders to fold that sort of like what we look for.

G1Participant3

I think a lot of it depends on kind of momentum in a game, like if we're getting going forward, if you say you make a second carry off like a scrum or something with Player T is carrying, then you're carrying off that it was feels easier. Whereas if you're making a carry of a slow ball especially which you know the other team is set and they can come off the line. You've got not really got much space there probably the collisions that feel the hardest and are the hardest to, you know, carry against.

G2Participant1

In in terms of like that carry as well for us forwards and even like backs are the same, there's a lot more intent to attack in like the like sort of prem standard then the URC at the moment so like we get coached a lot on how we use the ball. I think G2Participant2 touched on it earlier about how we use the ball before collisions to manipulate defenders, so we do find weaker shoulders I think back in back in the day you know you have forwards running up carry carry carry and go wide whereas. As forwards now we are getting coached a lot more on how we do manipulate defenders in that close contact so that we're not just running into brick

Getting held up as forwards slows the ball.

Momentum in the game.

Carrying of slow ball.

More intent in the attack.

Manipulate defenders to find weaker shoulders.

Generating quick ball from carrying low

Carrying off slow and quick ball

Manipulating defenders to generate quick ball

Strategies That Shape Ball Speed – Defensive Disruption and Generating Attacking Momentum.

walls I think that's the key thing you'll see more and more of 'cause that in itself does create space, if you can get those little bends and create quick ball like G2Participant2 earlier, it makes games more entertaining because the backs have got more space to run with so I think there is more emphasis leaning towards that.

G1Participant2

I know exactly what you mean, but I'm the opposite like if I play against Club Y or Club F. I find it easier because there's less running and less thinking. It's literally they're going to run straight out and put your head down, whereas you play at Club M and Club K and you've got to make decisions the whole time. And that's probably why I find it hard later in the game when I'm more fatigued

G2Participant4

So like being a winger, I'm probably less distribution focused, more like taking a man on so, so like a lot of it is trying to similarly find weak shoulders. And try and manipulate the defender with your movements and then if you do have to make contact, being aggressive into that contact, so accelerating into the contacts like I always think about trying to match my body height with the defender, so if you are going for like a shoulder barge or a Bosch or something, try and like match his height with the carry. and like step into him as well, like use his momentum to then allow you to like go forward more and like or like. If you step into them and use your momentum then you can like you know, step out of the tackle, do a

Creating space.		
More space for backs.		Strategies That Shape Ball Speed – Defensive Disruption and Generating Attacking Momentum.
Making decisions increases cognitive fatigue.	Making defenders make decisions increases cognitive demands	
Finding weak shoulders.		
Matching the defenders body height.	Matching the tacklers body height	
Use the defender's momentum.		

spin, whatever. Whatever it is, just any way you can keep the momentum going forward and having a few more contact metres or evading the tackle and making a line break.			
The Tackle Event Associated Risks			
G2Participant5 I'd say like a general trend, as I was saying earlier, the closer you get to a try line both in attack and defence, I'd say the collisions get a lot higher but both in like where they are in the body and also like how big they are. So if you're five metres away from the try line you're trying to score on tends to be the people are coming at you at twice the speed and they're a bit like less careful almost with the height that they go in at. And then also if we're defending our own line, we don't mind throwing three, two, three tacklers on that guy to try and repel him. So just as a general trend, both sides of the ball, the closer you get to a try line. That both higher on the body and the force of the tackle increases. **Moderator** Would that be because if you don't put enough numbers in the, the ball will come out quick or is that because you've got no room to play with behind you? **G2Participant5** Yeah, it's. I'd say it's both. And also like we, we're trying to get the ball back at that point because there's only so long that we can hold teams out.	Collisions are higher near the goal line. Greater line speed near goal line. Tackle height is higher.	Velocity into the tackle is greater near the goal line. Regaining possession is vital.	From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

So we've got to try and do something to get it back. So those both, all those three points are factors.

G2Participant5

And teams usually well, you have to change the way their system defends on their own try line, so you're less likely to connect and push people to an edge. You kind of just have to go and run and get them and hope that they mess up the pass rather than like getting numbers on and mapping up correctly. We say like you can almost leave the last guy on the edge if you shut down that play you don't have to worry about the guy on the edge to a certain extent. Obviously there's nuances to it, but the normally the system of defence tends to change when you're closer to your own line.

G3Participant4

I think it depends it depends where you are on the pitch as well so we were talking if you're defending your own try line like if you look at the game from the weekend you've got lads like heads going to people's shins just like diving straight down um compared to out field you'd never have that technique because you're just trying to keep them out

G3Participant1

But again, it depends on the area of the pitch, because here, defending the

A desire to regain possession.

Different defensive system for the goal line.

Leaving the last attacker.

Defensive systems change on the goal line.

Area of the pitch.

Operating lower.

Tackle height changes near the goal line.

Area of the pitch.

