SOUTH AFRICAN RUGBY COACHES' KNOWLEDGE OF THE PREVENTION, IDENTIFICATION AND MANAGEMENT OF CONCUSSION

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South African Rugby Coaches' Knowledge of the Prevention, Identification and Management of Concussion

We the undersigned, supervisors hereby certify that **Ms KJ Thomas (THMKAT005)** has completed the corrections to the above MPhil Sports Physiotherapy thesis to our satisfaction and as required by the Committee of Assessors.

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DECLARATION

I, Kathryn Joy Thomas, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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GLOSSARY OF TERMS

Concussion	Defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces[1].
Loss of Consciousness	A dramatic alteration of mental state that involves complete or near-complete lack of responsiveness to people and other environmental stimuli[2].
Neuropsychological	Referring to the interaction between the nervous system and cognitive function, the influence of one function on the other[3].
Post-concussion Syndrome	The prolonged presence of a cluster of symptoms, following a concussive blow to the head, lasting for days or weeks[4, 5].
Rugby Union	A full contact team sport, played with 15 players on each side, on a grass pitch, with an oval ball. Points are scored with a try, penalty, drop kick, and conversion[6].
Second Impact Syndrome	A rare condition in which the brain swells rapidly and catastrophically after a person suffers a second concussion before symptoms from an earlier one have subsided[1].
Tackle	To dispose an opponent of the ball, to stop the player from gaining ground towards the goal or to stop them from carrying out what they intend. Any instance in which one person forces another to the ground[6].
Maul	A loss scrum that forms around a player that is holding the ball and is still on his feet[6].
Scrum	The act or method of restarting play after an infringement when the two opposing packs of forwards group together with heads down and arms interlocked and push to gain ground while the scrum half throws the ball in and the hookers attempt to scoop it out to their own team. A scrum is usually called by the referee (set scrum) but may be formed spontaneously (loose scrum)[6].

Acceleration-deceleration	A collision between a body part and another object or body part while both are in motion. A type of whiplash effect, related to abrupt movement and deformation of the brain in the cranial cavity

LIST OF ABBREVIATIONS

AAN	American Academy of Neurology
ACK	Adequate Concussion Knowledge
ADHD	Attention Deficit Hyperactivity Disorder
ANAM	Automated Neuropsychological Assessment Metrics
ATP	Adenosine Triphosphate
BESS	Balance Error Scoring System
CI	Confidence Interval
CK	Concussion Knowledge
CMEP	Concussion Management Education Programme
CNS	Central Nervous System
COP	Centre of Pressure
CT	Computed Tomographic
ERP	Evoked Response Potential
fMRI	Functional Magnetic Resonance Imaging
GCS	Glasgow Coma Scale
ICK	Inadequate Concussion Knowledge
IRB	International Rugby Board
LD	Learning Disability
LOC	Loss of Consciousness
MRI	Magnetic Resonance Imaging
PCS	Post-concussion Syndrome
PTA	Post Traumatic Amnesia
QEEG	Quantitative Electroencephalographic
RTP	Return to Play
RWC	Rugby World Cup
SAC	Standardised Assessment of Concussion
SARU	South African Rugby Union
SASMA	South African Sports Medicine Association
SCAT	Standardised Concussion Assessment Tool
SD	Standard Deviation
SMC	Safe Management of Concussion
SOT	Sensory Organisation Test

ABSTRACT

Background: The incidence of concussion injuries is high irrespective of player ability, from professional to semi-professional and schoolboy rugby players. Concussion injuries are considered difficult to diagnose, particularly in an on field environment, and are often under-reported or unrecognised. The rugby coach has an important role in the multidisciplinary team, particularly in the South African setting where medical professionals are often not present at practices and matches. Rugby coaches are therefore often required to identify and manage concussed players. Previous studies have identified that the risk of concussion may be reduced through coach education and subsequent implementation of skills training and the education of players. In addition, the coach has an important role providing a safe, structured and supervised concussion rehabilitation.

Aim: To determine South African rugby coaches' knowledge of the prevention, identification and management of concussion.

Specific objectives: (a) To determine whether rugby coaches have adequate knowledge of the prevention, identification and management of concussion. (b) To determine whether rugby coaches are able to manage players with concussion safely. (c) To determine factors that may predict rugby coaches' knowledge of the prevention, identification and management of concussion. Predictive factors investigated included coaching qualifications, number of years of coaching experience, level of coaching, and course attendance.

Methods: This study had a descriptive, correlational study design. A questionnaire was designed to assess coaches' concussion knowledge (CK) and was validated by a panel of experts. 852 questionnaires were distributed to coaches nationally.

Results: 229 voluntarily completed questionnaires were used for data analysis (27% response rate). Mean CK scores were 72.2% ± 5.4%, with Provincial rugby coaches scoring the highest (mean score 73.2% ± 4.4%) and Junior School coaches having significantly lower CK scores (mean 70.0% ± 4.3%). BokSmart certified coaches scored significantly higher (73.1% ± 5.1%) ($p = 0.00079$) than coaches without the certification (70.6% ± 5.6%), specifically on sections of 'teaching safe techniques' and 'identifying concussion'. There was a highly significant ($p = 0.00008$), however weak ($r = 0.25$), positive relationship between coaches with higher Continued Education Scores (CES) and their CK scores. Only 26.2% of coaches had sufficient CK scores to be classified as having Adequate Concussion Knowledge (ACK). High School coaches had the greatest percentage (34.1%) of coaches with ACK, followed by Club and Provincial coaches (24.3% respectively) and Junior School coaches (14.7%). Only 26.1% of coaches with a first aid qualification were classified as having ACK.

Of the BokSmart certified coaches, 27.4% had ACK; interestingly, and 25.3% of the non-BokSmart certified coaches were also classified as having ACK. Safety scores were poor (mean score 60.9% ± 12.9%) across all coaching levels, with Junior School coaches having the lowest scores (mean score 57.6% ±12.3). Only three coaches (1.3%) scored above the required 90%, to be classified as 'safe'. BokSmart certification had a significant effect on improving coaches' safety scores ($p = 0.002$), whereas first aid qualification status did not influence safety scores. Multiple regression analyses identified that coaching level and continued education, including BokSmart certification, appeared predictive of coaches CK and safety knowledge.

Conclusion: Although BokSmart certified coaches had significantly higher safety scores compared to non-certified coaches, all coaches lacked knowledge pertinent to ensuring player safety. It may be recommended that the BokSmart programme place further emphasis on the principles of safe management of concussion. Coaching level and continued education, including BokSmart certification, were predictive of both concussion and safety knowledge. An important implication from these findings is that youth coaches in particular may benefit from extensive education and training on concussion. Furthermore, the evidence presented in this study suggests that further investment in coach education and training is warranted.

CHAPTER ONE

INTRODUCTION AND SCOPE OF THE THESIS

Rugby union is a high impact, full contact sport, with one of the highest reported incidences of injury, regardless of the level of play[7-9]. Concussion is a common rugby injury[7, 10-12] due to the intensity[13], aggressiveness[14], speed[13] and physical contact[15, 16] of match play. The incidence of concussion injuries in rugby is high, ranging from 22% to 55%[8, 17-20].

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces[1, 21]. Concussion results in a graded set of clinical symptoms that may include loss of consciousness (LOC)[1, 21-23]. Resolution of the clinical and cognitive symptoms of concussion typically follows a sequential course. However, in a small percentage of cases post-concussive symptoms may be prolonged[4, 5, 24, 25], and may be associated with serious complications, including death [9, 26-28].

Concussion injuries are considered difficult to diagnose, particularly in an on field environment, and are often under-reported or unrecognised [11, 13, 19, 29-32]. This may partly be due to inconsistent terms, definitions and guidelines, and may be further confounded by the lack of objective, quantifiable measures of the ensuing signs and symptoms[33]. Athletes have also admitted to not reporting suspected concussion due to a lack of understanding regarding the potential severity of a concussion injury[31, 34].

It is recognised that the coach has an important role in the multidisciplinary team [35, 36]. Medical professionals are often not present at practices and matches, thereby resulting in coaches being responsible for administering first-aid, and identifying and managing concussion injuries[35, 37]. The coach also has an essential role in providing safe, structured and supervised concussion rehabilitation, with progressive exposure to contact and competition[1, 4, 38-41]. Further, the risk of concussion may be reduced through effective coaching directed at injury prevention that may include skills training, tackling and falling techniques, and player education regarding the laws of rugby and fair play[42-44]. Previous studies have also identified the central role of coaches in facilitating player education regarding concussion[34, 45-47]. These studies highlight the importance of the coach in both the dissemination of knowledge, and in the prevention and management of concussion injuries.

Recently, much emphasis has been placed on educational programmes and training of South African rugby coaches with the primary aim of improving player safety[48]. However, there is a lack of evidence regarding rugby coaches' current levels of knowledge of concussion. In addition, although education programmes for coaches have had some success internationally[49-52], the efficacy of the South African education programme has not been established. Therefore the principle aim of this thesis was to determine South African rugby coaches' knowledge of the prevention, identification and management of concussion.

In preparation for the questionnaire-based study of the thesis, a comprehensive review of the literature on the diagnosis, management and prevention of concussion in rugby will be presented (Chapter 2). This will be followed by a description of the study designed to answer the above question (Chapter 3). The summary and conclusion section will complete this thesis (Chapter 4).

