Developing a motor analogy to teach children how to tackle safely in rugby union

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ABSTRACT

Implicit motor learning strategies have been shown to have benefits when learning a new skill, because they encourage users to accumulate little to no declarative knowledge about the motor task. The aim of this thesis was to investigate whether a specific implicit motor learning approach, learning by analogy, could help children perform safer rugby tackles and potentially reduce the risk of concussions.

Chapter One is a review of current literature and discusses concussions, concussions in rugby, various implicit motor learning theories, and current research.

Chapter Two represents the process in which focus groups were held with small groups of people who all had varying experience of rugby tackling. The focus groups were designed to supply us with knowledge, common ideas and themes, and the fundamentals of a safe rugby tackling, to then help us develop an analogy or analogies that encompassed most of what defines a safe rugby tackle. The first challenge was to identify the important fundamentals in a rugby tackle. From the focus group, the fundamentals commonly mentioned were ‘same foot same shoulder’, ‘eyes focused upward’, ‘head to the side’, ‘cheek to cheek’, and ‘strong wrap’. Animals were a common theme mentioned among all groups, highlighting the importance of the use of animals when developing analogies for children. Based on this information, we were able to come up with two analogies “tackle like a raging bull” (analogy 1) and “tackle like an angry bear hugging a pillow” (analogy 2).

Chapter Three details a pilot study that was conducted on 11-year-old rugby playing children. The pilot study was designed to test the two analogies that were developed in Chapter Two. All participants underwent two consecutive trials in a baseline control condition without receiving any instructions. Subsequently, half of the participants engaged in two trials using analogy 1, while the other group conducted two trials using analogy 2. The groups then swapped and completed the remaining analogy condition.

The baseline control condition had the highest score across most of the tackling fundamentals, albeit not significantly different from either analogy 1 or analogy 2. Analogy 2 closely mirrored the control condition in most aspects. Notably, the 'dip' (cheek to cheek) aspect in analogy 2 scored marginally lower than the control, while 'same foot same shoulder' obtained a diminished score. However, analogy 2 exhibited superior performance in the wrapping technique, displaying similarities in other aspects as well. Conversely, the 'same foot same shoulder' fundamental received relatively low scores across all conditions.

This informs us that more research is required to obtain conclusive data, with a larger participant group, stronger analysis methods, addressing the impracticality of specific fundamentals when tackling a bag versus a human, and developing analogy 2 “tackle like an angry bear hugging a pillow” further to include the aspects it scored low on.

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THESIS ORGANISATION

This thesis consists of four chapters. Chapter One provides a review of relevant literature, which provides the reader with background knowledge in concussions, concussions in rugby, implicit motor learning strategies, analogy learning, and current research. Chapters Two and Three present original research. Chapter Two is based around the data collection from the focus groups and progresses to Chapter Three, where a pilot study was conducted on the information gathered from the focus groups. Finally, Chapter Four provides a conclusion based on the findings of Chapters Two and Three, outlines identified limitations, and provides direction for future research.

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CHAPTER ONE

LITERATURE REVIEW

1.1 Concussions

Concussions are traumatic incidents that affect either the head or the body, resulting in temporary neurological impairments or symptoms (Edwards & Bodle, 2014). Many individuals worldwide are affected by concussions, with approximately 42 million people annually sustaining a mild head injury (Gardner & Yaffe, 2015). While a mutually accepted definition of concussion remains elusive due to varying perspectives across different organisations, the definitions all share similar attributes. Earlier definitions focused more on the long-lasting symptoms, then it was more centred around loss of consciousness. Post-traumatic amnesia was then identified as an indicator of concussion, which was revised further to include general confusion as a symptom. Then a wide range of symptoms were named as being potential concussion symptoms, these include headaches, visual disturbances, nausea, dizziness, sleep disturbances, and memory problems. Definitions have remained inclusive of these potential indicators in recent literature and have stated that even a brief presentation of any of the symptoms above could be indicative of a concussion (Robbins et al., 2014). The common perception is that concussions occur solely from direct head impacts, but it is essential to recognise that forceful impact to other body regions can transmit energy to the brain, leading to its absorption (Edwards & Bodle, 2014). Furthermore, impacts to areas beyond the head can induce linear or rotational forces within the brain. These forces, arising from acceleration and deceleration, play a role in the concussion's development (VanItallie, 2019). The brain undergoes forces that induce acceleration and deceleration, leading to damage in the neural and blood vessel components. Consequently, there can be abrupt shifts in the brain's electrical activity, along with momentary disruption in communication between nerve cells, resulting in periods of unconsciousness. In adolescents, brain imaging of the corpus callosum (nerve fibres facilitating communication and coordination) within six days of a concussion has exposed white matter swelling, correlated with symptom severity. Brain wave tests and imaging techniques have identified abnormal brain function in specific regions, reduced blood flow, and ongoing impairment of the brain's protective barrier in individuals with post-concussive syndrome (Leddy et al., 2012). Factors such as concussion history and age can contribute to the occurrence of post-concussive syndrome, potentially extending recovery periods. Prior

concussions can lower the threshold for future occurrences and worsen symptoms, potentially leading to the re-emergence of post-concussive syndrome (Edwards & Bodle, 2014).

The pathophysiology underlying concussions is complex. Within the context of sports-related concussions, their occurrence is frequently linked to factors like velocity and impact. The rapid acceleration and deceleration forces to a brain in motion significantly contributes to the onset of a concussion. This phenomenon arises from the brain's initial lag behind the skull during impact, followed by a rebounding motion in the direction of impact, leading to contact with the inner skull wall (see Figure 1.1). Additionally, rotational forces play a pivotal role, as concussions can result from shearing forces that cause distortion in the brain's vascular and neural elements (Edwards & Bodle, 2014).

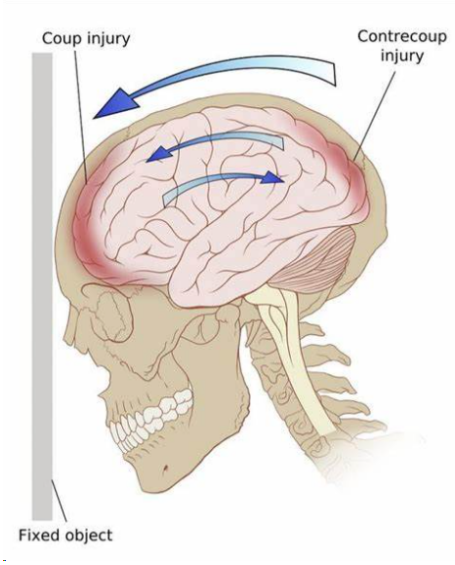

Figure 1.1 *Forces on the brain in concussion (Lynch, P.J, 2008).*

The variety of symptoms associated with brain injuries, including concussions, spans across physical, cognitive, and behavioural dimensions. Physical symptoms can include nausea, vomiting, dizziness, and headaches, while cognitive aspects may involve difficulties in concentration and memory. On the behavioural front, individuals might exhibit irritability and emotional volatility (Blennow et al., 2016). These symptoms are often detected and reported using self-assessment tools administered to patients (Blennow et al., 2016). The complexity in concussion symptoms highlights how important it is to thoroughly assess them.

Concussions in sports often don’t happen in isolation; certain sports carry a higher risk of concussion, and someone who has experienced a concussion is statistically more prone to another due to certain physical aspects, like impaired reflexes (Wetjen et al., 2010). A condition

called second impact syndrome (SIS) can develop after repeated concussions, this was identified when two young athletes died in 1973 after minor second injuries (Wetjen et al., 2010). This syndrome is most common in children and more likely when they don't allow sufficient time for recovery after the initial concussion (Edwards & Bodle, 2014). SIS is a condition that involves rapid brain swelling and herniation and is differentiated from other concussions by the symptoms present at the time of injury. Symptoms can include remaining conscious but seeming stunned, and sometimes able to walk to the sideline before collapsing. Sufferers may then become semiconscious. Their pupils may dilate rapidly, respiratory and brainstem failure may occur, and fixed eye movements are possible, usually all occurring within two to five minutes of the second impact (Cobb & Battin, 2004) . Like initial concussions, SIS does not only occur from a blow to the head, but a blow to the side, chest, or back, that causes the head, and brain to move indirectly. This condition highlights the importance of taking immediate breaks from sports or activities after a suspected concussion. Furthermore, growing evidence suggests that repeated head trauma, including both concussion and lesser impacts/ sub-concussive impacts, could lead to chronic traumatic encephalopathy (CTE), a neurodegenerative condition mainly affecting athletes in contact sports (Blennow et al., 2016). The discovery of CTE traces back to observations of declining health among boxers in 1928, initially named "punch drunk" due to the symptoms displayed. This term evolved into "dementia pugilistica" as similar behaviours were identified in athletes from other sports, like rugby. Subsequently, "chronic traumatic encephalopathy" (CTE) replaced "dementia pugilistica" in the 1960s and has since been detected in boxers as well as numerous athletes who engage in contact sports (Edwards & Bodle, 2014). Repeated mild head impacts following a more severe concussion can trigger subtle but gradual pathological changes in the brain, potentially leading to dementia. Unfortunately, these alterations often remain undetectable within current diagnostic methods. Athletes exposed to multiple concussions and sub-concussive impacts are at an elevated risk of developing CTE, a risk that further intensifies with the length of time dedicated to the sport. CTE can severely diminish a person's lifespan due to progressive brain damage or the escalating impairment of cognitive function, sometimes resulting in suicide. An examination conducted on deceased National Football League (NFL) players revealed that 110 out of 111 individuals had neuropathologically confirmed cases of CTE. The primary marker for identifying CTE in these cases was the accumulation of hyperphosphorylated tau protein, which can also be observed in individuals with Alzheimer's disease and dementia (VanItallie, 2019). CTE can be categorised into four distinct stages, with the initial stage often being asymptomatic. The symptoms of CTE continually worsen overtime,

until stage four is eventually reached. Potential indicators of stage one, if not asymptomatic, may include headaches, diminished concentration, and depression. In stage two, short term memory deficits, aggressive behaviour, mood swings, and organisational difficulties are commonly observed. This stage has also been associated with instances of suicide and paranoia. As CTE advances to stages three and four, cognitive impairment and memory loss become more prominent, ultimately leading to dementia by stage four. In individuals experiencing symptoms associated with CTE, like cognitive and psychiatric issues, such as memory and cognition problems, depression, impulsive behaviour, aggression, parkinsonism, and dementia, the condition is referred to as "probable CTE" while they are still alive because confirming or ruling out CTE in an individual requires a post-mortem examination of their brain tissue (VanItallie, 2019)

It appears that the frequency of concussions is growing, this is due to increasing participation in sports, as well as heightened awareness regarding the importance of seeking medical attention and care following such incidents (Theadom et al., 2020). The current concussion statistics might have remained consistent, but the rise in reporting has created the impression of an increase in these statistics.

Certain tools have been implemented into the rugby world to prevent things like SIS, and CT, by having off field psychometric tests like the Head Injury Assessment (HIA). This is a standardised tool for evaluating head injuries in rugby and has been employed to diagnose concussions (Tierney & Simms, 2018). However, the assessment largely relies on the clinician's experience and intuition. The HIA gained prominence in 2010 and was introduced into World Rugby as a trial in 2012 (Hume et al., 2013). In instances of clear head impact incidents or when players show evident signs of concussion, like loss of consciousness, they are promptly taken off the field for the rest of the match, but often not required to undertake an off-field concussion test (i.e., HIA). When a player experiences a head knock but does not exhibit definitive concussion signs, they are withdrawn from the game for off-field concussion screening. If the results appear normal, the players may return to play. The HIA assessments are conducted in the hours and days following the head injury to monitor and ensure the absence of potential concussions. A recent study evaluated the reliability of the HIA process in rugby union. Researchers found that decisions to remove players from play displayed moderate diagnostic accuracy for identifying concussion. Clinical judgement frequently played a key role in making these determinations. Given the importance of clinical judgement across various medical domains, its key role in assessing potential concussions is not surprising (Fuller et al., 2020). The identification of concussions is not always straightforward, posing a

challenge in accurate management and detection. This complexity opens the door for potential misdiagnoses and instances where concussions may go unreported among players or patients.