From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

goal line, I don't think we get coached really the technique that well, especially when we've been coached on, as backs, how to defend in there

G3Participant3

It's completely different tackle. It's because you're defending inches, isn't it? You don't want to give away an inch, whereas outfield, that doesn't matter so much, so you can often give half a meter or whatever, but when you're on your goal line, you can't do that, so you've got to literally just be as low. you can they can't because they're trying to be as low as they can as well so you it's just a battle.

G2Participant4

Yeah, I think one of the biggest things that dictates the collision is like distance between where the tackler starts and where the carrier starts. Like when that distance is greater, you can have a bigger collision. Like off the nine, like, you often get big collisions off first phase strike plays because like, particularly line out strike plays because both teams are set back 10, you've got 20 metre depth like zone that everyone's trying to gain ground in and but yes, that's why you always get big collisions in that area or on a kick chase. I've like as a wing or whoever it is chasing that kick. You got 20 metre run up, so obviously you have a big collision because of the momentum from that.

Technique changes at goal line.

Technique changes near the goal line.

A completely different tackle.

Matching body height of the opposition.

The shape of the tackler changes on the goal line.

Distance between the opposition.

Closing distance.

Momentum from the bigger run up.

Bigger collisions from first phase strike plays with the distance between the opposition.

From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

G3Participant3

For me, I think it's try line dropouts and 22 dropouts because you're trying to basically kick the ball as far away as you can. But they've got a big guy there, so they'll just pass it to him and he'll just come flying in from, it can be like 20, 40 metres away, the distance, he's got run up. So for me those are the biggest kind of collisions probably in terms of defensively is when we've done a goal line drop out and we try and kick it as far away but they know that so they're already set back there so they've got a bigger run up so I think that's probably the biggest one.

G3Participant4

I also think the other two big ones are off, scrum strikes and line out strikes, so say if you're like, because obviously the defence are 10 metres back, the attack are 10 metres back and it's all about winning that gain line, so you've got the attack, say if it's off a scrum or a line out, coming full pace, you've got the defence trying to close the gap to their coming up quick and normally you just get a massive collision in the middle like if you see something like the clips and the lions tours or people getting knocked out, it's from those just straight off a line out where you've hit the 12 flat he's travelling as quick as he can, you're 7 is coming off the back of the line, trying to hit him, his head hitting his hip, because everything happens so quick, the accuracy and how careful you can be kind of goes out the window. It's just all about winning that collision.

Try line dropouts and 22 drop outs.

Closing distance.

Bigger collisions with bigger run ups.

Line out and scrum closing distance.

Full pace.

Coming up quicker than normal.

Bigger collisions from set starts with larger closing distances.

Less reaction time in the tackle from greater velocity tackles.

From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

G4Participant5

I think as well because it's such a major rule change this this that they've bought this year around the no cradle, there's still sort of an area of uncertainty around. With some of the calls refs have made. But yeah, I think there is definitely a lot, a lot of the guys who are in those position are going up to catch the ball. There probably is a little bit more fear that you are going to, its to encourage that one-on-one contest in the air. But that fear that you probably are going to get taken out in the air. It's definitely crossing a lot. A lot more boys minds. Whereas with the cradle, it's something which has happened. They're pretty hard to try and avoid that but yeah, that's something's certainly something that's crossed my mind.

G1Participant1

I was thinking if we had a wing and or a full back in the room now. For them, they would say catching box kicks can be probably the biggest collision. They'd have in a game so.

G1Participant2

It's a bit of blind shot isn't it.

Lower accuracy due to the speed of the collision.

No cradle rule change.

An area of uncertainty.

More fear.

Taken out in the air.

Box kicks are the biggest collisions for wing/ fullbacks.

New rule changes to cradle the kicker creating uncertainty.

Blind shots on box kicks with

From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

G1Participant1

Yeah. So, like, if you think you're going up in the air, catching the ball and then as soon as you land, you're getting hit by someone that's got a 30 metre run up, you've got no way of bracing yourself because your feet literally just hit the floor and they've sometimes we've not got it right defensively like they've had a clear run through and they're a full pace. So probably some of the biggest collisions back on back would be a back three player catching the ball and getting hit man and ball from a big run up.

G3Participant1

That's one for me is that when box kicks go up, I'm up for a box kick landing and someone's well-timed hitting you. That's the worst one. Because you don't really know where they are because you're focusing on the ball. You're literally landing, they've got to run up, they're lining you up to hit you as hard as they can at that point. So that's definitely one that's position specific to me.

G3Participant1

The other one I was thinking is when you're playing against aggressive defenses, there's the tendency for your 13s and your wingers to be coming up really hard out to in, and that's when you can catch someone in a blind spot when they're not expecting it. When you don't know it, the intensity

A blind shot.

Longer closing distance.

A back three player getting hit man and ball.

Box kicks with a well-timed defender.

Focusing on the ball.

Position specific.

Aggressive defences out to in style.

long closing distances.

Focusing on the ball during box kicks.