CHAPTER TWO

LITERATURE REVIEW: THE DIAGNOSIS, MANAGEMENT AND PREVENTION OF CONCUSSION IN RUGBY

INTRODUCTION

The high incidence of injury in rugby has been well-documented[7-9]. The incidence of concussion in rugby has been reported as being between 4% and 50%[8, 18-20, 53-58]. Resolution of clinical and cognitive symptoms typically follows a sequential course[1]. However, if an athlete is not appropriately managed post-concussive symptoms may be prolonged[4, 5, 24, 25] and more serious complications, including death may result[9, 26-28]. In South Africa medical personnel are often not present at matches and practices[35, 37]. The coach may therefore be responsible for the identification of concussion, and may be required to make immediate on field decisions regarding the management of a concussed player. The coach may also facilitate a reduction in the risk of concussion by implementing skills training and player education, as well as ensuring the rehabilitation of the concussed player through a safe stepwise return to play protocol[52]. Therefore, this literature review will establish the incidence of rugby injuries with a focus on concussion. The review will outline concussion identification, management and prevention in sport; specifically focusing on concussion in rugby, where literature permits. This review will also discuss the central role of the rugby coach in managing a concussed player and their potential to aid in the prevention of concussion injuries. Data was sourced from sports medicine and science literature utilising searches on PubMed, Web of Science and Medline. Keywords used in the search included "*concussion", "rugby", "rugby injuries", "head injury", "concussion in children", "prevention of concussion", "concussion physiology", "concussion investigations", "surveys on concussion", "surveys with coaches", "coaches knowledge*". Additional information was gathered directly from the International Rugby Board (IRB), and other national rugby unions.

2.1. INCIDENCE OF RUGBY INJURIES

Rugby union is played in more than 100 countries, over five continents, by an excess of three million people between the ages of 6 and 60 years[59]; ranking second in participation only to soccer[60]. The overall injury rates seen at the highest level of the sport, being the Rugby World Cup (RWC), ranged from 30 to 43 injuries per 1000 player match hours in 1995[10], to 98 injuries and 84 injuries per 1000 player match hours in 2003 and 2007 respectively[8, 61]. In addition, injury rates of between 28 to 120 injuries per 1000 player match hours have been reported in South African club rugby players[7] and southern hemisphere, including South Africa, professional provincial rugby players[8, 9]. In South African club rugby sides 85% of injuries occurred during matches[7]. Similarly a number of rugby union studies have reported increased injury rates with increasing levels of competition[11, 12]. Jakoet et al[10] illustrated this in the 1995 RWC where the preliminary matches incurred an average of 30 injuries per 1000 player match hours. However, an increased injury rate of 42 injuries per 1000 player match hours was documented in the final knockout matches of the RWC [10]. The more efficient injury reporting regimens at more competitive or professional levels of the sport may account for the higher reported incidence of injuries at higher standards of play[11]. In addition, factors such as increased body mass, body composition, level of fitness and strength, ball in play times, the commitment to win and the more competitive nature of the matches may also contribute to this increased incidence of injury[10, 11, 57, 62, 63]. Further studies have shown that the top team or 'A' side sustains the greatest number of injuries irrespective of the age of the competitors[30, 60].

The introduction of professionalism to rugby in 1995 also resulted in an increase in injury rates[64]. In elite Australian rugby, the injury rate prior to professionalism was 47 injuries per 1000 player hours. Following the introduction of professionalism, from 1996 to 2000, the injury rate increased to 74 injuries per 1000 player hours[60]. Other studies have indicated that the proportion of players injured and the injury rates doubled following the introduction of professionalism in rugby[9, 60, 63, 65]. Professional players have had to adapt to the demands of increased physical and mental robustness, as well as the strength and pace expected of full time athletes. Expectations of higher standards have filtered down to amateur levels[65]. The increase in injury rates associated with professionalism may also be due to the lack of an appropriate preseason break, overtraining or carrying existing injuries into the new season[65]. Monetary or other considerations could also explain why the median duration of absence from playing or training due to injury was lower for professional rugby players, than for amateur rugby players.

However, professional rugby players may have better access to treatment and rehabilitation, which may account for less time off due to injury [65]. The high rate of injury among professional rugby players challenges the assumption that superior fitness, skill, and experience may reduce the risk of injury[8, 66]. In contrast the larger size, greater speed, strength, superior competitiveness and commitment to winning by the professional rugby players may explain the higher injury rate[10].

It may therefore be expected that a reduction in injury rates should occur with decreasing age and competition level[64, 66]. Nevertheless schoolboy and junior rugby leagues have relatively high injury rates of between 27 to 57 injuries per 1000 player hours[19, 56]. The high incidence of injuries in younger players may be due in part to the lower number of hours spent in training relative to hours playing matches, and may include predisposing factors to injury, such as poor technique[67].

Further, 68% of rugby injuries occur in the second half of the match. Factors that may contribute to the late onset of injuries during competition include fatigue, nutrition, hydration, incomplete warm-up when substituting in the second half or reduced concentration after the half time break[9, 57, 60].

An additional factor that may contribute to the high injury rate in rugby is the tackle. The tackle accounts for 31% to 59% of all rugby injuries [7-9, 12, 56, 60, 61, 63, 66-68], with head-on tackles causing the highest incidence of tackling related injuries[11]. Tackles made in open play are less predictable than the actions of scrumming and mauling. The incidence of injury, specifically concussion, from being tackled was significantly higher for backs than forwards[64] and may be related to the higher kinetic energy generated by running backs in open play and the dissipation of this energy during the tackle[11]. A general lack of skill from the tackler has been highlighted as a risk factor for catastrophic cervical injuries and concussion[69-71] and as the primary reason for a much higher rate of tackling injuries sustained amongst schoolboy rugby players[7, 30, 72].

Summary of the Literature: Incidence of Rugby Injuries

Rugby injuries are therefore a common occurrence, and are sustained across all levels of rugby regardless of age. Although the intensity of match play increases the incidence of injuries, the risk of sustaining an injury during practice remains high due to the time spent training. The tackle and poor tackling technique may both contribute to the high incidence of rugby injuries. The physical demands of rugby place the player at risk of sustaining any number of documented musculoskeletal injuries[9, 11, 30, 60, 63, 65, 73, 74]. Concussion, often not as extensively documented or researched, is a common injury in rugby and has been referred to as the 'silent injury'[75, 76]. Concussion injuries in rugby will be discussed in the following section.

2.2. CONCUSSION IN RUGBY

Concussion is a common rugby injury, and players are more likely to sustain a concussion during a match than practice due to the intensity[13], aggressiveness[14], speed[13] and physical contact associated with competitive rugby[15, 16]. The incidence of concussion in professional rugby players has ranged from 4% to 23%[8, 17-19]. In the 1999 Super 12 rugby competition, the incidence of concussion was 20%, and was the most commonly reported injury for that competition[24]. Similarly the incidence of concussion among South African schoolboy rugby players ranges from 22% to 55%[20]. The incidence of concussion and the recovery time in high school athletes may be higher and longer than for relatively older club and provincial athletes[77, 78]. In contrast, professional rugby players may have a higher risk of a concussion injury due to their physical size and strength, and the level of competition[77].

Current literature indicates that there is much variability in the incidence of concussion in rugby players. It is possible that the low reported incidence of concussion may be due to a lack of diagnosis, confusion regarding the diagnosis and management of concussion, concussion not being graded, or players monitoring themselves and relying on self reported symptoms[8, 60]. These factors may be further confounded by the absence of consensus by medical professionals in past years over the diagnosis, management and return to play (RTP) protocols of a concussed player[1, 4, 39, 40, 79]. In addition, professional rugby players are often employed under an incentive based contract. This may lead to an underestimation of the true injury rate, as players may hide their injuries or mask their symptoms to play more games and thereby enhance their income[60]. The underreporting of concussion injuries may also be attributed to a player not wanting to leave the game or let teammates down, or not knowing the signs and symptoms of concussion[80, 81]. In the past mandatory stand down periods following a concussion, ranging from a week to 5 weeks, may have discouraged players and coaches from reporting a concussion as they did not want to miss matches over that period[1, 82-87]. These issues are also evident among schoolboy rugby players[30, 42, 58, 88]. A previous study revealed that athletes admitted to not reporting suspected concussion due to lack of awareness regarding the severity, nature and consequences of concussion[31]. The higher concussion rates reported in more recent years may not only be due to professionalism and the intensity of match play, but may also potentially reflect an increased awareness and diagnosis of concussion[45, 77].

2.2.1. Definition of Concussion

Concussion injuries are considered difficult to diagnose, particularly in an on field environment, and are often under-reported or unrecognised[11, 13, 19, 29-31, 89]. This may partly be due to inconsistent terms, definitions and guidelines, and may be further confounded by the lack of objective, quantifiable measures of the ensuing signs and symptoms[33]. Despite the high prevalence and potentially serious outcomes associated with concussion, there is a lack of systematic research regarding differences in definitions of concussion[90], and the ethical and practical issues involved in identifying and monitoring brain injuries[4, 44]. These controversies resulted in medical professionals devising a comprehensive systematic approach to sport-related concussion. Since the initial conference and consolidation in Vienna 2001[4], guideline modification took place at the 2nd International Conference in Prague (2004)[40], while the National Athletic Trainers Association (USA, 2004)[39, 79] and the American College of Sports Medicine (2005)[71] have published clinical management guidelines based on these consensus meetings. The 3rd International Conference on Concussion in Sport (Zurich, 2008)[1] developed a conceptual understanding of the problem of concussion [4, 40]. These meetings have acknowledged that the science of concussion is evolving, and the current management of concussion and RTP decisions should be assessed according to individual clinical cases[1].