1.2 Concussions in Sports

Contact and collision sports are recognised for their elevated incidence of concussions during both games and training sessions. Rugby, in particular, boasts one of the highest rates of concussions, with evidence suggesting that the severity and frequency of these incidents vary by player position and increase with prolonged participation (Theadom et al., 2020). In professional rugby, the reported incidence of concussions can vary from 15 to 20 cases per 1000 player match hours (Fuller et al., 2020). Sport related concussions have been topical in the sports medicine industry for a long time. A study was done on the prevalence of concussions in New Zealand over 10 years, between the years of 2001 and 2011. The Accident Compensation Corporation (ACC) is the New Zealand government's no-fault national insurance system (Salmon et al., 2022), and the amount of concussion ACC claims lodged over this period were 20,902 (King et al., 2014). This number of course does not reflect the severity or ongoing treatments for concussions, nor is it a reflection of the individual sporting codes. However, it was found that rugby union recorded the most claims. This comes as no surprise as rugby is the national game of New Zealand and is a high contact sport (King et al., 2014). Rugby is played by, on average, 40,000 high school athletes, these students are aged between 13 and 18 years old and have been identified as having the highest amount of ACC claims compared to other age groups, 25% of which are from rugby (Salmon et al., 2022). With self-reporting being the relied upon source for diagnosis, this means that concussions are difficult to diagnose and therefore are under-reported. Youth are often given suboptimal concussion management and limited medical support and can often return to play without proper treatment and recovery time, increasing their chance of further neurological damage and repeated concussion (Salmon et al., 2022).

In many cases, concussion symptoms tend to diminish within approximately seven to ten days, with some individuals experiencing relief sooner. However, around 20% of sport-related concussion sufferers might encounter post-concussive syndrome, wherein persistent symptoms, encompassing those mentioned earlier, can endure for months to years (Blennow et al., 2016).

Unfortunately, the intense competitiveness prevalent in sports, coupled with the stigma surrounding vulnerability among athletes, has led to a concerning trend. Evidence indicates that individuals often refrain from seeking medical attention for fear of missing crucial training

sessions, important games, or jeopardising their position within the team. Consequently, the true extent of sport-related concussions might be underestimated, as these individuals are absent from hospital-based studies. This situation is worsened by the fact that certain individuals choose to refrain from treatment entirely, which can lead to additional injuries and result in enduring long-term consequences (Theadom et al., 2020). The pressure to maintain peak performance and the fear of seeming weak can deter athletes from prioritising their health, which not only hinders accurate understanding but also puts their well-being at risk.

Both recognition and handling of concussions have encountered significant challenges, particularly within sports where mild concussions were historically downplayed by players and coaches, often considered a normal aspect of contact sports. In sports like rugby, characterised by frequent physical interactions and players continuing after receiving a hard blow to the head or body, these actions were once celebrated as demonstrations of toughness and resilience (Edwards & Bodle, 2014). Over time, there has been improvement in identifying and managing concussions. Efforts have been made to educate players, parents, coaches, and trainers about the subtler signs and symptoms associated with concussions. However, there remains room for further enhancement in this area (Edwards & Bodle, 2014). While progress has been made, continued efforts are necessary to ensure the comprehensive and timely identification and management of concussions in sports settings.

1.3 Rugby Tackling

Injuries in sport can sometimes be overlooked, particularly in male dominant sports such as rugby. Those who play rugby in New Zealand have historically been portrayed as tough and unemotional people who drink beer and thus took a role in New Zealand's hegemonic masculinity, as the hard work and conquest of pain and fear had been emphasised (Van Campenhout & Van Hoven, 2014). Rugby is an invasive sport with a high number of concussion related injuries. It is a full contact sport, two teams ultimately compete for possession of the ball to try and score as many points as possible by scoring a try by running it to the oppositions end of the field and placing the ball over their try line, or by kicking the ball between the opposition's posts. On the other hand, the other team is trying to prevent that from happening by stopping the forward momentum by tackling the ball carrier (van Rooyen et al., 2014). Defined by the International Rugby Board (IRB) in 2007, a tackle occurs when "a ball carrier is held by one or more opponents and brought to ground" (Van Rooyen et al., 2014, p. 123).

On average, a rugby match contains around 200 tackle situations, most of these tackles being made from the front, or the side. The three commonly seen types of tackles are the arm tackle, which is when the tackler stops the ball carrier with their upper limbs, this accounts for over 55% of tackles. The shoulder tackle, this is when the tackler stops the ball carrier with their shoulder as the first point of contact, then followed by the arms, this type of tackle accounts for 22% of tackles. Lastly, there is the smother tackle, which is when the tackler uses their chest and wraps both arms around the ball carrier, accounting for 14.7% of tackles (van Rooyen et al., 2014).

Reha et al. (2021) sheds light on the prevalence of tackling in rugby, highlighting that each player engages in around 10-25 tackles per game. The frequent occurrence of tackling instances exposes players to a substantial injury risk, with approximately 84% of these injuries involving the head. Suzuki et al. (2019) conducted a study that identified tackling as the primary contributor to concussions in rugby games, given its frequent occurrence and potential impact on both the ball carrier and the tackler. By analysing 265 rugby matches, the researchers pinpointed 40 concussions through video analysis and records. Their findings highlighted several key factors that influence the likelihood of concussion. Firstly, a tackler faces an elevated risk of concussion when the ball carrier directly runs towards them, compared to when the ball carrier sidesteps just before the tackle. Secondly, the use of a collision tackle increases the chance of concussion for the tackler compared to a shoulder tackle. Thirdly, if the first point of contact between the tackler and the ball carrier is the tackler's head or neck rather than their shoulder, the risk of concussion rises. Fourthly, tacklers are at a heightened risk of concussion if they disengage from the tackle without maintaining their grip and arm wrapping. Fifthly, when the tackler fails to stop the ball carrier and allows them to successfully penetrate the tackle, the likelihood of concussion increases. Lastly, tacklers are more prone to concussion if the ball carrier does not go to the ground following the tackle (Suzuki et al., 2019).

In New Zealand, a program named RugbySmart has been developed with the aim of mitigating and preventing severe injuries in the sport of rugby by supplying coaches, parents, and those who visit the website with coaching tips and information regarding safe tackling. While this initiative has proven effective in reducing spinal cord injuries arising from scrums, the matter of concussions remains a multifaceted and unresolved issue. The difficulties surrounding concussions involve various perspectives and complexities, highlighting the need for crucial clarification, particularly concerning young community players (Suzuki et al., 2019). Despite advancements, the challenge of specifically addressing concussions in rugby

continues, emphasising the ongoing importance of continued research and measures for player safety.

Despite introducing specific rules and implementation of tackling programs such as RugbySmart to minimise head-to-head and head-to-body impacts, concussions can still arise from inertial forces even in the absence of direct head impact. Rapid deceleration and structural brain injury can result from sufficient force applied to other parts of the body (Reha et al., 2021) Consequently, the stabilisation of the head has been emphasised as a crucial aspect in mitigating this risk. Reha et al. (2021) conducted a study aimed at investigating head acceleration, neck strength, neck girth, and experience during one-on-one rugby tackling drills. The study involved 18 participants, comprising 16 males and two females aged 18 to 45, all of whom were active rugby players in Australia. The findings of the study indicated that neck strength did not have an impact on head movement. This suggests that enhancing neck strength may not effectively reduce the force exerted on the head during a rugby tackle. The study provides valuable insights into the complex relationship between neck strength and head movement during tackles, highlighting the need for further exploration in this area to enhance player safety and injury prevention.

Research has also been conducted on the potential impact of lowering the tackle height as a means to reduce inertial head kinematics. Tierney et al. (2018) highlighted that upper body tackles, particularly targeting the upper trunk or torso of the ball carrier, contribute significantly to direct head impacts during rugby matches. Their study investigated how altering the tackle height to below chest level affected the head kinematics of the ball carrier. Employing a multibody model test methodology (computer simulation), the researchers examined 45 front-on shoulder tackles. These tackles were developed based on video analysis and were further validated through staged rugby tackle trials involving pairs of professional rugby players. Each pair executed 10 tackles. Although additional validation and practical application within rugby settings are necessary, the findings from both simulation and trial suggest that modifying tackle height does influence the inertial head kinematics of the ball carrier. Specifically, tackles targeting the upper trunk resulted in significantly higher head kinematic values compared to tackles directed at the middle or lower trunk (Tierney et al., 2018). This research highlights the potential benefits of adjusting tackle height to minimise head impacts and enhance player safety, while highlighting the need for further exploration and real-world implementation in rugby.

In another study by Edwards et al. (2022), the aim was to examine the impact of four distinct front-facing, one-on-one torso tackles on the inertial head movements of ball carriers.

The participants comprised of 15 healthy, adult male rugby players with semi-professional background in rugby league or rugby union. During the study, two participants at a time were engaged, with one as the ball carrier and the other taking on the tackler's role. Under the guidance of a highly experienced coach, participants were directed to execute a series of 10 trials, each focused on one of four specific tackle techniques. The coach followed the NRL coaching manual to instruct the participants. The first techniques involved the tacklers shoulder contacting the upper torso of the ball carrier, referred to as SNRL. The second technique instructed the tacklers shoulder to engage with the hip region of the ball carrier, referred to as DNRL. The remaining two tackle variations included adjustments made during the contact phase. In one of these variations, the tackler decreased the vertical height of their body and executed a "pop up" movement, with the goal of redirecting the ball carrier upwards, referred to as SPL. The fourth tackle type involved a slight elevation of the point of contact, shifting from the hip area to the mid-torso, resulting in a redirection of the ball carrier in a vertical and backward trajectory, referred to as DTS.

The NRL coaching manual provides specific guidelines for tacklers, emphasising that they should maintain an upright posture as they approach the tackle. Subsequently, they are instructed to bend their knees while ensuring that their shoulders remain elevated above hip level, thereby facilitating a controlled lowering of their body position in preparation for the tackle. The manual further outlines that tacklers are advised to engage with their shoulder when initiating contact, position their head to the side of the ball carrier, and ensure proper alignment of the neck with the spine by keeping their head upright and in a straight position.

As per the Tackle Safe program, the concept of torso contact is categorised into three zones: the "green zone" corresponds to the hip area, the "orange zone" encompasses the mid-torso region, spanning from the top of the pelvis to the base of the chest, and the "red zone" encompasses the upper torso, ranging from the base of the chest to the line of the shoulders. Applying this framework to the four tackles examined in this study, the DNRL technique aligns with the green zone (hip area), the DTS technique corresponds to the orange zone (mid-torso), the SPL technique is situated within the mid to upper torso region, and the SNRL technique falls within the upper torso category.

The coach communicated to the participants which specific tackle they should perform and provided guidance on the proper execution. Feedback was given during the familiarisation trials, continuing until the tackle was performed accurately. To mitigate the influence of player speed, a potential variable, both the ball carrier and the tackler began from a static position. They were instructed to run towards each other simultaneously, making contact at a level of

intensity equivalent to 80% of actual game intensity. The intention behind this approach was to encourage participants to execute tackles with reduced force and at a slower pace. Given that player-to-player contact tends to result in more injuries compared to contact with the ground, the participants were explicitly advised not to take the tackle to the ground. This instruction aimed to ensure that the focus remained on the tackling technique itself rather than on completing a full tackle to the ground.

Full-body reflective markers were placed on both participants for a 3D kinematic of both, using a 15 Oqus 700+ camera optoelectronic motion capture system. Visual 3D software was used to analyse the data.

Key outcomes from this research indicate that the tackle technique involving the lowest point of torso contact (the hip area), often considered the safest, and categorised as a "green zone" tackle in the Tackle Safe program, results in the tackler experiencing the greatest levels of linear and angular head acceleration. Conversely, the ball carrier demonstrates the least linear and angular head acceleration in this scenario. Notably, most head injuries are typically observed in tacklers. As a result, these findings propose the need for a reassessment of traditional ideas regarding ideal tackling technique. The study implies that a shift in focus towards the mid-torso as the recommended point of contact height might be warranted (Edwards et al., 2022).

Evidence so far considering various variables such as technique, player positioning, timing, and other aspects does not produce conclusive interpretation of what is required for a safe tackle.