From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

of the collision goes up. If the attacker doesn't know that it's coming, because you're not braced for it, and you are just getting whacked when you're not expecting it, which it feels a big one.

Moderator

Do you think that when you're not expecting it that that can feel a bit bigger than when you are.

G3Participant1

Yeah, because you're not braced for it at all.

G3Participant2

It definitely feels more, even if it's just the same as normal, like if you don't know it's happening and you're not braced it's like whipping your head or like feeling like you've got winded in the ribs or something.

G2Participant2

Yeah. And I'd say obviously scrum wise like as a hooker, there's on the bind, there's quite a lot of weight for your neck but in terms of the impact, it's a bit. It's like obviously you engage, you feel it through your shoulders, but then it's just like offset it's more just weight against weight pushing. Definitely I'd say I'd say the collision, the collisions around the field are more like you feel them more than you would in a scrum. For me in a scrum or a mauls a bit different for me. Obviously I'm not quite in the

Catching attackers in their blind spot.

No ability to brace.

Bracing for contact.

Inability to brace for a tackle in the blind-spot, more intense than a normal contact

From Goal Line Defence to Aerial Battles – Contextual Factors That Augment Collision Intensity and Injury Potential.

Weight against pushing in the scrum.

Scrum and mauls are different.

Scrummages weight through the neck and pushing

Where Possession is Won and Lost – Strategic Execution Across the Ruck, Lineout and Scrums.

brunt of it, but I'd say definitely collisions around the field are higher than at scrum time and more time.

G2Participant2

You actually have sort of made me think like in when I'm in a ruck, if I'm getting cleared out, I feel like around the pitch if someone gets hit in the head in a tackle in a carry, it's pretty obvious you'll get looked at. Where I reckon in that rucks is actually where maybe that doesn't get seen as much. I'd say in a ruck, if I get cleaned out. Like there's and you get hit on the head, nothing will happen and it's like it's quite hard to actually for the technique because your head can be low anyway. But I feel like stuff like that, I reckon probably 10 times in a game someone gets hit in the head in a ruck, right with a shoulder or like head on head and it's sort of well, it's not really looked at because it's quite hard to officiate because if your head's basically by the ground and they're clearing out low, like, that's where you can see like shoulders to head, head on heads, which maybe aren't picked up by the TMO, but they do happen.

G1Participant3

No, I don't really feel it rucking at all. Sometimes if you're trying to go over a ball and that someone tries to come and hit you, but it's not, it's nothing like the tackle. There's nothing like being tackled or making a tackle. So I think I've definitely agree with this.

In-play collisions are higher than the scrum.

The ruck doesn't get seen as much as open play.

A hard to officiate area.

The ruck is a hard to officiate area due to lack of visibility.

A ruck is nothing like a tackle.

There are key differences between the

Where Possession is Won and Lost – Strategic Execution Across the Ruck, Lineout and Scrums.

G1Participant2

I just think the breakdown is a lot more niggly rather than collision based, you get twisted finger and you get like a maybe an elbow like a hyperextended elbow or a twisted knee. That's the sort in the in the breakdown rather than the actual collision.

G1Participant1

Again, for it's different, for backs and than for you guys, if you if you're thinking about like an edge breakdown so often for us it's more about. like a race to get into a position and then these guys are thinking about hitting people off the ball. We're actually thinking about just staying over the ball rather than taking someone out of it. So for like an edge breakdown, often there's not that much of a collision there. It's like just getting get into a good position and then just hold on rather than like actually hit someone and take them off their feet. Definitely less of a collision now.

G3Participant2

I've always felt that you can get more intensity in the clean-out just because you know the guy's not moving. There's never going to be any evasion, he's over the ball, so you know you can just have... You don't even have to be looking for the last couple of steps, you can probably head down and try and bury them. I don't know how you boys find it, but when you're tackling a player with the ball, that last couple of steps, you

The breakdown is more niggly than collision based.

Edge breakdowns are different.

Getting into a good position and hold.

More intensity in the clear out because of no evasion.

tackle and the ruck.

Edge breakdowns are less intensity.

Higher intensity of collisions in the

Where Possession is Won and Lost – Strategic Execution Across the Ruck, Lineout and Scrums.

can get stood up. If you think they're going to have to do some sort of step, then you slow down.

G3Participant3

Yeah, I would agree with that. I'd say often, especially if you're in attack, clearing someone out, it's quite a high impact, I'd say, because you know... where they are, and they're not moving, so if they're over it already, you're flying at them with whatever you can to get them off their feet, basically. It would be different if you win the race there, but I find if you lose a race, that's when you get probably the biggest collisions in your game, is you know you've got to do whatever it takes to get that bloke off his feet, clear him out, however you can, so you're just absolutely flying into it.