"*Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces*"[1]. Several common features that incorporate clinical, pathologic and biomechanical injury constructs may be utilised in defining the nature of a concussive injury[1, 21]. A concussion may be caused by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head[1]. The concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously[1]. Concussion may result in neuropathologic change, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury[1]. A graded set of clinical symptoms result from concussion that may or may not involve loss of consciousness (LOC)[1]. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however it is important to note that in a small percentage of cases, post-concussive symptoms may be prolonged. No abnormality on standard structural neuroimaging studies is seen in concussion[1].

2.2.1.1. Concussion Grading

The grading of the severity of a concussion is a controversial issue. There have been at least 17 different classification systems for the severity of head injuries[1, 28, 33, 40, 91]. All classification systems, except the Glasgow Coma Scale designed for the assessment of severe head trauma, are based on anecdotal evidence and not scientifically validated[58, 83-85, 92-98]. The two most commonly used grading systems in sport are the Cantu and Colorado Guidelines[82, 84].

There have been numerous practical difficulties with concussion scales, for example it may be difficult to determine whether LOC occurred, especially if momentary LOC occurred on the field of

play[99]. There are also inconsistencies between these scales in terms of RTP guidelines. For example, a first time concussion associated with a LOC for less than five minutes correlates with a Cantu grade 2 injury, which requires the player to miss a one–week period of play. However, the same injury would be a grade three injury according to the Colorado guidelines, which requires the player to be rested for a minimum period of one month[82]. In addition, 63% of coaches admitted to not using any grading scale due to confusion associated with grading of severity and subsequent management[37]. The lack of clarity associated with different grading systems may have led to the incorrect use of the guidelines, and subsequent inappropriate management of the concussed player[100].

Loss of consciousness is a poor prognostic indicator for concussion[100, 101], however it was previously an important factor in grading concussion. Therefore, the basis of grading concussion injuries and subsequent RTP decisions on LOC is now inaccurate[102]. The Cantu[87], Colorado[82] and American Academy of Neurology (AAN)[83] grading systems also do not consider the presence or duration of impaired neuropsychological test performance[103]. Moreover, post-traumatic amnesia may only be determined retrospectively and is of little use for on field evaluation[99]. In addition, the concept of traditional mandatory exclusion periods based on the concussion grading is not supported by recent consensus statements[104, 105]. The recent Zurich Consensus Statement[1] proposed abandoning grading terminology and the guidelines for grading of concussion injuries *(Table 2.1).*

Table 2.1: Concussion Grading Scales			
Progression from "Old" to "New"	**Severity of Concussion**		
	Mild Grade 1	**Moderate Grade 2**	**Severe Grade 3**

Bruno et al 1987[106]	Confusion: yes LOC: no	LOC: no PTA: delayed	LOC: yes PTA: immediate
Colorado Medical Society 1990[82]	Confusion: yes LOC: no PTA: no	Confusion: yes LOC: no PTA: yes	LOC: yes
American Academy of Neurology 1991[83]	Confusion: transient LOC: no PTA: no Symptoms resolve in < 15 minutes	Confusion: transient LOC: no Symptoms last > 15 minutes	LOC: brief or prolonged
Cantu 1986[87],1998[86], 2001[107]	LOC: no PTA: < 30 minutes PCSS: < 24 hours	LOC: < 5 minutes PTA: > 30 minutes or more but less than 24 hours PCSS: > 24 hours but < 7 days	LOC: 5 minutes or more PTA: 24 hours or more PCSS: 7 days or more
	Simple 1st degree	**Complex 2nd degree**	
2nd Int. Conference on Concussion and Sport, Prague 2004[40]	Symptoms: < 15 minutes Cognitive deficits < 24 hours	LOC: yes Symptoms: > 15 minutes	
3rd Int. Conference on Concussion and Sport, Zurich 2008[1]	Unanimous decision to abandon the 'simple' versus 'complex' terminology, as it does not fully describe the entities involved in concussion.		
Table Abbreviations: *LOC – loss of consciousness* *PTA – post-traumatic amnesia* *PCSS – post-concussive signs and symptoms other than amnesia* *< - less than* *> - more than*			

2.2.2. Signs and Symptoms of Concussion

Concussion may manifest with any combination of physical, cognitive, emotional and sleep-related symptom clusters including headache, dizziness, nausea, visual disturbances, amnesia, poor concentration, irritability, depressed affect, fatigue and drowsiness, inappropriate emotions (laughing, crying), slurred speech, and glassy eyes *(Table 2.2)*[21, 22]. Essentially, concussion results in a reduced speed of information processing, poor attention and impaired executive function[23].

***Table 2.2: Signs and Symptoms of Concussion*[1, 4, 40]**

Symptoms	Physical Signs	Behavioural Changes	Cognitive Impairment	Sleep Disturbance
Somatic: headache Cognitive: feeling 'foggy' Emotional: lability	LOC Dizziness Amnesia Photophobia Nausea Numbness Tingling Vomiting Vacant stare Glassy eyes	Irritability Mood Swings Aggressiveness	Poor concentration Problems remembering Feeling 'slowed down' Slowed reaction time Balance problems	Drowsiness Fatigue Insomnia Difficulty getting to sleep

Previously, cerebral concussion was defined as a posttraumatic state that resulted in LOC[33]. However, concussion rarely involves a LOC, with the most common indicators of concussion being

amnesia, headache and unsteadiness[33, 53, 108]. In school rugby players who were diagnosed with concussion, 69% had symptoms of alteration in mental state and confusion, and only 31% had LOC[19]. It has been suggested that the presence of amnesia, and not LOC, may be predictive of symptoms and neurocognitive deficits following concussion in athletes[33, 108]. However, the nature, intensity and duration of the clinical post-concussive symptoms may be more important than the presence or duration of amnesia alone in determining the severity of the concussion[101, 109]. A variety of immediate motor phenomena, for example tonic posturing, or convulsive movements may accompany a concussion. These clinical features are generally benign and require no specific management beyond the standard treatment of the underlying concussive injury[1].

Some post-concussive clinical features may also be related to vestibular dysfunction, such as dizziness and balance disorders[102, 110]. It is also recognised that concussion symptoms such as confusion, disorientation, memory or information-processing abnormalities are related to cerebral cortical dysfunction. Concussion symptoms that include the unconscious state, visual and auditory symptoms, nausea, vomiting, ataxia and poor coordination are related to brain stem abnormalities[1].

A history of repeated concussion injuries, that is, two or more episodes of concussion, may be associated with long-term deficits in the domains of executive functioning and speed of information processing, as well as an increase in self-reported concussion symptoms. A history of one concussion injury does not appear to result in the long term cognitive morbidity associated with two or more episodes of concussion[13, 29, 90, 111-115].

Although concussive injuries in children have a similar presentation to concussion in adults, the academic and social consequences of concussion in children is currently unknown. In addition, children may suffer from a variety of post-concussion behavioural sequellae despite normal neuropsychological testing[23, 33]. There may also be differences in adult and child brain tolerance to biomechanical forces. A child's brain is more vulnerable to concussion due to the greater head-to-body ratio, weaker neck musculature, underdeveloped cranial bones, and immature myelination of the nerves. A child may require a smaller biomechanical force to sustain an injury to the brain. It may be reasonable to assume that if a child exhibits clinical symptoms after head injury that are equivalent to an adults post-concussive symptoms, the child may have sustained a far greater impact force. This may be related to issues of understanding of a concussion injury and self reporting symptoms by a child, as well as continued maturation of a child's brain over the concussion period [23, 116]. In broad terms, a two or three fold greater impact force is required to produce the same clinical symptoms in children compared to adults[23].

2.2.3. Pathophysiology of Concussion

The pathophysiology of concussion is less well understood than that of severe head injury[83]. Moderate to severe brain injury causes a complex cascade of neurochemical changes in the brain[117]. It may be proposed that similar changes may occur in concussion injuries[118]. As kinetic energy is applied to the human cranium, both acceleration-deceleration and rotational mechanisms occur. Acceleration-deceleration injuries, also considered translational (linear) impact injuries, usually result when the body and head are travelling at a particular speed and strike a solid object; for example an athletes head at rest may be struck by a moving object. The resultant injury causes linear, tensile and compressive strains and disrupts the cerebral anatomy and cytoarchitecture. Rotational (angular) movements also take place, secondary to the fixation of the brain at the foramen magnum and craniospinal junction, and the relative tethering of the midbrain as it passes through the tentorial hiatus. Energy directed to the head may cause transmission of forces in a rotational direction, often producing diffuse brain injury with shearing of the white-matter fibre tracts[102, 119, 120]. The rotational component of cranial or mandibular impacts often contributes to the forces that cause LOC[102].