1.4 Implicit Motor Learning

Implicit learning is often characterised as a form of non-conscious learning, where the individual engages in a task or activity with little or no likelihood of accumulating declarative knowledge about the motor skill (Masters, 2012). On the other hand, explicit learning entails receiving specific instructions about how to effectively perform a skill, which leads to conscious learning with high accumulation of declarative knowledge of the motor skill. Using declarative knowledge depends on the existence of working memory, unlike procedural knowledge. Working memory plays a crucial role in making executive decisions embedded in declarative performance rules but is not adept at managing the details found in procedural knowledge. Generally, procedural knowledge is processed automatically unless it faces interference from controlled processing guided by working memory. Consequently, individuals have two separate parallel processes: one linked to declarative knowledge, relying on working

memory, and the other related to procedural knowledge, implemented automatically or without direct involvement of working memory (Maxwell et al., 2003). Learning that depends on working memory is characterised by declarative knowledge and a decrease in performance when additional tasks are introduced, as it heavily relies on working memory to manage the primary task. On the other hand, learning that is not reliant on working memory tends to exhibit insufficient explanation of the necessary task processes but maintains strong performance even when secondary tasks are added (Maxwell et al., 2003).

Expertise in an activity does not necessarily demand explicit knowledge of the fundamental movement principles underlying the activity (Stanley & Krakauer, 2013). Current learning methods focus on increasing declarative knowledge through explicit instructions, and are the most common way of learning when acquiring a new motor skill (Van Abswoude et al., 2019). Explicit motor learning involves motor skill progression which is characterised in stages. The initial stages require conscious or explicit control, but gradually become automated, or implicit over time (Van Abswoude et al., 2019, see Figure 1.2 below).

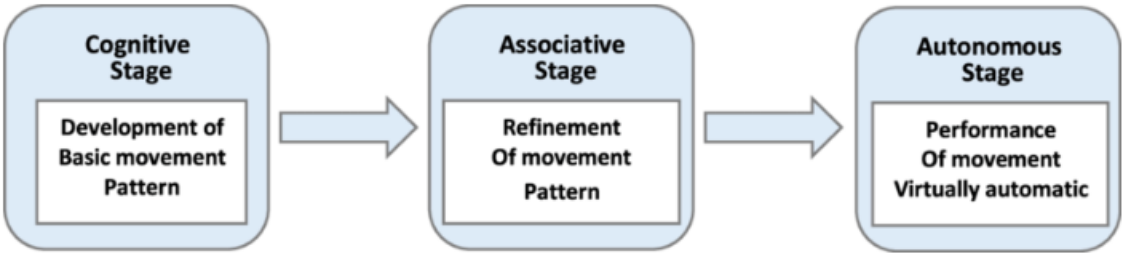

Figure 1.2 *Fitts and Posner's three stage model of learning (Salehi et al., 2021).*

These stages are used to explain motor skill development. The cognitive stage (Stage 1) is when learners are required to make a conscious effort to remember instructions, prior to performing the skill. The associative stage (Stage 2) is when learners can rely less on external instructions and are able to use familiar skills in specific situations. The autonomous stage (Stage 3) is when the learner has internalised the skill, they can perform without much cognitive processes (e.g., processing declarative knowledge), the movement becomes automatic (Kee, 2019). Although both motor learning interventions might (eventually) lead to reduced conscious engagement, research indicates that there are distinct advantages to initiating the learning process with implicit learning (Masters, 1992; Maxwell et al., 2000).

Implicit motor learning has demonstrated many advantages when compared to an explicit approach, particularly when applied to sports performance and outcomes (Gabbett &

Masters, 2011). Maxwell et al. (2000) described implicit learning as "the acquisition of a motor skill without the concurrent acquisition of explicit knowledge about the performance of that skill" (p. 111), while a decade later, Vinter et al. (2010) defined it as "implicit knowledge covers all forms of unintentional learning in which, as a consequence of repeated experience, an individual's behaviour becomes sensitive to the structural features of an experienced situation, without, at any time, being told to learn anything about this situation and without the adaptation being due to an intentional exploitation of some pieces of explicit knowledge about these features" (p. 111). These definitions highlight that declarative or explicit knowledge may not be completely necessary when performing a specific task or skill, and lack of explicit knowledge can contribute to improved success in performing that task or skill.

Evidence that confirmed motor skills and behaviours could be learned implicitly first came from serial reaction time tasks, and continuous tracking tasks. Serial reaction time tasks involve pushing a button in what seems like a random order; however, the button presses are occurring in a recurring sequence. The action of pushing a button is a motor response for the participants; this action, over the time of the task, becomes faster and faster, suggesting they have learnt the sequence implicitly. Continuous tracking tasks require the tracking of a seemingly random moving target with a cursor. The target seems as though it is moving in a random waveform pattern, one of the waves; however (usually the middle one), is repeated in each trial, and is therefore not random. Participants are not aware of this and as their performance improves, this indicates the occurrence of implicit motor learning (Hoskens, 2020). This suggests that learning can be achieved prior to any explicit knowledge being involved, and without awareness of what is being learned.

In initial investigations of implicit motor learning, participants learned a golf putting task: one group with explicit instructions, another without instructions but with a secondary task to limit working memory (implicit learning), and a third group with no instructions or secondary task (discovery learning). All groups improved, but the implicit learners progressed slower. After training, the implicit learners had the least verbal declarative knowledge about the task. Interestingly, they performed better under pressure, while explicit and discovery learners showed reduced performance. This indicates that accumulating verbal declarative knowledge might not be crucial for motor learning and can even hinder performance under pressure (Masters, 1992).

Psychological stress, multitasking, prolonged performance, and fatigue are universal challenges that can impair individuals, but their impact is particularly profound on a sports field. In this context, these factors can significantly undermine individual and team

performance outcomes. Implicit motor learning strategies appear as valuable tools to counteract these challenges and enhance success across these performance domains (Gabbett & Masters, 2011).

Effective implicit motor learning strategies include errorless learning, dual tasking, and analogies. These techniques serve to minimise conscious motor processes in order to facilitate successful performance.

1.4.1 Errorless Learning

Errorless learning involves practicing without errors, which prevents individuals from overthinking and reduces the interference of conscious processes during performance. It concerns the notion that when we learn without making errors, there is a reduced likelihood of engaging in hypothesis testing or excessive overthinking of performance. Often if scenarios are proceeding smoothly, there is a diminished need for modifying movements or strategies. On the other hand, frequent mistakes can prompt a continual process of explicit adjustments to gain success, which contrasts with errorless learning (Gabbett & Masters, 2011). Errorless learning promotes the development of intuitive skills as people become less conscious of their actions and have less conscious engagement in the skill, thus promoting implicit motor learning (Maxwell et al., 2001).

1.4.2 Dual Tasking

Dual tasking incorporates a secondary task to divert attention from the primary performance task. For instance, focusing on a secondary task like counting backwards in threes from 99 shifts attention away from the performance task, allowing it to become more automatic and less reliant on full conscious attention.

1.4.3 Analogy Learning

Analogies make use of familiar stories or concepts to provide a person with a holistic understanding of the movement that they are endeavouring to learn or relearn (Masters, 2000). Analogy learning proves valuable when modifying performance or technique to enhance outcomes or mitigate injury risks. Gabbett and Masters (2011) suggested that analogy learning may be beneficial when teaching rugby league defenders to maintain head positioning during contact tackles, reducing injury risks and enhancing defensive effectiveness. Instead of explicitly instructing defenders to keep their eyes on the ball carrier, they used the analogy "imagine a rod through your head and spine," otherwise referred to as the "Frankenstein"

analogy. This analogy can be tailored to resonate with the context, like "tackle like Frankenstein". Effective use of analogies requires personalisation to align with individual differences and ensure meaningful understanding within the intended audience (Gabbett & Masters, 2011). In sporting contexts particularly, the analogy instruction must convey all important aspects of the movement, and it must be familiar to the learner for optimal outcome (Van Duijn, 2018).

Employing implicit motor learning strategies optimises coaching effectiveness and skill acquisition among novices. Another example of analogy learning was when Liao and Masters (2001) instructed table tennis beginners to execute a topspin forehand using the analogy of "strike the ball while bringing the bat up the hypotenuse of a triangle," without additional instructions. The group taught with this analogy performed better under dual task load and under pressure after practice, compared to the group taught explicit rules for executing movements (explicit motor learning., Hoskens, 2020).

The successful use of analogies has been summarised after it was researched in cognitive psychology for six years. Initially, effective learning through analogy hinges on the understanding of the foundational concept. The greater the familiarity a learner has with this base concept and their experience in applying it, the more connections can be established between the foundational concept and the new one. Consequently, this leads to increased knowledge acquisition and a more comprehensive grasp of the new concept. Secondly, clarity around the context is important before the analogy can be introduced to the learner. Thirdly, visual analogies are recalled better than verbal analogies in most aspects of analogy learning. When the foundational concept is visible during instruction, or when visualisation techniques are encouraged, an example could be “imagine you are putting the ball like a pendulum on a grandfather clock” (Van Duijn, 2018).

Many experiments have been conducted and demonstrated the effectiveness of analogy-based learning on the development of motor skills, showcasing the comparable efficacy to explicit instructions. More importantly, analogy learning is beneficial when decisions need to be made concurrently, this could be crucial when the performer is faced with a decision while under pressure (Van Duijn, 2018).

Dual tasking and some other implicit learning strategies showed results of slower learning rates when compared to explicit learning techniques, this can be due to novices requiring some information in order to perform and adapt movements, and partially correct their own errors. They do not receive this from dual tasking; however, information is given when using analogies, the analogy can give an indication to the learner on how the correct

movement should occur. Analogy instructed learners have been shown to perform on average equally to explicitly instructed learners. This proves that analogy instructions can allow learning at the same rate as explicit instructions, particularly in children after immediate positive effects of analogy learning in children's motor skills were found after a single task (Van Duijn, 2018).

1.5 Implicit Motor Learning of Rugby Tackling

The "rugby tackle situation" is a widely explored and discussed subject, as it is recognised as a pivotal factor contributing to the risk of concussion in rugby. Research has shown that tackling is a primary cause of concussions in rugby matches. Factors influencing concussion risk include direct running towards the tackler, the type of tackle employed, first point of contact being the head or neck, inadequate wrapping of arms, and failure to stop the ball carrier (Suzuki et al., 2019). Coming up with effective strategies to ensure player safety, especially in tackling situations, poses a challenging task.

Coaches naturally tend to communicate various aspects of performance, including rules, technique adjustments, minor corrections, and instructions. However, research demonstrates that implicit motor learning methods produce significant benefits, particularly when instructing novices or beginners (Liao & Masters, 2001).

By implementing implicit motor learning approaches, such as analogy learning, athletes can mitigate the negative effects of psychological stress, manage multitasking demands, sustain performance over extended periods, and alleviate the impact of fatigue. Previous research highlights the efficacy of analogy learning and can enhance the ability of individuals to acquire skills and behaviours automatically, thereby promoting effective and efficient performance even in demanding conditions typically seen in sports environments (Van Duijn, 2018).

Implicit motor learning theories have been integrated into certain rugby contexts to enhance skill acquisition. Serpell et al. (2010) studied the domains of implicit and explicit motor learning within the context of agility testing in rugby. They emphasise that agility, being a motor skill, typically involves elements of both implicit and explicit learning. According to Serpell et al. (2010), the most effective learning often emerges from a combination of both implicit and explicit learning approaches, rather than solely relying on one. Gabbett et al. (2011) conducted a study exploring tackling technique among high-performance rugby players. They discovered that more experienced rugby players exhibited superior tackling technique. In terms of short-term training effects on tackling, Gabbett et al. (2011) employed implicit motor learning strategies and observed a non-significant enhancement in participants' tackling

techniques. The findings also indicate that players operating at the NRL level of rugby (with at least five years of experience), maintaining injury-free status, and engaging in substantial practice may experience significant improvements in tackling techniques. These studies collectively underline the importance of incorporating implicit motor learning methods in rugby skill development. They highlight the interplay between implicit and explicit learning processes and emphasise that a balanced approach is often optimal for maximising performance gains.

Considering what is already in the literature, there seems to be ample opportunity for the exploration of new research. For instance, in the context of children and adolescents, there is potential to develop novel studies centred around teaching effective tackling techniques through implicit learning strategies prior to explicit instruction. This approach has the potential to mitigate the risk of head injury among young players (Carey et al., 2021). Most evidence on safe tackling is related to using explicit instructions; however, there is limited evidence on whether implicit approaches (i.e., analogy learning) might result in safer tackling with the benefits of performing more non-consciously and thus more robust to pressure and other confounding factors.