G3Participant1

I feel like in the wide breakdowns, it's a bit different, because realistically, all we're trying to do is win the race and then not have a collision, and the collisions you do have are someone going back at you a bit, so you're the one that's set and they're coming at you, so I find in terms of collisions, it's probably, I'd say, lower. force and intensity because when we're getting tackled or tackling we're at higher speed and that's a smaller space, lower speed, collision and like you say you're more prepared for it so you can play more force but I've got a lot of the time

Shortening steps into the tackle.

Clearing someone out in attack is high impact.

Winning the race is key.

Wide breakdowns are different.

Winning the race.

ruck due to lack of evasion.

Winning the race is key, especially on wide breakdowns.

Edge breakdowns are

Where Possession is Won and Lost – Strategic Execution Across the Ruck, Lineout and Scrums.

when I'm in a breakdown it's like we've got there and someone's coming back at you rather than the way we're out there.

G3Participant2

I would say in a game there's less times where you've got a big clean-up like that that you would actually be carrying because you're only really in that situation where if you've lost, if the defender's beaten you to the breakdown, which ideally you don't really want, so I reckon the chances to get a big clean-up like that are probably less than the chances you have to have a big carry.

G1Participant3

I think so when you look at that plus one like the guy going to get the ball off the people jumping, that's horrible because you're like, it's almost like you're carrying into your own people, but it's with your head. Because you think about three people lift in the middle, two sorry jump in the middle, sorry two lifters either side you're hitting into that jumper. There's nowhere for you head to go. So that can feel like a big impact, especially in trying to give go forward to the maul. The rest of it not so much like when you're in there. Once you're in there, but obviously when you hit, that does feel hard. But once you're in there, I think it's the same. It's kind of like a breakdown. It's niggly like if it collapses, people landing

Time in the breakdown for edges.

different to the middle.

Less likely than a big carry due to getting to the breakdown first.

Lower incidence rate than carries.

Giving go forward in the maul.

Similar to the breakdown once in there.

Giving go forward in the maul inherently has risks.

Where Possession is Won and Lost – Strategic Execution Across the Ruck, Lineout and Scrums.

on you. So the biggest point I don't know about you G1Participant2, but in training, training feels completely different to a game. So like you think about like, what I spoke about having a collision, the first collision of the game. Usually the maul was never the first collision of a game, whereas in training, so training to do mauls, that is usually the first collision that you have within training. And so the opposition you play against obviously knows that what you're doing, because on the same team, you know, the same calls for me, that's probably the hard training wise. That's probably the hardest collision you get.

The maul is the hardest contact in training.

The maul is the most difficult contact in training.

G2Participant1

When you’re at that sort of front, the maul it's not as big of a collision, it's more of a sort of come together and then it's the sort of weight going through that sort of create sort of the. sort of fight there so comparing them. You can't really compare the both because like they are totally different. Sort of aspects of contact, like mauling’s a lot more physical strength and like trying to find seams and you know working away through the pack. Whereas when it comes to that collision in set piece in phase play is all about like G2Participant4 said like gaining yards and winning almost the collision when you come together.

A come together at the front of the maul.

Trying to find seams.

Set piece and phase play is about winning the collision.

Lower impact at the front of the maul, finding seams.

Where Possession is Won and Lost – Strategic Execution Across the Ruck, Lineout and Scrums

Coaching philosophies			
G2Participant4 I'd also say that there's a lot of variation from coach to coach and what they want, I've had some coaches where when it's full on contact, I know G2Participant2 was saying that you know it's you do alter a little bit, but I've had some coaches in the past where when it's full on contact they mean full on contact and it would be pretty much game like scenarios with all the all the kind of impact of a game and variation tackles you. You see in a game, whereas I've had also had simply had other coaches who don't like that and yeah who preferably would avoid any high level of contact and training	Variation from coach to coach. Inter coach differences in contact intensities.	Inter coach differences in contact training	Philosophy vs Practicality – How Coaching Beliefs Influence Contact Techniques and Preparation.
G2Participant5 Yeah, I think like a good example would be our season last year compared to this season like last season, we targeted our defence a lot more and I'd say we probably had high levels of collision. It's obviously like you can't really compare because I can't remember as such, but it seems like this year we're way more focused on our attack. So first few games of this year we sort of let in a lot of tries and defence and then they knuckle down a bit more in defence so I wouldn't say it's ever like it's quite a fluid process to flow like between the two whether you're more attacking or defensive minded but as a whole, as a team, I think especially this season we're a lot more attacking minded, so it feels like the collisions have decreased, but then maybe week on week if our defence is bad the week	Inter season focuses on sections of game play. Reaction to poor performance.	Reactionary element to contact training.	

before there might be a knee jerk reaction towards a more defensive focus the next week, which means the collisions in training are a lot higher, so I'd say it's not. It's never. It's quite a fluid process.

G2Participant2

And it's like when we're leaking all those tries, that was when we did loads of or every Tuesday, we defended our 22 full contact.

G2Participant5

Yeah.

G2Participant2

We've ramped back up the defence and now our defence has been better, so that's actually stopped. Now it's more with bags. So like, yeah.