The forces applied to the head during contact sports, such as rugby, are often referred to as impact or impulsive loading. Impact loading occurs when a direct blow to the cranium accrues over less than 200 milliseconds, leading to a rapidly applied energy input. This may cause skull deformation and energy shock-wave propagation through the skull and brain, resulting in underlying cerebral injury. In contrast, impulsive head loading occurs when the head is placed in motion and suddenly accelerated or decelerated as a result of either an impact to another part of the body, or as a secondary response to a direct impact. This mechanism causes compressive, shear and tensile stresses to the brain, leading to more diffuse or remote injuries. It is more often seen with rotational energy inputs and is less effectively prevented by protective headgear, which is better able to dissipate impact-loading energy input[102].

The abrupt and indiscriminate release of neurotransmitters and unchecked ionic fluxes occurs immediately after biomechanical injury to the brain. The binding of excitatory transmitters, such as glutamate, to the N-methyl-D-aspartate (NMDA) receptor leads to further neuronal depolarisation with efflux of potassium and influx of calcium. These ionic shifts lead to acute and sub-acute changes in cellular physiology. Acutely, there is increased activity of the sodium-potassium (Na^{2-} - K^{-}) pump in an effort to restore the neuronal membrane potential. There is a subsequent increased requirement for adenosine triphosphate (ATP), triggering a rapid increase in glycolysis. This 'hypermetabolism' occurs in the setting of diminished cerebral blood flow[13, 112], and the disparity between glucose supply and demand triggers a cellular energy crisis.

This, together with increased lactate concentrations resulting from glycolysis may possibly account for the symptoms and behavioural changes associated with concussion *(Table 2.2)*. These

metabolic changes may also be potential underlying mechanisms for post-concussive vulnerability. The brain may therefore become less able to respond adequately to a second concussion injury, which may lead to further, longer lasting symptoms[92, 102, 117-119, 121, 122].

A normal level of consciousness depends on a complex interaction of cortical, sub-cortical and brain stem nuclei. The reticular activating system extending through the brainstem must interact with the hypothalamus and cerebral hemispheres in a normal feedback-loop mechanism for consciousness to be maintained. Alteration in the state of consciousness occurs when the integrity of this neurophysiologic functional unit has been interrupted[102]. When extracellular potassium concentrations increase beyond the normal upper limits of 4 to 5 mmol.ℓ^{-1} to levels of 20 to 50mmol.ℓ^{-1}, inhibition of action potentials occurs, leading to LOC[123]. However the reticular activating system recovers relatively quickly and consciousness is usually regained fairly soon after injury[77]. Nevertheless, this biochemical mismatch lasts significantly longer; further emphasising that LOC is a poor indicator of the severity of a concussion injury.

The decline in postural control after concussion may be related to changes in neurophysiologic or mechanical constraints of postural control. For example, diffuse axonal injury may reduce or distort interactions among neurons in the brain, thereby increasing the regularity of cortical oscillations that subsequently manifested in a loss of randomness or increased regularity in patterns of centre of pressure (COP) oscillations. Alternatively, increased co-contractions of the lower extremity musculature generated by the injured athlete, in an attempt to gain control over postural sway, may also alter the randomness of COP oscillations[124].

2.2.4. Complications of Concussion

As will be discussed later in this review, a concussion injury may resolve within days or weeks[1], provided the correct management of the athlete is implemented from the time of injury[1]. Post-concussive symptoms may be prolonged[4, 5, 24, 25] and more serious complications, including death may result following either a misdiagnosed or undiagnosed concussion or a premature return to sport[9, 26-28].

Intracranial space occupying lesions may be one of the early complications of concussion. A less common complication of concussion may be damage to cerebral arteries and veins. Bleeding from these vessels may lead to epidural, subdural or intracerebral haematomas[26, 125]. Signs of raised intracranial pressure should be recognised immediately and require surgical management to decompress the brain.

Second Impact Syndrome or diffuse cerebral swelling is a rare but well recognised complication of minor head injury and occurs mainly in children and teenagers[23, 72, 126]. Second Impact Syndrome

was first reported in American Football players who died after relatively minor head injuries[18, 27], including concussion without LOC[83]. Second Impact Syndrome may occur if a player returns to play prematurely following a previous head injury. Brain oedema and an increased vulnerability to injury during the biochemical 'mismatch' following a head injury may still be present from the previous blow[117]. A second blow, however trivial, results in further swelling, followed by loss of the brain's ability to control blood inflow or autoregulation[27]. Cerebral blood flow increases rapidly and brain pressure rises uncontrollably leading to cardio-respiratory failure due to brainstem herniation and possible death[27]. Although repeated concussive injuries have been proposed as the basis for Second Impact Syndrome[72, 126], the evidence is not compelling and it may possible that a single impact of any severity may result in this rare complication[23].

Convulsions or seizures in collision sports are uncommon and are not necessarily associated with structural brain damage. Convulsions will generally occur within seconds following impact. Further, the absence of long-term cognitive damage reflects the benign nature of these episodes, and suggests that antiepileptic treatment and prolonged preclusion from contact sports may not be warranted[28].

Another complication of concussion is Prolonged Post-concussion Syndrome (PCS), where clusters of symptoms following a concussive blow may persist for days to weeks[4, 5]. The consequences of symptoms such as headache, dizziness, memory loss and fatigue may be particularly significant in young athletes in a learning environment. Therefore decisions regarding rest from cognitive and physical stresses are of primary importance[25].

Chronic traumatic encephalopathy is a condition that may develop as a consequence of the cumulative effects of long-term exposure to repeated concussive and sub-concussive injuries[127]. Recent evidence suggests that each episode of concussion may result in residual brain damage possibly associated with cerebral deposition of the abnormal Tau protein[70, 128-135]. This is particularly evident in the development of cognitive dysfunction in boxers. The degree of cognitive dysfunction may be directly related to the number of fights in a boxer's career[136, 137]. The cerebral damage that may occur in rugby players is thought to be largely cortical and more subtle than the cerebella and basal ganglia manifestations seen with cognitive dysfunction in boxers[138]. Cognitive deficits have also been documented in amateur, professional and retired soccer players[29, 139-142]. Genetic factors, associated with the ApoE4 gene, may also increase the risk of developing chronic brain injury in sport[24, 71, 118, 143, 144]. Further research is required to investigate the severity or extent of repeated head injuries and the potential cumulative effect on cognitive dysfunction[4].

The long-term consequences of multiple sport-related concussion remains unclear[145]. However, a recent study demonstrated altered neuropsychological and motor indices in athletes with a

previous history of concussion injuries 30 years prior to testing. These findings provided supporting evidence for the chronicity of cognitive and motor system changes following concussion[146]. It may therefore be proposed that a player's cognitive function should be assessed regularly to determine the presence of cognitive deficits[1, 70, 128-135].

2.2.5. Concussion Risk Factors

Certain risk factors have been identified due to their influence on investigations and management of concussion, and may in some cases, predict the potential for prolonged or persistent concussion symptoms[1, 40].

A past history of concussion increases the risk of subsequent concussion injuries[90, 111, 147]. A history of concussion may result in a lower threshold for subsequent concussion injuries; and may also be associated with poorer outcomes of secondary concussion injuries. Athletes with a history of three previous concussions were 9.3 times more likely to demonstrate three to four abnormal on field signs and symptoms of concussion compared to athletes with no history of concussion. These findings suggest a potential cumulative effect of concussion injuries[23, 111, 148-154]. Further, an athlete who has sustained one concussion injury has a three to six times greater risk of suffering a second concussion[13, 31, 112, 155]. Although a history of one or two previous concussions may not be associated with measurable preseason neuropsychological deficits, athletes with three or more previous concussion injuries showed decreased memory performance on neuropsychological testing[29, 112, 153]. In addition, a history of concussion may result in an increased risk of long term sequellae, for example prolonged headaches, dizziness, fatigue and memory loss. This is more commonly seen in younger athletes with a history of concussion and may increase their risk of developing PCS in subsequent concussions[112]. As expected, the risk of concussion is associated with participation in any collision sport, and may be directly related to the amount of time spent playing the sport. Arguably therefore, the risk of repeated concussion injuries may be related to the level of exposure to contact and impact forces[23].

The increased susceptibility of younger athletes to concussion may be associated with numerous factors, including an immature central nervous system, a lack of recognition of concussion, and the subjectivity associated with self-reporting of concussion symptoms[20, 33, 77, 78, 89]. It is theorised that the younger brain may be more vulnerable to the disruption of autoregulatory functions due to decreased myelination, a greater head-to-body ratio, and thinner cranial bones, all of which provide less protection to the developing nervous system[33].

In addition, younger athletes may not be educated as to the signs and symptoms of a concussion, may be nervous about reporting the concussion due to the associated restrictions on participation in sport, or may not understand the seriousness of the injury[33]. Further, the reliance on self-

reporting of concussion injuries and symptoms in younger athletes may also limit the reliability and validity of the clinical diagnosis of concussion[33, 103, 156]. Studies have shown that high school athletes with concussion may have prolonged memory dysfunction on neuropsychological testing compared with college athletes with concussion[121, 157] and that concussed high school athletes performed significantly worse than age matched individuals, without history of concussion[186].

Other potential risk factors that may predict more severe neurobehavioral consequences following injury in children include the presence of pre-morbid cognitive attention and behavioural impairments[23] and learning disabilities[90]. Adolescents with a history of two or more concussion injuries and learning disabilities (LD) had reduced levels of executive functioning, including the ability to plan and execute a nonverbal behaviour, and decreased speed of information processing, compared to adolescents with concussion who did not have associated LD. These findings suggest an additive effect of LD and multiple episodes of concussion in the reduction of cognitive function. Learning disabilities may make the initial diagnosis of concussion more complex and confusing, and may lower the threshold for neurobehavioral morbidity. Athletes with LD may also have difficulty in learning safe techniques for rugby and may have associated neurobehavioral characteristics such as impulsivity and attention impairment that may increase the risk of injury[90].