Investigating the impact of implicit learning strategies on tackling technique among individuals who have not yet acquired the skill may provide valuable insights into the reduction of head injury rates. This is particularly relevant in the case of children, who possess a greater vulnerability to injury and concussion, the consequences of which may extend into their later lives. By focusing on this area of study, it is plausible that the implementation of such strategies could offer substantial benefits in terms of head injury prevention and long-term well-being. Implicit motor learning offers a profound strategy for promoting safe rugby tackling due to its ability to instruct learners, such as rugby playing youth, of fundamental movements without overloading conscious cognitive processes. By employing this approach, athletes can instinctively react during a game or rugby, reducing the reliance on cognitive decision-making during high-pressure, or moments of high cognitive demand (i.e., when faced with more than one task) on the field.

CHAPTER TWO
EXPERIMENTAL STUDY
FOCUS GROUPS

2.1 Abstract

Sport-related concussions remains a prominent concern within the realm of sports, particularly for rugby. Rugby is a widely played sport embraced by individuals of various ages all around the world, and safe tackling and concussion risks have posed a challenge among those involved. A potential intervention to promote safer tackling from youth onwards might be implicit motor learning. Implicit motor learning is often characterised as a form of non-conscious learning, where the individual engages in a task or activity with little or no accumulation of declarative knowledge about the motor skill (Master, 1992; 2012). Therefore, implicit motor learning may promote safer and better tackling from a young age onwards. Learning by analogy is the implicit motor learning approach of choice for this study, which aims to develop an analogy that effectively encapsulates the fundamental aspects of a tackle. The overarching objective is to reduce the cognitive burden experienced by children, enabling them to execute a safe tackle.

This study involved the use of four focus groups held with a variety of groups of experts in different areas of rugby, concussions, and implicit motor learning/ skill acquisition experts. These focus groups had a few primary objectives; firstly, identifying the specific problematic aspects of a rugby tackle that pose a higher risk of causing concussions; secondly, establishing the core fundamentals integrated into the instructions over the many years of teaching tackling to others; and finally, exploring whether an analogy that integrates these fundamental instructions, and that reduces the occurrence of the problematic aspects that were identified, can be developed.

Using Braun and Clarke's, (2006) six-phase approach to thematic analysis, it was clear that there were some common themes among all groups. First, the movement fundamentals of a safe tackle were clearly identified from all the groups (same foot same shoulder, positioning the head to the side, cheek to cheek, executing strong wrapping motion, and keeping the eyes focused upward). Secondly, animals were commonly discussed among the groups, the use of animals in teaching analogies to children is valuable due to their universal relatability (e.g., bear hug, cat pursuing a bird and tiger chasing a pray). Children often have exposure to animals through many different sources. This ensures that the use of animals when developing an analogy should resonate with children. Finally, important key points such as "strong" and

“tight” where often used when describing safe tackling. This approach assists in limiting the movement of the neck and head during tackles, which is acknowledged as a key factor influencing the likelihood of concussions.

Each focus group produced valuable data which allowed us to develop two analogies. This was developed in the fourth focus group with skill acquisition experts. The two analogies are: Analogy 1 = “tackle like a raging bull”, and Analogy 2 = “tackle like an angry bear hugging a pillow”.

2.2 Introduction

Due to the physically demanding nature of rugby matches, injuries are common occurrences. While catastrophic injuries resulting in permanent disabilities are rare, they remain a potential risk. Studies focusing on youth rugby have highlighted match injury rates ranging from 24 to 47 injuries per 1000 player-hours, with lower limb joint and ligament injuries being the most commonly reported. Notably, injuries to the knee and shoulder regions pose substantial challenges, and instances like tackling present the highest risk of injury in contact situations, including concussions. These sports-related injuries can have lasting impacts, affecting both immediate and long-term health, potentially leading to reduced overall well-being, increased disability, and a lower quality of life. Consequently, acquiring safe tackling skills at a young age becomes crucial to mitigate the likelihood of injuries, including concussions, and uphold the long-term physical health of rugby players (Hislop et al., 2016). Efforts to decrease injury risks in rugby have primarily aimed at reducing severe head and spinal cord injuries, as these carry profound consequences for both the affected players' quality of life and the sport's public image. Strategies have revolved around enhancing coaching standards, implementing stricter adherence to appropriate game rules, and fostering a culture of safety within the sport. These interventions intend not only to prevent catastrophic injuries but also to promote a safer environment for players, instilling confidence among participants, spectators, and the broader community regarding the sport's commitment to player welfare and injury prevention (Hislop et al., 2016). There has been a push for the strict enforcement of safe tackling methods, incorporating harsher penalties for unsafe or illegal tackles. Yet, presently, there is only subjective evidence available to confirm any resulting decrease in the frequency of risky tackle-related injuries (Hislop et al., 2016).

To diminish the frequency and danger associated with concussions in rugby tackling, acquiring safe tackling skills from a young age, such as the use of analogies might be a solution. Traditionally, coaches often use many instructions to instruct a player on how to perform a movement such as a rugby tackle. However, information and instructions that are more implicit, (i.e., little declarative knowledge on the motor skill) than explicit (i.e., precise instructions about the motor skill) regarding performance and technique, such as the use of motor analogies, has shown to have many benefits such as maintaining a stable performance when dual tasks are involved and when under pressure, the information can also be processed faster. Learning by analogy is the transfer of knowledge from a known situation to a new one, by conveying each aspect of a complex task into one package, thus promoting implicit motor

learning. Cognitive resources are in less demand when using implicit motor learning strategies when compared to explicit motor learning, which has been proven to show better learning (Kim et al., 2021)

In a previous study, focus groups were utilised to engage various relevant participants in the development of a motor analogy aimed at promoting safe landings during falls. The use of focus groups allowed for researchers to discuss the topic with people who had an interest in falling (Oladi et al., 2022). The participants encompassed different groups such as the elderly, physiotherapists, occupational therapists, gymnasts, and others. Through these focus groups, researchers were able to identify three recurring themes that emerged when participants were asked to describe safe landings: 'soft', 'silent', and 'slow'. Building upon these themes, analogies like "land like a snowflake" or "land like a feather" were recognised. Subsequent testing of these analogies revealed that participants in the motor analogy group, instructed to land like either a snowflake or a feather, indeed landed with reduced force regardless of the direction of their fall (forward, backward, or sideways), as compared to the control group whom were instructed to "land safely" (Oladi et al., 2022).

In the present research we wished to develop an analogy that incorporates rugby tackling fundamentals and safe tackling ideas to discover whether concussion risks in children who play rugby, can be reduced. To develop this analogy, focus groups were conducted to gather information. We hypothesised that these focus groups will provide us information to construct one or two meaningful analogies, which aim to promote safe tackling in rugby for children.

2.3 Methods

This study received ethical approval from the University of Waikato Human Research Ethics Committee before proceeding. It involved conducting semi structured interviews within a focus group setting, which spanned across four sessions. The first session involved a neuroscientist affiliated with the University of Waikato, followed by a session with second-year students from the same university, the third session involved two experienced rugby coaches, and the final focus group was held with skill acquisition experts. This approved research design facilitated discussions encompassing rugby, rugby coaching, safer rugby tackling, and implicit motor learning strategies, such as analogies. These discussions involved individuals from various fields of expertise. The primary objective of these focus groups was to gather qualitative data and insights from small and diverse groups of participants, allowing for comprehensive understanding and utilisation of different perspectives.

2.3.1 Focus Group - University Neuroscientist

2.3.1.1 Participants

The first focus group took place with a (male) neuroscientist who also served as a grassroots rugby coach. In addition, two researchers and an expert in implicit motor leaning theory were present. All participants in this discussion were affiliated with the University of Waikato.

2.3.1.2 Procedure

The main focus of this discussion was to gather information concerning the brain and the scientific aspects related to concussions, as these were the targeted areas of expertise. The discussion went for one hour, it was open-ended, allowing participants to freely share any ideas they had. During this session, the discussions were recorded using pen and paper methods.

2.3.2 Focus Group - University Students

2.3.2.1 Participants

This focus group was conducted with a cohort of university students from the University of Waikato. The student participants, aged between 18 and 20 years old, were divided into three different groups, each comprising approximately 20 individuals (total of 60 participants, mean age = 19 years, 23 female).

2.3.2.2 Procedure

To enhance their understanding of concussions in rugby and analogies, the students were presented with a short education presentation. During this, they were actively encouraged to ask questions in order to gain a comprehensive grasp of the subject matter.

Following the presentation, each group of 20 participants was further subdivided into four smaller groups, consisting of approximately five individuals per group. While the overall grouping was random, it was ensured that at least one member with experience (past or present) was included in each smaller group. This deliberate selection aimed to ensure the incorporation of fundamental rugby tackling principles into the task at hand.

The smaller groups were instructed to proceed outside, where four rugby tackle bags had been set up for their use. Collaboratively, the groups engaged in discussions regarding the essential components of tackling and sought to identify crucial information. Their objective was to collectively devise an analogy that encapsulated their understanding. Subsequently, participants were required to perform a rugby tackle against the tackle bag, utilising the analogy they had developed, while assessing whether their analogy sufficiently encompassed all the

fundamental aspects they had discussed, thereby determining the safety of the tackle. Throughout the sessions, notes were being taken and ideas regarding tackling and analogies were recorded. Each of these sessions ran for approximately one hour.

2.3.3 Focus Group – Experienced Coaches

2.3.3.1 Participants

The two experienced (male) coaches had over 20 years coaching experience each, ranging from coaching young children, teenagers, and in the high-performance space. They have worked and consulted for New Zealand Rugby where they are considered leaders in training and development. One participant, a previous educator, has experience teaching and coaching in both Primary and Secondary Schools. He possesses the credentials of a certified World Rugby Trainer and Educator and has recently completed a Master's degree in Sport, Health, and Human Performance, with a specialisation in Game Sense Coaching.
The other participant started playing rugby at 19 years old and has played all around the world. Following his playing career, he transitioned into a coaching position where he coached junior rugby from Under 8 to Under 12-year-olds.

2.3.3.2 Procedure

Semi structured interview questions and discussion topics were employed to facilitate the collection of valuable data with two experienced rugby coaches. The primary objective of this focus group was to develop comprehensive understandings of the significant concerns currently prevalent in rugby and subsequently narrow them down to a select few that would serve as the basis for the creation of an analogy, aimed at mitigating these concerns. Another important aspect targeted for exploration was the existing methods of teaching tackling to children, which would contribute to the development of the analogy.

This focus group session went for a duration of two hours and was recorded using voice recording software on a laptop. The session commenced with a brief presentation, providing background information on concussions, specifically within the context of rugby, and the concept of analogy learning. This introductory segment was crucial in acquainting the coaches with the concept of analogies and served to inform them about the purpose and rationale behind the research.

Following the presentation, the structure of the focus group was outlined to the coaches. They were informed that the session would involve open discussions, with some questions posed to guide the conversations.

2.3.4 Focus Group – Skill Acquisition Experts

2.3.4.1 Participants

The final focus group was held with five skill acquisition experts (two male and three female). All participants in this focus group are well educated on implicit motor learning and analogy learning, which made for an educated discussion.

2.3.4.2 Procedure

This particular focus group took place after the prior three sessions, aiming to leverage the insights gathered in those prior discussions to construct a well-informed analogy. Each participant received a handout containing the essential principles of rugby tackling, key terminology derived from prior focus group sessions, tackling regulations from the Rugby Toolbox Website, and common mistakes in tackling (as outlined on the Rugby Toolbox Website) ("The Tackle Clinic," n.d.). Using this provided material, participants engaged in a two-hour open discussion where they all shared ideas about potential analogies that could be developed and tested in a pilot study with children. The participants were initially informed of the objective of the focus group. The primary objective was to develop two separate analogies that could be trialled in a pilot study, the analogies needed to incorporate most, if not all the fundamentals that had been highlighted in previous focus groups.

2.3.5 Analysis

To analyse the data, Braun and Clarke's, (2006) six-phase approach to thematic analysis was used, this provided a systematic way of analysing qualitative data. The six steps are summarised in the following: (1) Familiarisation with the data: researchers thoroughly engage with the data to gain a deep understanding of its content, (2) Creating initial codes: researchers identify and assign labels to meaningful segments of data, capturing important concepts, ideas, or patterns, (3) Exploring potential themes: researchers search for patterns, connections, and repetitions in the initial codes to identify potential themes, (4) Reviewing and refining themes: researchers carefully review and improve the identified themes by examining the data within each theme and comparing them across the data, (5) Defining and naming themes: researchers provide clear and concise definitions and descriptions for each theme, emphasising their key characteristics and supporting them with relevant examples, and finally (6) reporting the analysis: researchers present their findings in a coherent manner, incorporating the identified themes and using quotes or excerpts from the data to illustrate and support their analysis (Braun & Clarke, 2006).