G3Participant4

Yeah, so I've had two clubs where it's all been about timing the tackle, get two people in there, try and hold them up, change the momentum, get our defensive line set, and that was very much like, that's what they'd review every week, and then I've had two clubs where we've had real good jacklers in the side, so it's been like, right, chop, chop and roll, because obviously once you've made the tackle, in order for our jackler, because we had a few real good jacklers,to be able to get over the ball, the tackler who made the tackle had to roll out of the way, because otherwise it would give the penalty away. So that philosophy was very much like, right, chop, tackle, roll, chop, tackle, roll. Yeah, and just the way they go about it, for example here, one of the other clubs, it was like, all the drills

It's quite a fluid process.

Focus on performance areas.

Holding the attacker up for slow ball.

Chop and roll for good jacklers.

Chop and the jackler gets over the ball.

Defence is an evolving Process.

Different defensive philosophies

Jackler versus higher up contacts.

Philosophy vs Practicality – How Coaching Beliefs Influence Contact Techniques and Preparation.

would do would be very much like two men in the tackle, change momentum. Whereas the other clubs I was at was like, right, chop and roll, chop and roll, you've got to operate low, you've got to live low. A big emphasis would be like, right, once you've made the tackle, you need to roll out, you need to roll out, you've got to roll out. Whereas here, for example, it's a lot more like, right, you've made the tackle, can you get through that breakdown and counter it almost.

Changing momentum by getting through the breakdown to counter.

G3Participant1

I think it can depend on the wider defensive system as well. I feel like a lot of the teams that want to go with more line speed, I've been coached before, a coach that really wanted loads of line speed, and the way that you could definitely get that is to put bodies in the tackle and slow it down so you can get set. Whereas I have had other coaches that they're focused on like connection in the defence and filling the field, in which case you are going to chop lower and roll out, like you were saying.

Coaching line speed for slow ball.

Inter coach differences of filling the field.

Line speed with upright bodies in the tackle versus fill the field and chop.

G3Participant4

I also think like depending on what so I've been in clubs in the past where they've wanted they've not wanted chop tackles they wanted you to kind of be a bit more upright try and get into like an upper body wrestle and slow the guy down that way because obviously if you chop tackle them the balls on the floor they can play away straight away whereas if you get two men in the tackle go a bit higher and hold them up slows their

Different defensive philosophies.

The focus of philosophies will change to suit the tactical needs.

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ball down the defensive line can get set so i reckon like where you are on the pitch and then different like philosophies and how to you know defend kind of come into it depending on what club you're at.

G4Participant3

I think there's a difficulty between. It's like a bit of a balance, right, because the rules have been changed to drop the tackle height to promote safety. But then at the same time, on the other side of the ball, part of like attack coaches and like coaching people to carry lower in order to stop like what you're saying, like the ball being ripped and ball being put in danger. So, like, I suppose the question is like, how, how does the game make it safer for everyone if we can't just keep bringing the height down. You've got to tackle lower because people are carrying lower and you got to tackle lower, you know. So I suppose that that's one area where like there's a bit of. It's a bit like an endless cycle, really, isn't it? You can't. You can't just keep on making people tackle.

G4Participant1

I think the tackle height protects the carrier. It probably puts the tackler more at risk.

G4Participant3

Yeah

G1Participant1

Upright focus for slow ball.

Rule changes to promote safety and drop tackle height.

Coached to carry the ball lower.

Tackle height protects the carrier.

Ball carrier and tackler height matching to protect the ball.

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Just something I thought obviously talking there, it's kind of probably seems obvious to us, body height in training is much higher than body height in a game because we're not trying to actually hit each other off our feet. We're like wrapping each other up in semi contact that we do. So yeah, body height generally on a training session is going to be way higher than in a game where you're trying to take someone.	Higher body height in training than a game.	Altered body height in training has the perception to effect match habits.	Philosophy vs Practicality – How Coaching Beliefs Influence Contact Techniques and Preparation.
G1Participant2 Well, when I had those two red cards back-to-back in 2021, I blame that solely on training habits, completely on training habits. Where because we train that way all the time, and we'd have a it wasn't a big Level 2, but it was a kind of like a grab level 2. So you never change your body height, and then you go into the game and you've been doing that for 12 weeks of pre season plus the six weeks is 20 weeks from practising this kind of like high grab and then you go into a game where you get to, I've got two, Player S got two red cards, Player U got two red cards, Player Z got two red cards. Player O also got 2 red cards like 5 out of our starting eight had two red cards within six months.	Training habits are higher than the game.		
G3Participant3 I think chop tackles can be a confidence thing as well like if you're not as confident tackling a bigger person you maybe go for a chop just get around his legs and get him down whereas if you want to, like if you i could say a bit more confident that's when you, probably tend to go a bit higher up.	Higher contacts need more confidence.	Confidence is needed for higher up contacts.	