Illegal activity is often overlooked as a risk factor for concussion injury. At high school level sports-related injuries, including concussion, due to illegal play have been reported to be significantly high[158]. Reducing illegal activity through improved enforcement of sports rules and targeted education about the dangers of illegal play for players, coaches and referees may reduce the incidence of injuries. Recent concussion guidelines have stated that sports governing bodies should be encouraged to address violence that may increase the risk of concussion[1, 159]. Fair play and respect should be supported as key elements of the sport, thereby minimizing the risk of injury, particularly concussion[1].

Summary of the Literature: Concussion in Rugby

Collectively, the literature demonstrates a high incidence of concussion in rugby, regardless of the level of play or age of rugby players. The high incidence of concussion is due to a number of

factors including the nature of the sport, the physique of the athletes, competitiveness of the game, and playing technique. Although the science of concussion is still evolving, it is acknowledged that in recent years significant progress has been made to improve the consensus on concussion definitions and grading, which may facilitate improved identification of concussion in rugby. Understanding the potential complications and risk factors for concussion, as discussed in the above literature, highlights the importance of effective management of a concussed athlete. The following sections of this review will attempt to demonstrate the practical implications for evaluation and management of the concussed player.

2.3. EVALUATING THE CONCUSSED PLAYER

Concussion evaluation and management should be based on a multifaceted protocol[1, 22, 40]. Numerous consensus and position statements have recommended the use of a clinical examination, symptom checklist, postural stability assessment and neuropsychological testing[1, 4, 39, 40].

The diagnosis of acute concussion requires the assessment of a range of domains, including clinical symptoms, physical signs, behaviour, balance, cognition and sleep. A detailed concussion history is an important part of the evaluation of the injured player, and during the preseason examination[1]. The suspected diagnosis of concussion may include one or more of the following clinical domains *(Table 2.2):* somatic (e.g. headache), cognitive (e.g. feeling 'foggy'), and / or emotional symptoms (e.g. lability); physical signs such as LOC, or amnesia; behavioural signs for example irritability or aggressive behaviour; and cognitive impairments (e.g. slowed reaction time) and sleep disturbance (e.g. drowsiness)[1]. If any one of the above components are present, a concussion should be suspected and the appropriate management strategy instituted[1]. It is also important to note that baseline self-reported symptoms of concussion may be increased in athletes with a history of concussion, acute fatigue, physical illness or orthopaedic injury[160].

2.3.1. On Field Evaluation and Management

The aim of immediate management is to stabilise the head-injured player. Basic aspects of first aid, including cervical spine protection, and the assessment of airway, breathing and circulation are the

immediate priorities of management[99]. This is of particular importance where there has been LOC, if the player is confused, or if there is any suggestion of associated neck injury (neck pain, numbness or limb paraesthesia)[39, 71]. In more subtle cases, a validated brief on-field neuropsychological test may be administered using the Sport Concussion Assessment Tool 2 pocket booklet (SCAT2) *(Figure 2.I)*[1, 161]. SCAT2 enables the calculation of the Standardized Assessment of Concussion (SAC) score[162]. Maddock's questions, which may be modified for rugby, are also included in SCAT2 and assess recent memory[161]. These questions are sensitive in discerning between concussed and non-concussed players[163-165]. The standard approach of asking orientation item questions of time, place and person are unreliable, as this component of cognitive function may be preserved in concussion[164, 166].

Pocket SCAT2

Concussion should be suspected in the presence of **any one or more** of the following: symptoms (such as head-ache), or physical signs (such as unsteadiness), or impaired brain function (e.g. confusion) or abnormal behaviour.

1. Symptoms

Presence of any of the following signs & symptoms may suggest a concussion.

- Loss of consciousness
- Seizure or convulsion
- Amnesia
- Headache
- "Pressure in head"
- Neck Pain
- Nausea or vomiting
- Dizziness
- Blurred vision
- Balance problems
- Sensitivity to light
- Sensitivity to noise
- Feeling slowed down
- Feeling like "in a fog"
- "Don't feel right"
- Difficulty concentrating
- Difficulty remembering
- Fatigue or low energy
- Confusion
- Drowsiness
- More emotional
- Irritability
- Sadness
- Nervous or anxious

2. Memory function

Failure to answer all questions correctly may suggest a concussion.

"At what venue are we at today?"
"Which half is it now?"
"Who scored last in this game?"
"What team did you play last week/game?"
"Did your team win the last game?"

3. Balance testing

Instructions for tandem stance

*"Now stand heel-to-toe with your **non-dominant** foot in back. Your weight should be evenly distributed across both feet. You should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Observe the athlete for 20 seconds. If they make more than 5 errors (such as lift their hands off their hips; open their eyes; lift their forefoot or heel; step, stumble, or fall; or remain out of the start position for more that 5 seconds) then this may suggest a concussion.

Any athlete with a suspected concussion should be IMMEDIATELY REMOVED FROM PLAY, urgently assessed medically, should not be left alone and should not drive a motor vehicle.

Figure 2.1: SCAT2 Pocket Version to assist On-Field assessment of concussion
Permission for reproduction obtained from Dr P McCrory, SCAT2 has no copyright restrictions[1]

Players with concussion are often not removed immediately from the field[18, 31, 34]. In one study only 42% of concussed players left the field[18]. The concussed player must be removed from the field of play or practice immediately[1, 4, 39, 71]. In rugby a possible challenge in making this clinical diagnosis and therefore decision to remove the player from the field of play may be due to current regulations

regarding permanent replacement of injured players[18]. The Zurich Consensus of 2008, did state that appropriate time and facilities to assess the potentially concussed player adequately may require rule change in the future, so as not to affect the flow of the game nor penalise the injured athlete[1].

2.3.2. Side Line Evaluation and Management

The player should be assessed by a medical doctor as soon as possible after the injury to confirm the diagnosis of concussion, to determine the severity of initial symptoms, and to determine if there are any indications for urgent referral to hospital *(Table 2.3)*[39, 99]. This assessment is best performed in a quiet medical room as it involves a thorough history and neurological examination, noting any symptoms of concussion and excluding potential catastrophic signs of intracranial injury. A history of concussion, acute fatigue, physical illness and orthopaedic injury, have been found to increase self reported concussion symptoms. It is advised that these conditions be thoroughly investigated and controlled by the clinician before baseline self reported symptom scores are documented[160]. The SCAT2 or SAC may be used to assess neuropsychological function *(Appendix I)*. The SAC has been shown to be specific and sensitive to changes in orientation, concentration and memory immediately following a concussion compared with pre-injury baseline measurement[33, 162, 166].

Table 2.3: Indications for Urgent Referral to Hospital[39, 99]

Any player who has or develops the following:
• Fractured skull
• Penetrating skull trauma
• Deterioration in conscious state following injury
• Focal neurological signs
• Confusion or impairment of consciousness > 30 minutes
• Loss of consciousness > 5 minutes
• Persistent vomiting or increasing headache post injury
• Any convulsive movements
• More than one episode of concussive injury in a match or training session
• Where there is assessment difficulty (e.g.: an intoxicated patient)
• All children with head injuries
• High-risk patients (e.g. haemophilia, anticoagulant use)
• Inadequate post injury supervision
• High-risk injury mechanism (e.g.: high velocity impact, missile injury)

The first Sport Concussion Assessment Tool (SCAT) was developed following the 2nd International Conference on Concussion in Sport (Prague, 2004) as a standardised tool for assessment of concussion in sport[40]. The SCAT combined existing tools into one: the sideline evaluation for concussion[32, 166], the AAN management of concussion sports palm card[167], SAC[33, 162, 166], McGill

abbreviated concussion evaluation (ACE) (unpublished)[40], the United Kingdom Jockey Club assessment of concussion[40], and Maddock's questions[164]. Where part of the content had been previously validated, specifically SAC and Maddock's questions, the authors gave input through a process of collaboration and literature review, such that SCAT was evaluated for face and content validity on the basis of scientific literature[40]. Small updates have been made in producing the latest version and SCAT2 now supersedes the original SCAT. Although this is seen to be the 'gold standard' concussion assessment tool, SCAT2 is yet to be validated, and this has been identified as a key area of research for the future[1]. The SCAT2 was designed for the use of medical and health professionals. It has been recommended that scoring data from SCAT2 should not be used as a stand alone method for diagnosing concussion, measuring recovery or making RTP decisions *(Table2.4)*[1]. Once the player has been assessed on the sideline, the concussed player may either be referred to hospital if indicated, or may be managed at home[1].