2.3.6 Results/ Discussion

Analysing the data to uncover meanings, patterns, and insights within the data set was the purpose of the analysis. We were wanting to determine whether there were commonalities among the data between the four separate groups of participants - this would inform whether there were shared attributes, characteristics, themes, or patterns across the data. Finding a consistent idea that features across all the groups provides a foundation for generating meaningful interpretations to then develop practical implications based on these collective insights from the participants.

The essential findings derived from the focus group with the Neuroscientist from the University of Waikato predominantly revolved around anatomical considerations. The discussion encompassed notable insights regarding the alignment of the head, eyes, and shoulders, which directly pertain to the core principles of rugby tackling. Fundamental techniques that were emphasised were maintaining visual focus (eyes up), maintaining close proximity between the tackler's cheek and ball carriers bottom (cheek to cheek), and executing a secure wrapping motion (strong wrap). Moreover, there was extensive deliberation on the importance of adequately supporting the players head, as increased stability in this regard can effectively diminish brain rotation and mitigate the shearing force experienced by both grey and white matter in the brain.

The groups involving second-year students from the University of Waikato shared extensive knowledge in their focus groups. Given that some of the students had personal experiences as current or former rugby players, the fundamentals that were discussed hold relevance. Consistently, all groups emphasised the same fundamentals and the significance of employing these techniques, such as same foot same shoulder, positioning the head to the side, cheek to cheek, executing strong wrapping motion, and keeping the eyes focused upward. When prompted to devise an analogy that incorporates these fundamentals, the groups exhibited similarity in their approaches. Analysis of the data reveals that the majority of students drew inspiration from animal behaviour to articulate their understanding. Analogies such as a bear hug, a cat pursuing a bird, and a tiger chasing its pray emerged as notable examples developed by the students. Additionally, they formulated analogies like jumping onto a bed like spiderman, diving into a foam pit, diving into a swimming pool, and pushing on a closed door, among others. Other aspects that should be highlighted as key themes in their analogies are maintaining a low body position; all proposed analogies ensured this would

occur, along with strong wrap (i.e., a cat in the final stages of catching a bird, and the diving motion).

The focus group conducted with the two experienced coaches produced significant benefits. The data obtained from this discussion aligned closely with both the Neuroscientist and University Students in terms of the tackling fundamentals that were mentioned previously. Notably, additional data emerged pertaining to the utilisation of the terms ‘strong’ and ‘tight’ when describing safe tackling. This observation aligns with the Neuroscientist’s emphasis on head support. By ensuring that the tackler tightly tucks their head into their neck, it aids in minimising neck and head movement during the tackle. Consequently, when being tackled to the ground, the likelihood of the head encountering forceful impact or excessive movement is diminished, thus, reducing the potential for the brain shift within the skull and minimising the chances of head-to-ground contact. It is worth noting that current regulations, instructions, and coaching guidelines regarding rugby often contain explicit knowledge, as emphasised by one of the coaches who referred to the instructions outlined in the New Zealand Rugby Coaches Handbook. When coaches were prompted to develop an analogy, animal related concepts were also explored. For instance, the idea of imagining oneself as a bear covered in honey was suggested, aiming to incorporate the concept of tightness. By envisioning a sticky bear covered in honey, the notion of the bears head adhering tightly to its neck was highlighted.

The theme of animals emerged as a prominent topic of discussion across the various focus groups (see Figure 2.1). This reoccurring emphasis on animals informed us that the use of animals could be valuable, signifying that it was highly likely to be a central element when developing analogies. The recurrence of animals among the groups could be because of the shared/ similar psychological traits shared between humans and animals (Alvargonzález, 2020). As mentioned, the final focus group utilised insights gained from the previous three focus groups to develop relevant analogies. The identification of recurring themes and ideas discussed in the previous focus groups played an important role in the development. Ideas and common themes were discussed, notably those pertaining to animals, which helped to build a strong foundation that significantly influenced the ultimate outcome.

The final focus group had the objective of finalising two analogies by utilising the information given from the previous focus groups. As mentioned, animals are a key component when developing these analogies. Using the fundamentals that were mentioned by all groups were also vital in ensuring the analogies still implemented safe tackling techniques. The two analogies developed were analogy 1 = “Tackle like a raging bull” and analogy 2 = “Tackle like an angry bear hugging a pillow”.

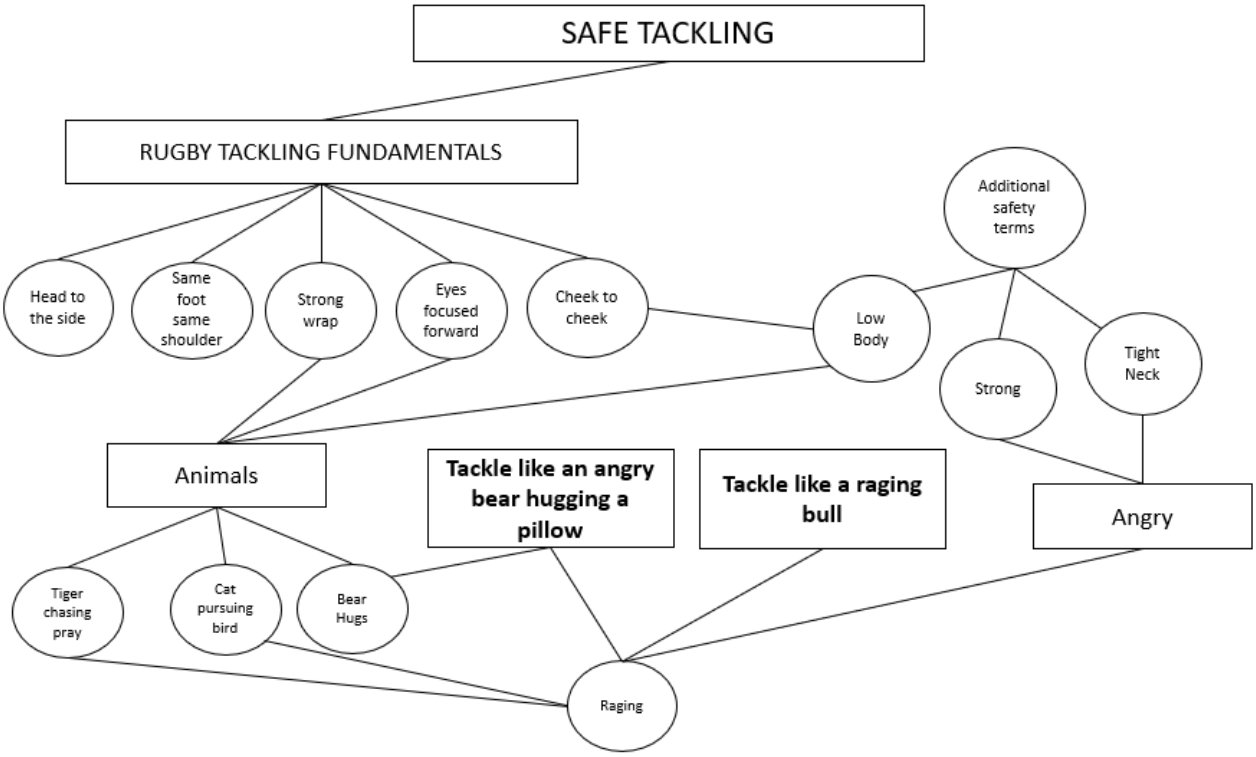

Figure 2.1 Thematic map showing themes found among focus groups.

These analogies were constructed using the safe tackling techniques that were discussed in the previous focus groups, as well as information derived from the Rugby Toolbox Website. The key points that were focused on were being low, to encourage cheek to cheek contact, keeping the eyes focused upward, and a strong wrap. For instance, in the analogy featuring a raging bull, we drew parallels to the animal's behaviour. A raging bull moves on all fours, emphasising the importance of staying low to the ground. Its aggressive nature mirrored the need for a strong, assertive wrap, while its forward-focused gaze reinforced the importance of keeping one's eyes fixed on the target. In the analogy of the angry bear, we aimed to evoke the image of a bear running on all fours. This imagery reinforced the idea of staying low during a tackle. The notion of an "angry" bear and "hugging a pillow" highlighted the need for a strong and aggressive wrapping technique.

These analogies were constructed to enhance comprehension and execution of safe tackling techniques by leveraging comparisons to animal behaviour and physical actions. By likening the movements involved in tackling to those of animals or specific physical actions, these analogies aimed to create vivid mental images that would resonate with learners. For instance, comparing a tackling technique to a lion's pounce or a bear's strong and assertive grip while hugging a pillow allows players to visualise these movements during tackles. This approach not only provides a relatable framework but also encourages automatic responses resembling the behaviours seen in animals, hopefully reinforcing safe tackling techniques.

CHAPTER THREE

EXPERIMENTAL STUDY

PILOT STUDY

3.1 Abstract

This study investigates the potential of analogy-based learning to improve the motor skills of young rugby players, with a specific focus on safe tackling techniques. To investigate this, a pilot experiment was conducted with a junior rugby team, consisting of nine 11-year-old male players. The participants underwent two distinct phases, in which they first performed a tackle to a tackle bag without instructions (baseline control condition). Afterwards, they performed the tackling again; however, this time they were instructed with a motor analogy (in a randomised order)– "tackle like a raging bull" and "tackle like an angry bear hugging a pillow". Throughout the phases, participants were filmed using frontal and side-view cameras.

The videos were analysed by a rugby expert, who conducted an individual assessment, giving 'yes' or 'no' feedback on specific movement fundamentals (same foot and shoulder, eyes focused upward, positioning the head to the side, cheek to cheek, and executing a strong wrapping technique). Following this, the Cochran's Q test was utilised to assess the consistency of outcomes across different categories within a dichotomous dataset. In cases where significant results were observed from the initial test, a subsequent post-hoc analysis employing the McNemar test was performed.

The analysis revealed that there were no significant differences observed between the 'same foot same shoulder,' 'eyes focused upward,' and 'head to the side' fundamentals for all three conditions (baseline control condition, analogy 1 "tackle like a raging bull" and analogy 2 "tackle like an angry bear hugging a pillow"). The 'cheek to cheek' fundamental was quickly changed to 'dip' by the analyser who indicated that 'cheek to cheek' would not be realistic or possible to look for when participants are tackling a tackle bag, rather than a human. With this knowledge, the 'dip' and 'strong wrap' fundamentals exhibited significance differences; however, post-hoc tests did not reveal significant findings between conditions. The analysis, furthermore, revealed that certain fundamentals were impractical to assess due to participants tackling a bag instead of a person.

The findings from this pilot study lay the groundwork for further investigations into the effectiveness of analogy-based learning in the context of safe tackling in rugby. This research offers valuable insights for coaches and educators looking to optimise skill development and

performance in young rugby athletes. While conclusive data on the efficacy of analogy-based learning for safe tackling remains elusive, it's important to note that a larger participant pool and an analogy encompassing all fundamentals might provide intriguing findings.

3.2 Introduction

When aiming to enhance an individual's motor skills, it's crucial for a coach to deliver clear and replicable instructions. Analogy-based learning might be an effective way to achieve this by offering learners guidance that simplifies many of the technical aspects by using a single metaphor of the desired movement (e.g.,Poolton et al., 2006). For instance, in basketball, a player might be instructed to "put their hand in the cookie jar" when shooting, or a golfer could be told to "swing the club like a pendulum" when putting (Poolton et al., 2006). Studies on analogical learning have demonstrated that this approach enables consistent motor performance, even when the learner is concurrently engaged in a cognitively demanding task, such as counting backward in multiples of three. Typically, such a task would disrupt motor performance, especially for those who have already acquired a substantial amount of explicit knowledge about the skill. Analogies, however, require less information processing, minimising the room for error (Poolton et al., 2006).