G3Participant2

It seems to go through phases. Every club seems to do similar things at the same time. In the league now, it's definitely more of a double shot tackle. It's been before where it's double shot, hold up the ball, which I guess is quite similar. And then the times before, there's been where it's been a massive chop tackle, jackal.

G3Participant4

It's when they changed the law. The club I was at, we had a couple of really good jackals, and it was around Covid time, and they changed the laws around the jackal. Whereas if the jackal can get his hands on the ball, he's literally going to blow for a penalty straight away. So our whole thing was like, right, chop, jackal on it, chop, jackal on it. We got so many penalties that worked really well for us. Then as they reviewed that law and changed it a bit, that's when we moved away from that.

G3Participant1

I actually think that's increased the height at which people tackle has gone up since then. Which is probably more dangerous. They're obviously trying to go away from that but because there's not as much benefit for the jackal because they're obviously going to speed the ball up, the tackle heights gone up because the only way you can do it is have time and tackle and be up there around the ball.

Double shot tackle taking precedence.

Previous focus on the chop tackle.

Law changes influence.

Lower contacts through jackal benefits.

Tackle height perception of increasing.

The game goes through phases that effect the tackle.

Tackle height can be influenced by the Jackal.

Philosophy vs Practicality – How Coaching Beliefs Influence Contact Techniques and Preparation.

G1Participant3

I mean, there's a bit psychologically but psychological factor to it. Because the way I kind of get up for games is very different from the way that I approach training. If I approached training also like I did for the game. I'll have no energy for the games like type of thing. And I just feel like I said, you know, you know exactly what the other team's gonna do but ((laughing)) I'm talking ball wise here. You know exactly what the other team's gonna come up with. He's saying this because he thinks I go full contact in training.

G1Participant2

Right. What I was going to say before G1Participant3 brought it up. The thing is like in a game you all go at 100% and you give everything you got. But in a game, let's say we all go 70%, right we're all saying we're going 70%, but G1Participant3 100% is a whole lot stronger than my 100%. So if he goes 70%, he still could be stronger than 100%. So he's still knocking me over, but I'm not trying my hardest because I'm 70% as well, so I feel like it's a real tough skill as a squad to develop where you find that level of the teams 70% because you go to 31 or 70% and you'll still skin me. Even if I'm running at 100% and the same in the people, you can see that you quantify that quite easily with speed, but you can't quantify that with collisions. You can't say that collision was too quick. You know there'll be someone on iPad on the side of the pitch on a Monday saying slow down, slow down. We're running too fast. They're

The psychological approach for games and training is different.

Mismatched intensities during training.

Speed can be quantified but not contact.

Matching training intensities is a tough skill as it cannot be quantified.

There is no measure for

Philosophy vs Practicality – How Coaching Beliefs Influence Contact Techniques and Preparation.

running too fast. But there's no way you can quantify that on a Tuesday in the level two level, which is like level 2's like a semi contact like a no chop tackle body in front kind of mentality. But if you go to 90% and I go 60%, there's no way you can know that. There's no way any coach can say stop. Calm down a bit, that's probably where that, that hard bit comes from on that.

G3Participant1

I feel like sometimes in training, because that's actually a good point that you mention, is that people are on different pages about how big the collision's going to be in training, and that makes it worse, so when we were talking about when you're expecting a collision, it's alright when you're not, it's worse, sometimes that'll happen when you're carrying the ball in, you're not expecting to get hit that hard and someone actually does whack you, and you can get a bit of a whiplash with your neck or you'll knock heads with them or something

There is no measure for contact level.

Players are on different pages for contact intensity.

Not braced for contact.

contact percentages.

Lack of bracing when contact intensities aren't matched.

Philosophy vs Practicality – How Coaching Beliefs Influence Contact Techniques and Preparation.

G1Participant1

On that the psychological thing you were talking about as well in terms of the mindset difference in training and in games. Obviously, so we've recognised backs do less contact, less collision in a training week than the forwards do. But if ever we do, do it. There's definitely I find more like little niggles, little things that hurt like a, you know, finger or like your toes getting stamped on or like, actually, that's like giving me a bit of a dead arm that in a game I wouldn't notice because, like, mentally I'm clued in and I've taken a couple of collisions already. But when I go into it, like, still mentally focused, but not like as aggressive as and as sort of switched on.

Like all those little things hurt a little bit more and I wondered sometimes wonder whether it's 'cause you're not, like, fully going for it, like maybe a little bit, like, handsy in a contact and then you end up taking a finger or something like that. You're not hitting with your shoulder. You end up hitting with your arm. You get a dead arm. But I don't know whether it's like a psychological thing where you're not, like, amped up. So you feel collisions more or whether you're not amped up. So you're actually hitting with the correct technique.

G1Participant2

I think it's like I've used the word adrenaline as a wider substance here, but like you haven't got that adrenaline for the game. That adrenaline for

Backs mindset towards contact in training.

Still mentally focused but not as aggressive.