Table 2.4: Concussion Tools[1]

Tool	Contents of the Tool	When to use the Tool
SCAT2	Symptom Checklist Physical Sign Checklist (LOC and balance problems) Glasgow Coma Scale Maddock's Questions SAC Balance Examination Coordination Examination Athlete Information Concussion Injury Advice	Preseason baseline testing Sideline valuation of concussed player Detailed clinical assessment of concussion Management of Concussed player – serial assessment to document improvement or decline
Pocket SCAT	Symptom Checklist Memory Function Balance Testing	Abbreviated version of SCAT2 – for rapid on field identification of concussion

2.3.3. Hospital Referral

Standard brain imaging techniques are almost always normal in concussed players[4, 40, 71]. However, if the player has been unconscious for any period of time, has deteriorating drowsiness, recurrent vomiting, unusual or aggressive behaviour or focal neurological signs, it is recommended that either a Computed Tomographic (CT) scan or a Magnetic Resonance Image (MRI) scan be performed[99]. If there are no indications for these investigations and the concussed player's condition improves over an initial two-hour observation period, the player may be discharged home. Home management requires a responsible adult to be present, as well as a set of guidelines for management *(Table 2.5)*[1, 40, 99].

In children, a previously healthy child with a concussive injury who has normal mental status, no abnormal or focal abnormalities on neurological exam and no physical evidence of skull fracture simply requires observation by a competent caregiver or adult. Although children have a high risk of brain swelling and associated complications, the risk of clinically significant intracranial pathology in a child presenting with concussion is less than 0.02%[23].

Table 2.5: Patients' Home Care Information[1]

Patient Information - Important Reminders for the First 48 Hours

A normal X-ray, CT or MRI scan does NOT exclude concussion. You may be referred home after being assessed. In this case:
• Always make sure that you are in the presence of a responsible adult for 48 hours.
• Record and monitor the symptoms of concussion including headache, nausea, dizziness, fatigue, sleep disturbances, memory lapses, mood swings, poor concentration or any other feeling that concerns you.
• Complete rest & sleep will help recovery.

Do not:
• Drive a motor vehicle or motorcycle if symptomatic.
• Consume alcohol
• Take excessive amounts of painkillers (follow doctor's orders)
• Place yourself in an environment of loud noise and excessive light
• Study
• Work at the computer, use playstation/videogames, send text messages
• Exercise until re-evaluation by a doctor

Contact your nearest Emergency Department immediately if:
• Any of the symptoms deteriorate
• The headache becomes severe or does not respond to mild analgesics (e.g. Panado)
• You have a seizure (fit)
• You experience excessive irritability
• You experience visual disturbances
• You experience balance problems
• You or anyone else is concerned about your condition

Decisions regarding returning to sport will be made taking into consideration your individual circumstances including medical history, previous head injuries and current symptoms.
You must receive clearance from a doctor before returning to sport.

2.3.4. Follow-up consultation

Return-to-play decisions require serial multidisciplinary medical evaluations, and may include sports physicians, neurologists, neuropsychologists, physiotherapists and biokineticists[4, 39, 40, 71, 168]. A neuropsychologist is an important part of the multidisciplinary team making RTP decisions, particularly where neuropsychological testing reveals significant, persistent or recurrent discrepancies in psychometric function. The aim of serial evaluations is to determine whether the player has fully recovered from concussion and is able to RTP. The combination of a clinical assessment with neuropsychological testing is the most effective method of determining recovery. Serial assessments allow for the comparison with previous testing, and the tracking of recovery. The following parameters should be thoroughly assessed at follow-up consultations: the history of the specific head injury, and history of previous concussions or associated injuries (neck, maxillo-facial). Symptoms at the time of injury and current symptoms should be documented. Verbal and numeral competency, as well as balance should be assessed. An assessment of cardiovascular status and neurological status; cranial nerves, motor function, sensory function, and cerebella function should be included. Finally any associated injuries, especially involving the neck, should be addressed[4, 39, 40, 71, 84, 85, 168]. The Acute Concussion Evaluation form devised by Gioia and Collins[169] and used by the Centre for Disease Control has been modified to provide a standardised assessment protocol for South African athletes. This tool has however not yet been validated.

Summary of the Literature: Evaluating the Concussed Player

As previously discussed, the complications of a concussion injury are serious and the lack of identification of concussion may have serious consequences. It is apparent from the above literature that concussion assessment tools, for example SCAT2, have been developed to assist in the identification and subsequent diagnosis of concussion, thereby facilitating appropriate management of concussion injuries[1]. The initial examination and documentation of the concussion and calculation of the SAC score are important baseline reference points for tracking recovery after concussion[1]. Additional tools are available to facilitate the diagnosis of concussion, as well as monitor the recovery phase of concussion[1]. These tools will be discussed further in the following section.

2.4. CONCUSSION INVESTIGATIONS

2.4.1. Neuroimaging

Conventional structural neuroimaging is normal following a concussive injury. However, CT or MRI scans are recommended if an intracranial structural lesion is suspected. This may include symptoms of prolonged disturbance of consciousness, focal neurological deficit or worsening symptoms[1]. It has been demonstrated that abnormal functional MRI (fMRI) scans during the first week after a concussion injury may predict clinical recovery. Athletes with hyperactivation on initial post-concussion fMRI scan demonstrated a prolonged clinical recovery time, compared to athletes without hyperactivation on fMRI. Functional MRI may represent an important developing technology for monitoring brain recovery after concussion, and may potentially shape RTP guidelines in the future[170-173].

2.4.2. Balance Assessment

Although not a direct measurement of cognitive function, postural stability has been shown to be very sensitive to concussion[33, 174]. Concussion may be associated with acute balance deficits which may be due to poor information processing from the vestibular and visual systems, due to potential involvement of the brainstem[124, 174-179]. The measurement of postural stability increases the objectivity of the post-concussion assessment[33, 173].

Concussed athletes demonstrated significant deficits in postural stability, compared to pre-season scores and matched controls. There were no significant associations between LOC and amnesia, and deficits in postural stability or recovery time of measurements of postural stability[174]. Complete recovery of postural control after concussion is an important determinant of an athletes readiness for RTP[124]. Catena et al[180] observed no significant differences in single-task walking (simply walking straight on flat ground) between controls and individuals with concussion. Significant differences within the groups were identified during obstructed gait tasks (having to step over varying height blocks whilst walking), where individuals with concussion acquired a more conservative gait pattern (less movement in the sagittal plane) and slower walking times. There was also a significant difference between groups when a divided attention task was performed. This involved unobstructed gait whilst continually responding to questions involving spelling out words, counting and reciting the months of the year. It may therefore be proposed that attention dividing tasks and obstacle crossing tasks may be more sensitive in identifying changes in gait and balance control post-concussion, compared to simple straight walking[180].

In addition, exercise and / or fatigue may negatively affect postural control[179, 181]. Fox et al[179], used aerobic and anaerobic exercises to induce fatigue in healthy individuals, and demonstrated that the

fatigue effects on postural control lasted more than 13 minutes after the cessation of exercise. Similarly, static and dynamic balance tasks were affected by moderate and high intensity exercise, with significant improvements in balance tasks following a 15 minute recovery period[181]. A 20-minute post-exercise recovery time has therefore been suggested prior to testing postural control either for the assessment of a suspected concussion injury, or for the assessment of readiness for RTP.

2.4.2.1. Measurement tools for balance assessment

Early assessments of postural stability were measured as the Sensory Organization Test (SOT) using reflective markers, cameras and force plates, requiring NeuroCom Smart Balance Master system software. This required a laboratory setting and relatively sophisticated equipment[124, 174, 179 182, 183]. Recently, more practical and inexpensive measurement instruments have been utilised. For example, the Balance Error Scoring System (BESS) may be conducted on the sideline with a piece of medium density foam or wobble mat (*Appendix II*)[184]. Alternatively, attention dividing tasks and obstacle crossing tasks as described above may also be used to assess and monitor postural control during the recovery period following concussion[180].

2.4.3. Neuropsychological Testing

The subjective assessment of concussion should be routinely supported by an objective neuropsychological assessment to provide essential clinical information following a concussion injury[80 90, 185-189]. Neuropsychological or neurocognitive tests are designed to assess the ability of the brain to process information, that is, cognitive function[41, 80, 190-192]. As a measurement tool, SAC demonstrates a weak relationship with some neuropsychological measures[184], as it assesses gross cognitive function relative to specific cognitive abilities. More advanced neuropsychological tests are useful in detecting subtle and prolonged deficits in cognitive function following concussion[184].

Traditional "paper and pencil" neuropsychological tests have been replaced by more practical, computerised neuropsychological tests[190, 193]. Computer tests are quick and easy to administer,

show fewer learning effects, and are able to detect subtle changes in cognitive function[108, 194, 195]. However, the cost and accessibility of these computerised tests should be considered for individual clinical cases and the available resources. Examples of computerised neuropsychological tests include Automated Neuropsychological Assessment Metrics (ANAM), CogState Sport, Headminders and the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT). The CogState Sport neuropsychological test is used by the South African Rugby Union. This test was developed by leading concussion neuroscientists in Australia as an objective measure of cognitive function following head injury[69, 194-198].

Neuropsychological tests are based on psychometric principles[199-201], however these tests are not practical for sideline administration since they require approximately 20 minutes to administer. Although concentration, working memory, immediate memory recall, and rapid visual processing appear to be mildly affected[174], neuropsychological deficits are sometimes more difficult to identify in the acute stages of concussion. In addition, cognitive recovery from concussion may not be linear in nature and some tests may be differentially sensitive to early and late stages of recovery[202]. Randolph et al[203] established that no existing conventional or computerized neuropsychological test battery used for sport-related concussion met all the criteria necessary to warrant routine clinical application[192, 203]. The 'paper and pencil', ANAM, CogSport, HeadMinder, and ImPact tests all lacked in some aspect of reliability, validity, stability, and clinical utility[203]. However, neuropsychological testing is a reliable and objective method for evaluating the effects of concussion on the central nervous system (CNS).