In sports coaching, analogies are frequently employed to aid learners in comprehending the skill they're trying to master, such as mimicking gestures like a goose head movement in basketball shooting or imitating a frisbee throw for a table tennis backhand drive (Liao & Masters, 2001). The purpose of these analogies is to encapsulate the intricate rules of the skill being learned into a straightforward biomechanical metaphor that the learner can easily replicate. Under pressure, reduced performance can occur as explicit knowledge disrupts the usual flow of movement, leading to increased reliance on it to control the skill. Masters (1992) argued that motor skills acquired through implicit learning demonstrate increased resilience in high-pressure situations. This resilience stems from learners' limited possession of explicit knowledge regarding the skill, which subsequently reduces their ability to consciously disrupt or interfere with the execution of the movement. Consequently, this limited interference contributes to maintaining greater stability when facing pressure-induced scenarios. If learners who use analogies display resilience in stressful situations, it would further strengthen the argument that analogy-based learning can enhance the performer's motor skills by instilling implicit traits to them (Liao & Masters, 2001).

The purpose of this study is to see whether two analogies derived from focus groups with various groups of people, would be beneficial in reducing concussion risks in rugby playing children by enhancing safe tackling. The analogies were trialled among rugby playing children by comparing control groups to analogy instructed groups, to see whether safe tackling

fundamentals were prominent. We hypothesised that the acquired analogies will promote more or at least similar fundamentals of safe tackling, compared to the control condition.

3.3 Methods

This study received ethical approval from the University of Waikato Human Research Ethics Committee before proceeding. It was ensured that all participants, and caregivers, read relevant information sheets, detailing the outline of the study, and signed consent forms prior to beginning the pilot study.

3.4 Participants

A junior rugby team coach was approached regarding whether their training session could be utilised for data collection for research on safe rugby tackling for children. The training was attended by nine participants (n = 9), all of whom were 11-year-old males. The team participates in the local Grade 11 rugby competition, and this training session was the final one for the season.

3.5 Procedure

We used a within-subjects cross-over design. Participants were directed by the coach to carry out their regular warm-up routine. After the warm-up, the researchers introduced themselves and provided a brief overview of their upcoming activities without revealing the exact purpose. Each participant was assigned a unique number ranging from one to nine.

Phase 1 – Standard tackle, no instructions.

All participants were instructed to complete a standard tackle of a tackle bag, for two separate trials each. They completed this in assigned order from participant one to nine in the first trial, and in reverse order, nine to one, in the second trial. While each participant was performing their tackle, the other eight participants were instructed to face the opposite way, reducing the risk of imitating behaviour. Each tackle was filmed on either a cell phone, or a video camera, capturing both frontal and side views. After completing Phase 1, the group was divided into two subgroups. The first group included participants numbered one to five (Group 1 = 1 - 5), while the second group comprised the remaining participants with numbers six to nine (Group 2 = 6 – 9).

Phase 2 – Analogies

To begin, Group 1 were assigned analogy 1, while Group 2 received analogy 2 (see Table 3.1). The groups were physically separated to minimise the possibility of them overhearing or observing each other's actions. Group 1 was instructed to "tackle like a raging bull" (referred to as analogy 1), whereas Group 2 was directed to "tackle like an angry bear hugging a pillow" (referred to as analogy 2). Each participant was tasked with completing two trials. The initial set of trials were performed in assigned order from participant number one through five in Group 1, and participants number six through nine in Group 2. The order was reversed for the second set of trials. During periods when participants were not actively engaged in the task, they were instructed to face away from others to discourage imitation behaviour. For recording purposes, both groups were equipped with frontal and side view cameras to capture each participant's tackle performances. Upon completing both sets of trials, Group 1 and 2 swapped over (i.e., Group 1 performed analogy 2, and Group 2 switched to analogy 1) and were required to complete two trials using the new analogy, with the same instructions. The session concluded after all participants had completed their required trials.

Table 3.1 *Analogies and control condition instructions.*

Condition	Instructions
Control	No instructions
Analogy 1	"Tackle like a raging bull"
Analogy 2	"Tackle like an angry bear hugging a pillow"

3.6 Analysis

An experienced rugby coach analysed the 90 rugby tackling videos that were collected. The coach provided a 'yes' or 'no' for each of the following movement fundamentals developed in the focus groups in Chapter 2, in order to perform a good and safe tackle, participants must: maintain the same foot and shoulder alignment, focus the eyes upward, position the head to the side, maintain cheek to cheek contact, and execute a strong wrapping technique. The best scores for each movement fundamental out of the two trials per condition were taken for further analysis.

The Cochran's Q test was conducted to assess the consistency of results across different movement fundamentals using a dataset categorised into two groups. This statistical analysis

aimed to discover whether there were consistent patterns or significant differences among the various aspects of movement within the dataset. This test is a valuable way to identify any notable differences among multiple groups (Aslam, 2023). Subsequently, if significant results were obtained from the initial test, a follow-up analysis using the McNemar test was carried out. The McNemar test is specifically designed to compare proportions between two categorical variables (Lachenbruch, 2014). All statistical analysis were performed with SPSS (version 29).

3.7 Results

The Cochran's Q test results (see Table 3.2) for the 'same foot same shoulder' fundamental found no significant difference between the three different conditions (control, analogy 1, and analogy 2) ($\chi^2(2) = 1.333$, $p = .513$), which was the same for 'eyes focused upward' ($\chi^2(2) = 4.000$, $p = .135$) and 'Head to the side' ($\chi^2(2) = 4.000$, $p = .135$). The fundamental 'dip' (horizontal back), however, did show a significant difference between conditions ($\chi^2(2) = 9.333$, $p = .009$) (see Figure 3.1). Results for the follow up McNemar's test showed no significant difference between conditions after Bonferroni corrections were made. The 'strong wrap' fundamental also revealed a significant difference ($\chi^2(2) = 6.500$, $p = .039$) between conditions (see Figure 3.2). However, the follow-up McNemar's test found no significant difference among any of the conditions.

Table 3.2 *Cochran's Q statistical analysis results looking for statistical significance.*

	Analogy 1		Analogy 2		Control		
Fundamental	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	*p*-value
Same foot same shoulder	0.56	0.53	0.56	0.53	0.78	0.44	.513
Eyes focused upward	0.78	0.44	1	0	1	0	.135
Head to the side	0.78	0.44	1	0	1	0	.135
Dip (Horizontal back)	0.78	0.44	0.33	0.50	1	0	.009
Strong wrap	0.56	0.53	1	0	0.89	0.33	.039

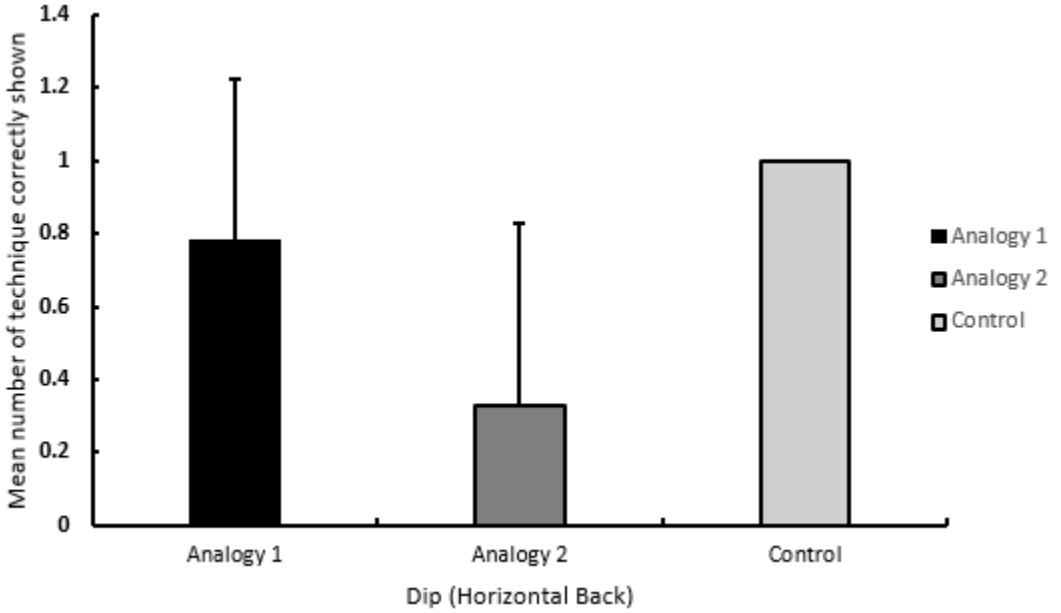

Figure 3.1 *Correct technique means for analogy 1, analogy 2, and the control condition for the 'dip' fundamental.*

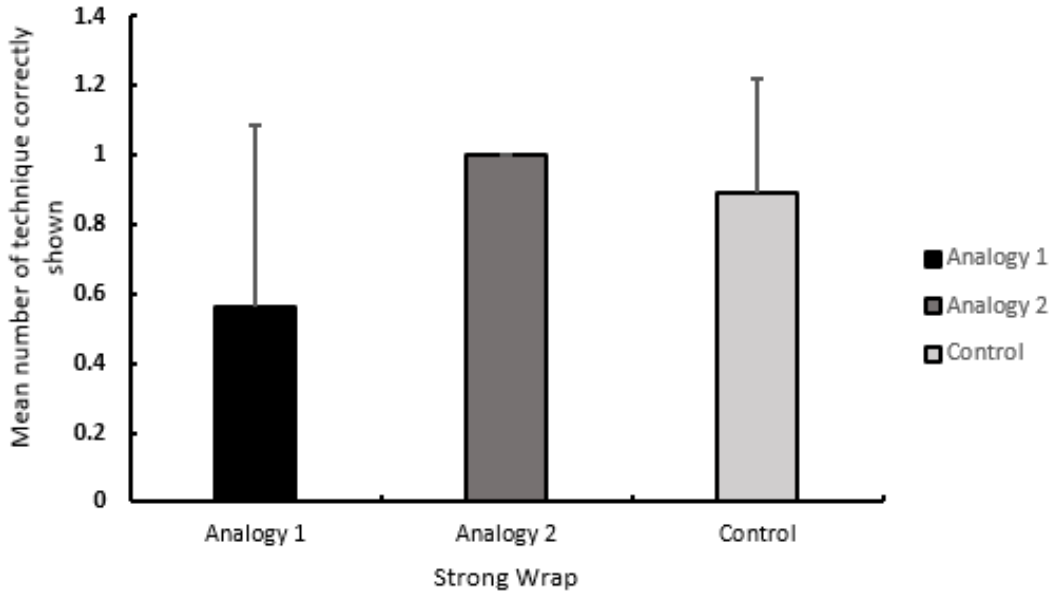

Figure 3.2 *Correct technique means for analogy 1, analogy 2, and the control condition for the 'Strong wrap' fundamental.*

Table 3.3 *Means and standard deviations of the rugby tackling fundamentals for analogy 1, analogy 2, and the control condition.*

	Analogy 1		Analogy 2		Control	
Fundamental	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Same foot same shoulder	3.5	0.5	3.5	0.5	4.0	1.0
Eyes focused upward	6.0	1.0	9.0	0.0	8.5	0.5
Head to the side	7.0	0.0	8.0	0.0	8.5	0.5
Dip (Horizontal back)	6.0	1.0	3.0	0.0	8.0	1.0
Strong wrap	4.5	0.5	9.0	0.0	7.0	0.0

3.8 Discussion

The prediction for this study was that the analogies would provide similar to better performance in children performing a rugby tackle on a tackle bag compared to control conditions (i.e., no instructions).

Summarising the results, analogy 1 received poor ratings in ‘same foot same shoulder’ (3.5) and ‘strong wrap’ (4.5) (see Table 3.3). Observations on the ‘strong wrap’ fundamental highlighted that some participants took the analogy too literally. For instance, envisioning an angry bull prompted certain individuals to charge at the bag headfirst, resulting in lowered eyes and no proper wrapping technique. Such a tackle was deemed unsafe and posed a high risk of injury. The fundamentals that received higher scores in analogy 1 were ‘eyes focused upward’, ‘head to the side’, and ‘dip’ (see Table 3.3). This might be attributed to participants visualising a bull moving on all fours, encouraging them to keep their back horizontal, maintain upward eye focus as if targeting something, and instinctively turn their heads to the side.

Analogy 2 scored well in the fundamentals of ‘eyes focused upward’, ‘head to the side’, and ‘strong wrap’. This success might be attributed to the analogy's emphasis on hugging. Participants appeared to tackle the bag in a more upright manner, resembling a hugging motion. However, analogy 2 scored low in ‘dip’ which is likely due to the upright motion of a hug, children may also envision a bear as being on its hind legs. The findings for analogy 2 demonstrate a contrast to those observed in analogy 1.