Focused based in training, lacking adrenaline.

You feel the collisions more because you're not amped up.

Adrenaline.

Psychological change.

Feeling the collisions more due to a lack of adrenaline.

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the game, no, there's so many things you do in the game. That's fine that didn't hurt and then, for example, in the offseason I stub my toe on a coffee table and was like fuck that really hurts, whereas just playing against rugby. And I think that's like more physiological change. I know adrenaline is the word I'm gonna use, but whatever happens to wanting to go to for a game that isn't there, that isn't there on a Tuesday or Thursday,

G1Participant1

Definitely.

G3Participant2

Do you ever visualize like your game before you play? Like would you think of it.

G3Participant1

Bits of it, yeah. But it's all, it's never collision stuff. It's all like, it'd be like high balls or like a play where I know I'm going to get the ball on the edge, what I'm going to do there. Or if there was an issue from a previous week, like if you'd like been, like turned over at a breakdown of stuff and you're thinking about just like presenting the ball. I would think about stuff like that.

G3Participant2

I would think about my game before, even like days before, it's nearly always collision.

Lack of adrenaline for training.

Visualisation.

Backs visualising attacking.

Forwards visualising contact.

Different use of visualisation techniques for forwards and backs.

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G1Participant2

I also think like bigger picture stuff on the game at the minute is that emotional side of the game is getting less and less and less. So if you wind back the changing rooms to 12 years ago or 14 years ago when I started you, that's where you had boys headbutted walls still. And you have boys slap on each other, screaming, shouting. They're spraying water in their face, but then 14 years ago, just throw a punch, maybe a penalty. So now you throw a punch it’s a red card and a six week ban. So the game physicality is the style of physicality has changed. I believe it's a way more physical game now. As in the collisions are bigger and harder, but they're less aggressive as in there's less punching there’s less, it’s more controlled. There's much more controlled aggression rather than just raw aggression. And I think that comes across in the pregame stuff as well. You look back to like videos of the Lions tour whenever like 90s and they were in there hugging each other, squeezing each other, but if you try to get someone like Player R or Player E to do like now, they'd laugh at you like they would. That's not they don't emotionally need to be there because they've got so much control over their skill and what they can do. There's probably two or three boys to the changing rooms now, who were probably 32 plus who still have a little bit of emotional shout and roar. So yeah, I think the game has changed massively and because the games changed the that state you get in pregame is now changing as well.

The emotional side of the game is getting less and less.

Rule changes influence on this.

Controlled aggression.

Control of the skill.

Older players slightly more emotional.

Rule changes influencing the games emotional side.

Controlled aggression is key.

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G2Participant5

I'll say, like most of the time, I feel quite calm. Like the more the more amped up I get. I think that's where errors come into my game, so I just I try and stay calm and normally it's sort of like muscle memory kicks in and you end up doing the things that you that you want to do.

G2Participant3

Everyone's different, I'd say, cause for me, obviously I've gotta get myself like for me. I'll probably say look forwards, wise as well. It's totally different back. So I've got to get myself amped up because I feel like I'm like, I'm going to go to war type of thing. So I've got to like, yeah, I'll get myself hooked up to be fair.

Value calmness.

Amped up associated with errors.

Positional/ player differences in emotions.

Inter-positional differences in match emotions.

Beyond the Rush – Balancing Arousal, Calmness and Tactical Knowledge in Training and Games

G1Participant2

I think there's two parts to it. I don't know how you break it up psychologically, but there's one about the game plan and your role and you knowing, and having like you really knowing it, so you're not thinking about it, you know where you're going you know where your job is. And then the other part of it is like that emotional get up for the game. The way I play and where I am, the second one, I've never had an issue with I've never gone into a game thinking oh, I don't know if I fancy this

Knowing your role.