Pre-season testing is important for the assessment of neuropsychological function. Pre-season data allows for reliable comparisons with post-concussion assessments[40, 71, 186, 190], assists in the detection of subtle cognitive impairment, eliminates comparisons with normative data, and facilitates accurate clinical decision-making. Baseline data also ensures that test performance is not adversely affected by disease, drugs, practice effect[80, 204, 205] and malingering[108, 163, 196, 198]. However, pre-season testing may not be performed due to the time required for testing, and the expense of testing, as well as poor accessibility to testing[22]. It has been observed that the level of experience of coaches was positively associated with the use of pre-season neuropsychological testing[22].

Athletes demonstrate impaired neuropsychological function post-concussion compared to baseline measurements, despite denying the presence of concussion related symptoms[80, 112, 206]. It may be

suggested that cognitive deficits may extend beyond symptom resolution, warranting a conservative RTP[80]. Concussed athletes who were symptomatic displayed significant cognitive deficits on computerised tests of motor function[202]. However, Broglio et al[207] established a poor association between the magnitude of self-reported symptoms and deficits in postural control and cognitive function. This illustrates the importance of conducting neuropsychological testing when assessing the readiness of asymptomatic players for RTP. Moreover, it has recently been proposed that neuropsychological testing should not be included in acute post-concussion assessment. It is postulated that early testing may induce unnecessary cognitive stress, which may prolong concussive symptoms, and may also increase the possibility of a learning effect with testing. In addition early neuropsychological testing will not alter the immediate management of a concussed player[40, 71].

There is currently equivocal evidence for long-term neurological damage[70, 128-135, 146, 208, 209] and increased risk for future concussion[13, 23, 31, 90, 111, 112, 147-152, 155] following repeated concussion injuries. A study comparing neuropsychological performance of individuals, 12 months after sustaining a first concussion, with or without LOC showed that a sub-group of participants with PCS performed poorly on computerised neuropsychological tests batteries, when compared with matched controls with no history of concussion. In contrast, a sub-group of participants with a single concussion history and no PCS performed similarly to matched controls[25]. This study questioned the theory that PCS is driven by psychological factors and not structural consequences of concussion. In addition, the long-term neurological consequences of concussion were not evident in participants with a history of one concussion[25].

Similarly in large studies conducted by Iverson et al[29] and Collie et al[122]; with 867 and 521 athletes respectively; there was no association between the number of past concussions and decrements in current cognitive function. Any cumulative effect of two or more concussions on cognitive state were either negligible or undetectable with the current neuropsychological methodology[29]. Nevertheless, recent evidence in rugby union players showed that athletes with a history of three or more concussions had significant detrimental effects on cognitive function[153]. It has been shown that the number of past concussions has a significant effect on neuropsychological decrements in the acute stages of the subsequent concussion and that an athlete with a history of two or more concussions takes longer to recover on neuropsychological tests than an athlete with no history of concussion[112]. Further research is required to resolve these conflicting findings and to determine long-term effects of repeated concussion injuries on neuropsychological testing.

Cognitive function in adults is relatively stable over time, whereas cognitive function in children continues to develop over time. This may confound neuropsychological testing in children as improvements in cognitive function due to normal development between baseline and post-

concussion testing may offset any injury related cognitive impairments in concussed children and adolescents[23, 179]. It is recommended that during the period of rapid cognitive maturation between 8 to 15 years of age, baseline neuropsychological testing should be performed at least every 6 months to enable accurate comparisons for serial testing. However, such regular testing may be difficult in resource-limited environments, therefore annual neuropsychological testing is recommended as the minimum requirement for children participating in collision sports such as rugby[23 1, 210-214].

Further, it is recommended that a neuropsychologist be part of the multi-disciplinary sports concussion team and should be consulted for younger athletes, particularly in the presence of learning disorders and attention deficit hyperactivity disorder (ADHD)[1, 24, 71]. The neuropsychologist should also perform assessments where cognitive dysfunction is severe and prolonged[186]; in cases of recurrent concussion over a short period; in players who appear to suffer concussion with relatively minor impacts; where neurological or psychological co-morbidity exists (e.g. depression, attention deficit disorder, migraine sufferers); and in cases where a decision to advise a player to stop participating in contact or collision sport is to be considered[111].

2.4.4. Genetic Testing

The significance of apolipoprotein (Apo) E4, apolipoprotein E promotor gene, tau polymerase, and other genetic markers in the management of sports concussion risk or injury outcome is currently unclear[118, 191]. Further studies are needed in this area[1].

2.4.5. Experimental Concussion Assessment Modalities

Different electrophysiologic recording techniques (e.g.: evoked response potential [ERP], cortical magnetic stimulation, and electroencephalography) have demonstrated reproducible abnormalities in the post-concussive state. However, not all studies reliably differentiated concussed athletes from controls[92, 139, 140, 163, 164, 215, 216]. Concussed athletes, despite functioning normally in their daily lives, showed subtle neuronal changes indicative of persistent sub-clinical abnormalities on ERP, potentially leaving the athlete vulnerable to subsequent concussion[217]. The exact clinical significance of changes in electrophysiological responses following concussion remains to be established.

A recent study testing such a device, still in the developmental stages, showed that athletes with concussion followed the typical course of clinical and cognitive recovery within the first week of injury. The quantitative electroencephalographic (QEEG) results, however, suggested the duration of physiological recovery after concussion extended longer than the observed clinical recovery.

With further research the utility of QEEG as a marker of recovery for concussion may be developed[218].

Biochemical serum and cerebrospinal fluid markers of brain injury have been proposed as indicators of cellular damage in concussion[23, 32, 40, 99, 127, 166, 219]. There is currently insufficient clinical evidence to justify the use of these markers in the assessment or management of a concussed athlete[1].

Summary of the Literature: Concussion Investigations

Different brain regions and systems serve different cognitive domains. Concussion may affect various neural networks; therefore every test in a concussion battery is unlikely to be significant in a particular sample group or even individual. This emphasises the importance of using a multifaceted approach when evaluating and managing concussion. Collectively, the evidence discussed highlights the options available, and reiterates the current recommendations that neuropsychological tests, including SAC or SCAT2, be used in conjunction with symptom checklists, postural stability tests and a clinical examination as the most thorough evaluation for a concussed player[1, 121, 173, 184, 220, 221]. These investigations may be repeated during the recovery phase to monitor the athletes' progress[1]. The combined results enable the practitioner, together with the coach and athlete, to make informed decisions as to when the athlete, may safely RTP[1]. The 'rest' or 'recovery' period, that is the time between sustaining a concussion and returning to sport[1], has been referred to throughout this review. The next section will discuss the management of the athlete during this period.

2.5. CONCUSSION MANAGEMENT

The goals of managing an athlete with a concussion include the prevention of catastrophic outcomes, to ensure a safe RTP, to minimise the time away from competition, and to decrease the risk of second impact syndrome or a more severe head injury. The main components of concussion management are physical and cognitive rest[1].

2.5.1. Rest

Rest is an important component in the management of concussion injuries. Exercise or physical activity modulates glucose uptake in the brain and increases cortisol in a dose-dependant manner,

thereby worsening the metabolic 'mismatch' following concussion[222]. In addition, both physical and cognitive exertion may alter metabolic activity of the brain[223-225]. The exacerbation of post-concussive memory deficits and processing speed has been demonstrated after cognitively demanding tasks[224].

Rats that engaged in voluntary exercise early after concussion performed poorly on tasks of learning acquisition and memory, compared to rats that rested, and where voluntary exercise was delayed after concussion[226]. In a retrospective cohort study, athletes that had sustained a concussion injury were classified into groups according to their level of post-concussion activity. Athletes in the high activity group, which included attending school and participating in some sport, performed poorly on post injury assessments when compared with the group of athletes involved in no school or exercise activity. Interestingly, this study showed that athletes involved in a moderate level of activity, which included attending school and participating in very light home chores, performed best on post injury neuropsychological tests and had faster symptomatic recovery times. It was speculated that the group of athletes participating in no activity had sustained more severe concussion injury, and their poorer neuropsychological performance and longer recovery time may be associated with the extent of the original concussion injury. In contrast, athletes in the high activity group may have sustained a less severe concussion initially; however the continued high levels of activity may have worsened the concussion effect. It is also recognised that the retrospective study design may have limited both the determination of the grade of the concussion, and the control of post injury activity variables within groups[121]

It is recommended that concussed athletes should reduce any task that requires concentration post-concussion, as cognitive activity may exacerbate symptoms and delay recovery[1, 40]. Based on the evidence and guidelines for rest following concussion, the IRB had proposed a mandatory 'stand-down' period of three weeks for all rugby players with concussion *(Figure 2.2)*[6]. However, the IRB are currently changing this ruling to comply with the most recent Zurich Consensus Statement[1], where a concussion injury should be treated individually and follow the recommended Stepwise RTP protocols[227, 228]. The three week stand down period was also adopted by SARU[48], and to date there has been no indication from SARU regarding changes to this ruling.

International Rugby Board Regulation 10.1 Concussion
10.1.1 A Player who has suffered concussion shall not participate in any Match or training session for a minimum period of three weeks from the time of injury, and may then only do so when symptom free and declared fit after proper medical examination. Such declaration must be recorded in a written report prepared by the person who carried out the medical examination of the Player.