The fundamentals of tackling to a rugby tackle bag may need to be changed in future studies, for example, ‘cheek to cheek’ was impractical since participants were tackling a bag rather than a person, making it impossible to gauge cheek-to-cheek contact. This fundamental

was revised to focus on a ‘dip’ instead, seeking a horizontal back position which is a similar outcome around tackle height. Similarly, for the ‘same foot same shoulder’ fundamental which opposes a different challenge with a static bag compared to tackling a person. When tackling a tackle bag, the challenge lies in players hitting it harder, resulting in a different impact than in a typical rugby game where adjustments in body positioning are needed based on the opponent's ball carrier. In order to gain an effective understanding of what the analogies are able to do, further studies will need to be done, highlighting the importance of more game-like tackling scenarios. Alternatively, changes to the scoring/ analysis of the data may be beneficial to determine whether the analogies provided more of an implicit performance compared to the control condition.

Another factor that was acknowledged as having potential to influence results was whether performing analogy 1 before analogy 2 (or the other way around) had any impact on the outcome of results. Due to the small sample size we decided to not do any further analysis on this. However, future studies should take this into consideration by, for example, conducting a between-subject design with a larger sample size.

The findings indicate that the analogies effectively conveyed the principles of safe tackling, enabling participants to demonstrate comparable performance to the control condition across most of the described fundamentals. This implies that the analogies sufficiently encapsulated the areas of safe tackling techniques. Moreover, the results highlight the potential effects of using analogies as a teaching tool, showcasing their potential to teach crucial skills and knowledge for safe and effective tackling in rugby.

CHAPTER FOUR

SUMMARY AND CONCLUSION

4.1 Key findings

The focus groups outlined the key fundamentals for safe tackling, these being ‘same foot same shoulder’, ‘eyes focused upward’, ‘head to the side’, ‘cheek to cheek’ which was later described as ‘dip’ (horizontal back), and ‘strong wrap’. These fundamentals were used for the remainder of the study to identify and represent safe tackling in rugby.

The focus groups highlighted animals as a significant recurring theme crucial for analogy development in promoting safe tackling techniques. The discussions emphasised the value of incorporating animal behaviours into the analogies. The two analogies “tackle like a raging bull”, and “tackle like an angry bear hugging a pillow” seemed to integrate most of the fundamentals described above, indicating they should be as effective, or more effective than explicit learning.

The pilot study found that the control condition (i.e., no instructions) achieved the highest score across most aspects of the tackling fundamentals, although not significantly different from analogy 1, or 2. Analogy 2: “tackle like an angry bear hugging a pillow” closely aligned with the control condition in most aspects. The 'dip' aspect for analogy 2 scored almost significantly lower than the control, and 'same foot same shoulder' scored lower. The bear analogy also showed superior performance in the wrapping technique. The 'same foot same shoulder' fundamental received relatively low scores across all conditions as this fundamental was identified by the analyser as challenging when using a tackle bag. The angle/body positioning and impact of the tackle is different compared to tackling a human because people tend to hit a tackle bag harder.

4.2 General Discussion

Techniques that are learned independently of working memory suggests that these skills become automatic, requiring less conscious effort during performance. For teaching safe tackling, incorporating such learning methods could help players develop reliable skills less affected by distractions. Implicit learning, like analogy learning, offers advantages over explicit instructions by sustaining performance in challenging situations and reducing cognitive load. This approach can lead to faster information processing and improved learning outcomes, as supported by research (Maxwell et al., 2003).

However, learning through analogies can pose challenges, as the analogy must connect with the intended audience effectively. Factors such as age, gender, interests, and cultural background should all be considered. When developing the specific analogies for this study, age played a vital role, given that the target audience was 11-year-old children. Those who teach the analogy must tailor it to resonate with the individuals to that the important movement aspects can be conveyed meaningfully. Clear context and visual analogies enhance recall and understanding. Animals could be deemed invaluable when developing analogies for children because they are universally relatable. Children from diverse backgrounds and cultures often have some sort of exposure to animals, whether that is through pets, wildlife, or educational resources such as books and television. Children acquire the ability to observe and interact with the world that surrounds them, and it is through these experiences that they acquire knowledge and understanding. Their natural curiosity drives them to explore, question, and engage with their environment, fostering a dynamic learning process (Tunnicliffe et al., 2008). Therefore, analogies that involve animals should allow children to utilise their observations of animals to apply the analogy accurately.

A contrast between certain safe tackling fundamentals were found between the two analogies used in the pilot study “tackle like a raging bull”, and “tackle like an angry bear hugging a pillow”. These results create an opportunity to develop an analogy that can narrow down even more on encapsulating all fundamentals, in the hope of receiving high scores for all aspects. If an analogy can be developed that includes all of the safe tackling fundamentals, this will allow the children to understand the movements, help to modify performance and technique, reduce injury risks, and therefore enhance outcomes (Gabbett & Masters, 2011).

4.3 Limitations and Future Research

Various limitations must be acknowledged within the experiments detailed in Chapter Two and Chapter Three. Firstly, in Chapter Two we conducted several focus groups to gather insights on safe tackling fundamentals to develop relevant analogies. However, the turnout for these sessions was not as robust as desired, leading to limited data collection. In seeking a more comprehensive understanding and a wider range of perspectives more focus groups may be needed. A more substantial participation rate would have enhanced the discussions, provided diverse viewpoints, and facilitated a deeper exploration of the topics.

The pilot study (i.e., Chapter Three) presented a few limitations. The potential of influence of one analogy being performed prior to the other could have had an impact on performance and results. Future researchers should aim to conduct larger-scale studies, in

which longitudinal learning interventions are used to ensure more reliable and valuable data can be collected. Additionally, the movement fundamental criteria used in this pilot study might not have all been appropriate for tackling against a tackle bag. Therefore, future studies should consider changing these fundamentals to tackling a tackle bag or by aiming to replicate tackling conditions that closely resemble real-game scenarios.

Concerning the data analysis for the pilot study, the reliance on a single rater restricted the assessment to a single person's opinion. Involving multiple raters would have allowed for the exploration of diverse perspectives providing more reliable performance scores. Furthermore, objective measures such as quantitative metrics or standardised assessment tools could have been employed to enhance the assessment process, offering a more comprehensive and unbiased evaluation of the participants' performance.

Consideration of cognitive load becomes crucial in assessing participants' actions and outcomes. The likelihood exists that during analogy 2 (i.e., "tackle like an angry bear hugging a pillow"), participants might have performed the tasks more implicitly compared to the control condition. This potential implicit performance might be further recognised in situations involving dual-tasking or when individuals experience heightened pressure. Cognitive load introduces a layer of complexity in understanding how individuals process information and execute tasks, particularly in the context of learning and performing new skills like tackling in rugby. Exploring these could provide deeper insights into the impact of cognitive load on learning and skill execution within the analogical framework, therefore, this is something to consider for future research. This current study emphasises the importance of delivering clear and replicable instructions to enhance motor skills, suggesting that analogy-based learning, using a single metaphor to simplify technical aspects, can be effective in this regard.

4.4 Conclusion

The results of this thesis suggest support for the concept that analogy-based learning could be advantageous in instructing safe tackling techniques to children. However, certain factors such as the size of the participant pool, reliability in analysis, and the impracticality of specific fundamentals when tackling a bag pose significant implications. Furthermore, future studies should include measures of whether the analogy leads to more implicit performance, and consequently whether this enhances safer tackling by promoting better performance under pressure and/or dual task load. Addressing these concerns in future research holds the potential

for obtaining valuable data, thereby enhancing the viability of adopting this strategy when teaching young children to tackle in rugby.

REFERENCES

Alvargonzález, D. (2020). Proposal of a classification of analogies. *Informal Logic*, *40*(1), 109-137.

Aslam, M. (2023). Cochran's Q test for analyzing categorical data under uncertainty. *Journal of Big Data*, *10*(1), 147.

Blennow, K., Brody, D. L., Kochanek, P. M., Levin, H., McKee, A., Ribbers, G. M., Yaffe, K., & Zetterberg, H. (2016). Traumatic brain injuries. *Nature Reviews Disease Primers*, *2*(1), 1-19.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Carey, L., Terry, D. P., McIntosh, A. S., Stanwell, P., Iverson, G. L., & Gardner, A. J. (2021). Video analysis and verification of direct head impacts recorded by wearable sensors in junior rugby League players. *Sports Medicine-Open*, *7*(1), 1-13.

Cobb, S., & Battin, B. (2004). Second-impact syndrome. *The Journal of School Nursing*, *20*(5), 262-267.

Edwards, J. C., & Bodle, J. D. (2014). Causes and consequences of sports concussion. *Journal of Law, Medicine & Ethics*, *42*(2), 128-132.

Edwards, S., Gardner, A. J., Tahu, T., Fuller, G., Strangman, G., Levi, C. R., Iverson, G. L., & Tucker, R. (2022). Tacklers' head inertial accelerations can be decreased by altering the way they engage in contact with ball carriers' torsos. *Medicine & Science in Sports & Exercise*, *54*(9), 1560-1571.

Fuller, G., Tucker, R., Starling, L., Falvey, E., Douglas, M., & Raftery, M. (2020). The performance of the world rugby head injury assessment screening tool: a diagnostic accuracy study. *Sports Medicine-Open*, *6*, 1-12.

Gabbett, T., & Masters, R. (2011). Challenges and solutions when applying implicit motor learning theory in a high performance sport environment: Examples from rugby league. *International Journal of Sports Science & Coaching*, *6*(4), 567-575.

Gabbett, T., Wake, M., & Abernethy, B. (2011). Use of dual-task methodology for skill assessment and development: Examples from rugby league. *Journal of Sports Sciences*, *29*(1), 7-18.

Gardner, R. C., & Yaffe, K. (2015). Epidemiology of mild traumatic brain injury and neurodegenerative disease. *Molecular and Cellular Neuroscience*, *66*, 75-80.

Hislop, M., Stokes, K., Williams, S., McKay, C., England, M., Kemp, S., & Trewartha, G. (2016). The efficacy of a movement control exercise programme to reduce injuries in youth rugby: a cluster randomised controlled trial. *BMJ Open Sport & Exercise Medicine*, *2*(1), e000043.

Hoskens, M. C. J. (2020). *Disrupting working memory to reduce verbal-analytical engagement in motor performance: Squeezing in a tiresome new approach to implicit motor learning!* The University of Waikato.

Hume, P., Carlson, I., & Hardaker, N. (2013). ACC National concussion guidelines. *7PM t/P t*, *40*, 79-80.

Kee, Y. H. (2019). Reflections on athletes' mindfulness skills development: Fitts and Posner's (1967) three stages of learning. *Journal of Sport Psychology in Action*, *10*(4), 214-219.

Kim, S.-M., Qu, F., & Lam, W.-K. (2021). Analogy and explicit motor learning in dynamic balance: Posturography and performance analyses. *European Journal of Sport Science*, *21*(8), 1129-1139.

King, D., Gissane, C., Brughelli, M., Hume, P. A., & Harawira, J. (2014). Sport-related concussions in New Zealand: a review of 10 years of Accident Compensation Corporation moderate to severe claims and costs. *Journal of Science and Medicine in Sport*, *17*(3), 250-255.

Lachenbruch, P. A. (2014). McNemar test. *Wiley StatsRef: Statistics Reference Online*.

Leddy, J. J., Sandhu, H., Sodhi, V., Baker, J. G., & Willer, B. (2012). Rehabilitation of concussion and post-concussion syndrome. *Sports Health*, *4*(2), 147-154.

Liao, C.-M., & Masters, R. S. (2001). Analogy learning: A means to implicit motor learning. *Journal of Sports Sciences*, *19*(5), 307-319.

Masters, R. S. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology*, *83*(3), 343-358.

Masters, R. S. (2000). Theoretical aspects of implicit learning in sport. *International Journal of Sport Psychology*.

Masters, R. S. (2012). Advances in implicit motor learning. *Skill Acquisition in Sport* (pp. 85-102). Routledge.

Masters, R. S., & Poolton, J. M. (2012). Advances in implicit motor learning. *Skill Acquisition in Sport: Research, Theory and Practice*, *59*.

Maxwell, J., Masters, R., & Eves, F. (2003). The role of working memory in motor learning and performance. *Consciousness and Cognition*, *12*(3), 376-402.

Maxwell, J., Masters, R., Kerr, E., & Weedon, E. (2001). The implicit benefit of learning without errors. *The Quarterly Journal of Experimental Psychology: Section A*, *54*(4), 1049-1068.