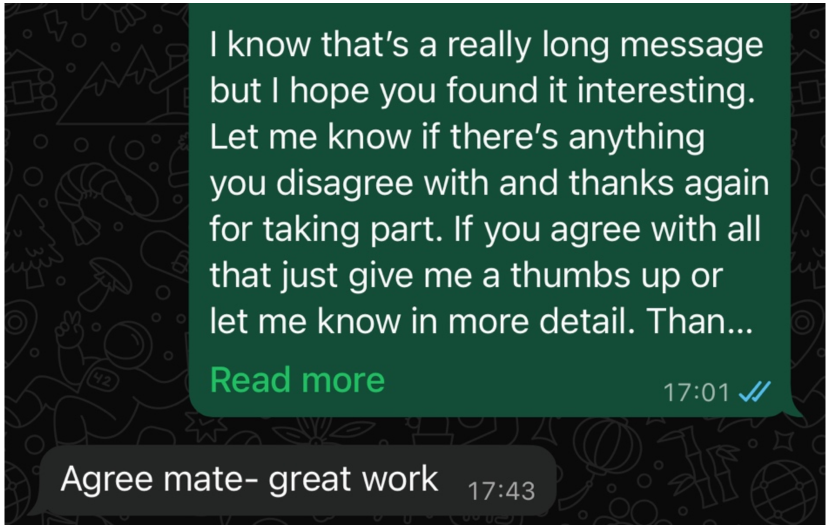
The emotional get up for the game

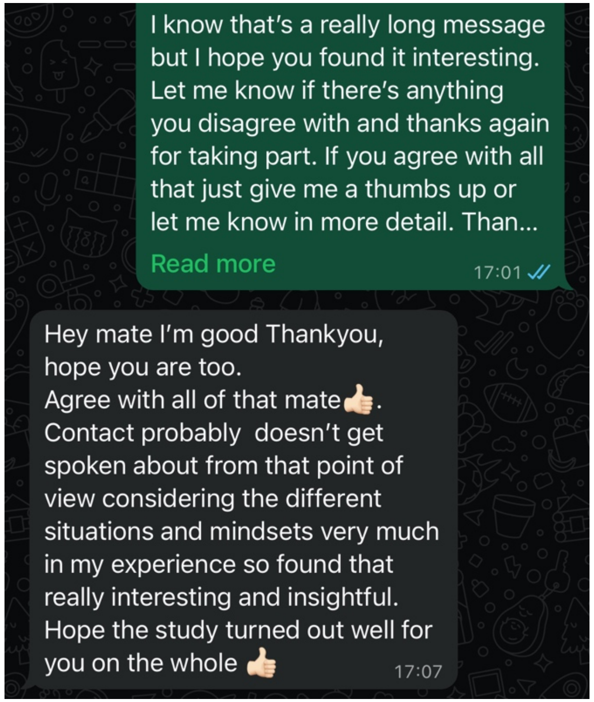
Knowing the game plan and

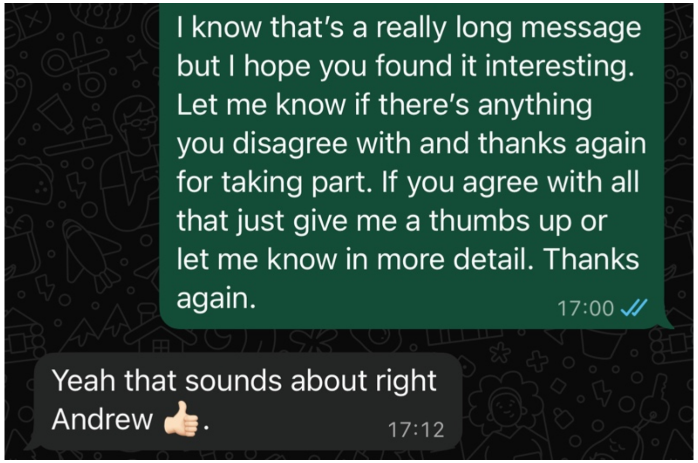
.

today, you know, I've never had that feeling. Whereas I have had that feeling where I go into the game or like I'm not 100% sure if he calls a 7-man line out shift one where that ball is going so. For me, having both of those things concrete as I know exactly what I'm doing and where I should be, and then I'm then I'm sweet, but then that the first one says, well, can perhaps impact the second one because emotionally, if I'm thinking I'm not thinking, let's go. Let's go. Let's go. Which is where I am in a good place. I'm thinking I need to go there, but I haven't done that right is that bit right then I need to go there. So I feel like having that understanding and clarity of the game allows them to be emotionally and completely committed.	Having both is concrete. Clarity on the game plan allows players to be emotionally committed.	being amped up to be psychologically ready.

Appendix Figure 8. Member Reflections Elite Rugby League Players.




I know that's a really long message but I hope you found it interesting. Let me know if there's anything you disagree with and thanks again for taking part. If you agree with all that just give me a thumbs up or let me know in more detail. Than...
Read more
17:01
Hey mate I'm good Thankyou, hope you are too.
Agree with all of that mate👍.
Contact probably doesn't get spoken about from that point of view considering the different situations and mindsets very much in my experience so found that really interesting and insightful.
Hope the study turned out well for you on the whole 👍
17:07


I know that's a really long message but I hope you found it interesting. Let me know if there's anything you disagree with and thanks again for taking part. If you agree with all that just give me a thumbs up or let me know in more detail. Thanks again.
17:00
Yeah that sounds about right Andrew 👍.
17:12

Appendix Figure 9. Elite Stakeholders Member Reflections

Hi Andrew,

"Agree"

Thanks,

Hi

Agreed

Best wishes

Appendix Figure 10. Member Reflections Elite Rugby Union

Hi Andrew,

Apologies - for some reason I thought I'd responded but had only drafted the message.

I read through the document and it matches my thoughts from our discussion a while back.

Thanks a lot and good luck with the rest of your analysis.

Best,

Hello,

Apologies for my slow response. I hope you are well, I have read through your findings and I would agree with everything stated.

Thank you and good luck with the rest of your study.