Maxwell, J. P., Masters, R. S., & Eves, F. F. (2000). From novice to no know-how: A longitudinal study of implicit motor learning. *Journal of Sports Sciences*, *18*(2), 111-120.

Oladi, S., Uiga, L., Hebert-Losier, K., & Masters, R. S. (2022). Testing the efficacy of a motor analogy designed to promote safe landing by older adults who fall accidentally: a study protocol for a randomised control study. *BMJ Open*, *12*(8), e060144.

Poolton, J. M., Masters, R. S., & Maxwell, J. (2006). The influence of analogy learning on decision-making in table tennis: Evidence from behavioural data. *Psychology of Sport and Exercise*, *7*(6), 677-688.

Reha, T., McNabb, C., Netto, K., Davey, P., & Lavender, A. P. (2021). Head accelerations during a 1-on-1 rugby tackling drill performed by experienced rugby union players. *Brain Sciences*, *11*(11), 1497.

Robbins, C. A., Daneshvar, D. H., Picano, J. D., Gavett, B. E., Baugh, C. M., Riley, D. O., Nowinski, C. J., McKee, A. C., Cantu, R. C., & Stern, R. A. (2014). Self-reported concussion history: impact of providing a definition of concussion. *Open Access Journal of Sports Medicine*, 99-103.

Salehi, S. K., Tahmasbi, F., & Talebrokni, F. (2021). A different look at featured motor learning models: comparison exam of Gallahue's, Fitts and Posner's and Ann Gentile's motor learning models. *Movement and Sports Sciences - Science et Motricite*, *112*, 53.

Salmon, D. M., Badenhorst, M., Walters, S., Clacy, A., Chua, J., Register-Mihalik, J., Romanchuk, J., Kerr, Z. Y., Keung, S., & Sullivan, S. J. (2022). The rugby tug-of-war: Exploring concussion-related behavioural intentions and behaviours in youth community rugby union in New Zealand. *International Journal of Sports Science & Coaching*, *17*(4), 804-816.

Serpell, B. G., Ford, M., & Young, W. B. (2010). The development of a new test of agility for rugby league. *The Journal of Strength & Conditioning Research*, *24*(12), 3270-3277.

Stanley, J., & Krakauer, J. W. (2013). Motor skill depends on knowledge of facts. *Frontiers in Human Neuroscience*, *7*, 503.

Suzuki, K., Nagai, S., Ogaki, R., Iwai, K., Furukawa, T., Miyakawa, S., & Takemura, M. (2019). Video analysis of tackling situations leading to concussion in collegiate rugby union. *The Journal of Physical Fitness and Sports Medicine*, *8*(2), 79-88.

Theadom, A., Mahon, S., Hume, P., Starkey, N., Barker-Collo, S., Jones, K., Majdan, M., & Feigin, V. L. (2020). Incidence of sports-related traumatic brain injury of all severities: a systematic review. *Neuroepidemiology*, *54*(2), 192-199.

Tierney, G. J., Richter, C., Denvir, K., & Simms, C. K. (2018). Could lowering the tackle height in rugby union reduce ball carrier inertial head kinematics? *Journal of Biomechanics*, *72*, 29-36.

Tierney, G. J., & Simms, C. K. (2018). Can tackle height influence head injury assessment risk in elite rugby union? *Journal of Science and Medicine in Sport*, *21*(12), 1210-1214.

Tunnicliffe, S. D., Gatt, S., Agius, C., & Pizzuto, S. A. (2008). Animals in the lives of young Maltese children. *Eurasia Journal of Mathematics, Science and Technology Education*, *4*(3), 215-221.

Van Abswoude, F., Van Der Kamp, J., & Steenbergen, B. (2019). The roles of declarative knowledge and working memory in explicit motor learning and practice among children with low motor abilities. *Motor Control*, *23*(1), 34-51.

Van Campenhout, G., & Van Hoven, B. (2014). 'It is where blokes can be blokes': making places in a New Zealand rugby club. *Gender, Place & Culture*, *21*(9), 1090-1107.

Van Duijn, T. (2018). *The Influence of Analogy Instructions on Motor Skills: Processing, Preference and Performance.* The University of Waikato.

van Rooyen, M., Yasin, N., & Viljoen, W. (2014). Characteristics of an 'effective'tackle outcome in Six Nations rugby. *European Journal of Sport Science*, *14*(2), 123-129.

VanItallie, T. B. (2019). Traumatic brain injury (TBI) in collision sports: Possible mechanisms of transformation into chronic traumatic encephalopathy (CTE). *Metabolism*, *100*, 153943.

Vinter, A., Pacton, S., Witt, A., & Perruchet, P. (2010). Implicit learning, development, and education. *Rethinking Physical and Rehabilitation Medicine* (pp. 111-127). Springer.

Wetjen, N. M., Pichelmann, M. A., & Atkinson, J. L. (2010). Second impact syndrome: concussion and second injury brain complications. *Journal of the American College of Surgeons*, *211*(4), 553-557.

APPENDICES

Appendix 1 – Ethics Approval

The University of Waikato
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Hamilton, New Zealand

Human Research Ethics Committee
Roger Moltzen
Telephone: +64021658119
Email:humanethics@waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

16 December 2022

Kayla Povey
Te Huataki Waiora – School of Health
DHECS
By email: kp144@students.waikato.ac.nz

Dear Kayla

HREC(Health)2022#54 : The effectiveness of analogies to reduce concussion risks in rugby tackling in children

Thank you for your responses to the Committee feedback.

We are now pleased to provide formal approval for your project.

Please contact the Committee by email (humanethics@waikato.ac.nz) if you wish to make changes to your project as it unfolds, quoting your application number with your future correspondence. Any minor changes or additions to the approved research activities can be handled outside the monthly application cycle.

We wish you all the best with your research.

Regards,

Emeritus Professor Roger Moltzen MNZM
Chairperson
University of Waikato Human Research Ethics Committee

Participant Information Sheet – Pilot Study

Project Title

The effectiveness of analogies when teaching young children to tackle in rugby.

Purpose

You are invited to participate in an experiment by Ms Kayla Povey, Dr Merel Hoskens and Prof Rich Masters in the Te Huataki Waiora Faculty of Health, Sport and Human Performance. The aim of this research study is to use analogy learning to teach rugby tackling to children to minimize the risk of concussions by decreasing the mental load.

What will you have to do and how long will it take?

You have been asked to attend one experimental session that will take approximately 30 minutes to complete. You will 1) complete a warm up, 2) Be given instructions about the task you will be completing and have any questions answered, 3) complete the task.

Potential risks/discomforts and their minimization

The potential risks in this study are no greater than the risks involved in a regular rugby training session. Please also note that a video recording software will be used to analyse their performance.

What will happen to the information collected?

Your personal information, including the data we will obtain from you, is strictly confidential. Only the named researchers will have access to all of the data. The information collected will be used by the researchers for a master's thesis. This data will be identified using number identification, which means that no names will not be associated with the recorded data. No participants will be named in the publications/reports and every effort will be made to disguise their identity. All data will be retained in a secured password protected computer for five years. Afterwards, notes and documents will be destroyed, and recordings erased.

Participation and withdrawal

You will have the opportunity to withdraw and stop participating at any time during the study, simply by informing any of the researchers. You can withdraw your results from our study up to 2 weeks following your participation. You can contact the researchers using the email address on this form.

Declaration to participants

If you take part in the study, you have the right to:

- Refuse to answer any particular question, and to withdraw your data from the study up until 2 weeks following participation.
- Ask any further questions about the study that occurs to you during your participation, at any time.
- Be given access to a summary of findings from the study upon request.

Who's responsible?

If you have any questions or concerns about the project, either now or in the future, please feel free to contact either:

Ms Kayla Povey
Email: kaylap123@hotmail.com
Phone: +64 27 876 9022

Prof Rich Masters
Email: rich.masters@waikato.ac.nz
Phone: +64 27 838 6206

Dr Merel Hoskens
Email: merel.hoskens@waikato.ac.nz
Phone: +64 27 826 0535

Participant Information Sheet – Pilot Study

Rugby Tackling Study!

What is a study?

A research study is something you do when you want to learn about something or find out something new. Which is what you are going to help us with today!

What am I here for?

We heard you play rugby! That is awesome news to us! Because we want to see how you tackle in rugby. Don't worry, we only need you to be here for about 30 minutes.

What do I need to do?

When you arrive, we will get you to fill out a short form, with questions like "what is your name?" this won't take long.

Here are the **3 main steps** that we need you to do:

1. We first need you to do a warmup! Warm-ups are important so that you don't get any injuries and so that you can do the best tackle you can do!

2. Now that you are ready to do some rugby tackling, we need you to pay close attention to the instructions we give you! This is when you can ask us questions if you are a little bit confused.

3. Now that you know what to do, it's time to tackle! We will be using video software and special mouthguards to collect some information from you.

Do I have to?

If this makes you feel a little funny inside, feelings like scared, uncomfortable, or nervous and you don't want to do it anymore, just let us know.
We know you love to play rugby though, so think of it as a rugby game with your friends, and remember that if you do get hurt during the study, we are right here to help you!

You have 2 weeks from today to tell us you no longer want to be part of this study.

Contact Details

If at any time you need to contact us throughout this study, please use the information below.

Miss Kayla Povey
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Appendix 4 – Consent Form

Consent Form for Participants

The effectiveness of analogies when teaching young children to tackle in rugby.

Consent Form for Participants & Caregivers

Please read on behalf of your child/ family member.

I have read the Participant Information Sheet for this study and have had the details of the study explained to me. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I also understand that I am free to withdraw from the study at any time, or to decline to answer any particular questions in the study. I understand I can withdraw any information I have provided up to 2 weeks following my participation. I understand that upon my request I will be given access to a summary of findings from the study when it is concluded. I agree to provide information to the researchers under the conditions of confidentiality set out on the Participant Information Sheet.

I agree for my child/ family member to participate in this study under the conditions set out in the Participant Information Sheet.

Signed by caregiver: _____

Name of caregiver: _____

Date: _____

I agree to participate in this study under the conditions set out in the Participant Information Sheet.

Signed by participant _____

Name of participant _____

Additional Consent as Required

I agree / do not agree to my performance to be video recorded.

Signed: _____

Name: _____

Date: _____

☐ I would like to receive a summary of the results of the study to the following e-mail address:

Ms Kayla Povey
Email: kaylap123@hotmail.com
Phone: +64 27 876 9022

Prof Rich Masters
Email: rich.masters@waikato.ac.nz
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Appendix 5 – Question sheet for Focus Groups

Focus Group: Questions for coaches

1. What are the main concerns around tackling with young children at this present moment?
   e.g., parents not wanting their kids to play, kids being taught how to tackle incorrectly – more of a "just stop the player" rather than safe technique etc.

2. What is the standard/ common way of teaching children to tackle? Is it generally the same fundamentals?

3. What is the main goal when teaching children to tackle?
   e.g., Safety or stopping the ball carrier no matter what?

4. Is stopping the ball carrier the goal for children because it is assumed there is less hard for children because they are slower and weaker? Therefore, less force?

5. At what age do these concerns really start becoming a problem?

   e.g., is it not a problem until they start to get faster at running, is it a problem as soon as they begin tackling in rugby, is it not until they are teenagers playing proper rugby etc.

6. **Discussion:** We have the understanding that rotational forces in the brain are a ,ain cause of concussions, so any prevention of this happening will help to reduce concussion.

   Therefore, should we be looking for an analogy that will help prevent these rotational forces.

   Benefits of analogy learning: Stable performance under dual-task and stable performance under pressure. Information is packaged into one-unit, lower load on information processing resources (less mental load).
   Learning by analogy means learning by transferring knowledge from a known situation to a new one "the heart works like a pump" or more specifically in motor learning – for a golf putt "use your arms the same way a pendulum of a grandfather clock operates".

7. **Discussion:** tackling in a game can change every time e.g., side on, front on, high, low etc. these rotational forces and blunt impacts need to be reduced from all types of tackles. Is this even possible?

Analogy Example: An analogy for elderly people was developed “fall like a feather” to encourage older people to fall more softly – “fall like you are carrying a baby” still meant they were hitting the ground hard, but just on their back side instead, whereas “fall like a feather” or “fall like a snowflake” encourages softer landings, not just protecting the face. People can also fall in many different directions/ ways, so this analogy can be used for all types of falls.

Note: Potential for more questions to arise. This is just a guide.