10.1.2 Subject to sub-clause 10.1.3 below, the three-week period may be reduced only if the Player is symptom free and declared fit to play after appropriate assessment by a properly qualified and recognised neurological specialist. Such declaration must be recorded in a written report prepared by the properly qualified and recognised neurological specialist who carried out the assessment of the Player.

10.1.3 In age grade rugby the three-week minimum period shall be mandatory. It is the responsibility of coaches and club administrators, in conjunction with medical practitioners to ensure that these requirements are closely observed.

If referees are doubtful as to the ability of a player to continue in the game they should apply the provisions of Law 3.9, which requires that player to leave the field.

Figure 2.2: IRB Regulation 10. Medical[6]

2.5.2. Pharmacological Interventions

There are currently no evidence-based pharmacological treatments for concussion[127]. Certain pharmacological agents, including corticosteroids, calcium channel blockers, anti-oxidants, and glutamate receptor antagonists, may potentially influence the underlying neurometabolic cascade of concussion. Pharmacological interventions may also be used in the treatment of post-concussive symptoms. Headaches may be treated with mild analgesics that do not influence the potential for bleeding, for example paracetamol. Nausea may be treated with anti-emetics, prolonged dizziness with anti-vertigo agents, and cognitive or attention deficit with neurostimulants such as methylphenidate. Further, pharmacological interventions for prolonged post-concussive symptoms should be monitored by the multidisciplinary team, including neurologists and neuropsychologists[23, 127, 229]. Depression has been reported as a long-term consequence of traumatic brain injury, including concussion[1]. If antidepressant therapy is used for the management of concussion, the decision to RTP while using medication should be carefully considered by the multidisciplinary team[1]. An important consideration in RTP is that concussed athletes should be symptom free, and should not be using any medication to appear asymptomatic.

2.5.3. Return to Play

The majority of concussed athletes will recover spontaneously over several days[1]. It has been established that 48% of concussed players are able to safely RTP in less than seven days after the initial injury[18]. However, previous studies reported that some athletes RTP with residual neurologic symptoms, while other athletes resumed sport without medical clearance[34]. Athletes have reported returning to play and playing while dizzy[31], or playing with a headache after a concussion injury[31].

A number of guidelines have been proposed for RTP following concussion *(Table 2.6)*[37]. There are several negative factors associated with universal mandatory exclusion criteria. It may be assumed that players have completely recovered from concussion following the mandatory rest period and that a medical assessment is not required. However, cognitive deficits may still be present in the

absence of apparent symptoms[186, 206]. Post-concussion recovery rates vary considerably between individuals[38, 105, 117, 137, 230], with recovery times from days to weeks after the initial injury. Individual factors associated with each concussion injury are different and recent evidence suggests that genetic factors may be involved in both the response to head injury and recovery rates[4, 24, 71, 118]. The risks associated with RTP before full recovery are unclear[80]. Concussion negatively influences reaction times and decision making, therefore on field decisions may be delayed or erroneous, which may increase the risk of recurrent injuries[80].

Table 2.6: Return-to-Play Guidelines

Progression from "Old" to "New"	***Severity of Concussion***		
	Mild	***Moderate***	***Severe***
Colorado Medical Society 1990[82]	RTP if asymptomatic (no PTA) after at least 20 minutes	RTP in 1 week if asymptomatic	RTP not before 1 month and then only if asymptomatic for a least 2 weeks
American Academy of Neurology 1991[83]	RTP is no symptoms in 15 minutes	RTP in 1 week if asymptomatic	RTP in 1 week if LOC was brief, 2 weeks if LOC was prolonged
Cantu[86, 87, 107] 1st concussion	RTP if asymptomatic for 1 week	RTP in 2 weeks if asymptomatic for 1 week	Terminate season, may RTP next season if asymptomatic
2nd concussion	RTP is asymptomatic for 1 week	RTP not before 1 month and only then if asymptomatic for 1 week	Terminate season, may RTP next season if asymptomatic
3rd concussion	RTP not before 1 month and only then if asymptomatic for 1 week	Terminate season, may RTP next season if asymptomatic	
3rd International Conference on Concussion and Sport, Zurich 2008[1]	No concussion grading, the majority of concussions (80-90%) will resolve in a short (7-10 day) period. Recovery time may be longer for children and adolescents.[40] Athletes must be cognitively and physically asymptomatic prior to commencing a graduated, stepwise RTP		

Table Abbreviations:
RTP – return-to-play
PTA – posttraumatic amnesia
LOC – loss of consciousness

Current RTP guidelines therefore recommend baseline cognitive evaluations for all athletes participating in contact sport[1]. This allows for the individual assessment of post-concussion symptom elevation and cognitive dysfunction, compared to arbitrary classification according to a retrospective scale[23, 80, 122, 231]. Further, the latest stringent Stepwise RTP following concussion *(Table 2.7)*[1, 4, 39, 40, 166, 232] includes progressive exposure of the recovering player to increasing degrees of exercise intensity while monitoring their symptoms[4, 38-41, 71].

A safe RTP is ensured when the player is asymptomatic, with a normal neurological examination and neuropsychological data. There is currently no consensus regarding the effects of multiple concussion injuries, and therefore caution should be exercised when clearing athletes with multiple

concussions for RTP[77, 233]. In addition, athletes with any residual neurologic symptoms post-concussion should be strongly encouraged not to RTP[67].

Table 2.7: Stepwise Return-to-Play[1]			
Rehabilitation Stage		***Functional Exercise at Each Stage of Rehabilitation***	***Objective of Each Stage***
1.	No activity	Complete physical and cognitive rest	Recovery
2.	Light aerobic exercise	Walking, swimming, or stationary bicycle, keeping intensity to < 70% of maximum predicted heart rate, no resistance training	Increase heart rate
3.	Sport-specific exercise	Skating drills in ice hockey, running drills in soccer and rugby for example. No contact, no head impact activities	Add movement
4.	Non-contact training drills	Progression to more complex training drills, agility drills, e.g.: passing drills in rugby, may start progressive resistance training	Exercise, coordination and cognitive load
5.	Full-contact practice	Following medical clearance, participation in normal training activities	Restore athlete's confidence, coaching staff assesses functional skills
6.	Return to play	Normal game play	
	The athlete should proceed to the next level provided asymptomatic at that current level, generally taking 24 hours per level. If any post-concussive symptoms occur the athlete should drop back to the previous asymptomatic level and try to progress again once 24 hours of rest has passed. This should take the athlete approximately 1 week to proceed through the rehabilitation protocol.		

Athletes frequently return to competition earlier than what is recommended[37, 234]. Factors contributing to the premature RTP may include a lack of knowledge of the current guidelines; emotional pressure from various sources, including coaches, managers, media, and parents to RTP; or simply non-compliance to the guidelines[120, 234]. The RTP guidelines recommend three categories for the assessment of readiness to RTP, including symptom checklist, neuropsychological testing, and the assessment of postural stability (for example, BESS). It has been determined that less than 3% of athletic trainers (coaches) used all three categories when assessing readiness for RTP. Approximately 24% of trainers used two categories, and 80% of trainers used only one category when making RTP decisions[22, 235]. Complete symptom resolution, normal cognitive function and postural control remain important considerations for ensuring safe RTP[1, 124].

Summary of the Literature: Concussion Management

The literature discussed in this section has emphasised the importance of appropriate rest in the management of concussion. It has also highlighted the negative effects of both physical and

cognitive activity on concussion symptoms and subsequent recovery rates. Although blanket stand down periods are no longer recommended, SARU have yet to indicate any changes in rulings on mandatory rest periods for rugby players. This may result in conflict between players, coaches, medical staff and the authorities as to which regulations to follow. Although rugby laws have not changed regarding concussion management protocols, current literature illustrates a clear management plan for each individual concussion that includes complete rest, followed by a progressive stepwise return to exercise and contact activities once clinical symptoms, neuropsychological and postural control deficits have resolved[1]. To date changes in rugby regulations have focused on technique, player safety and potentially the prevention of concussion injuries. This will be discussed further in the following section.

The evidence has highlighted the potentially grave consequences and long-term complications of concussion. The importance of identifying a concussion injury, and the management to ensure player safety, has been discussed. Despite this, there is no one treatment that can directly reduce the concussion effect or long-term consequences, or speed up the recovery process. Conceivably the best intervention for an athlete would be the prevention of a concussion injury. As mentioned above, this will be discussed further in the next section.

2.6. PREVENTION OF CONCUSSION

The brain cannot be trained to withstand injury and therefore extrinsic methods of injury prevention are essential. The use of protective equipment, safe rugby techniques and education may reduce the risk of concussion in rugby[18, 23, 42-44, 51, 52, 81, 92, 219, 236].

2.6.1. Equipment

It is proposed that wearing headgear may reduce the risk of concussion injuries through the attenuation in impact forces, a reduction in acceleration at the point of impact, the distribution of force over a larger surface area, and protection against abrasions[92, 237]. However, current evidence suggests that although headgear provides protection from lacerations and abrasions, it provides limited protection against impact injuries such as concussion[81, 92], and is minimally effective in the prevention of concussion[88, 238, 239]. In contrast, a recent study showed that the use of headgear may be associated with a reduced incidence of concussion[18]. Further, players wearing headgear had less concussion symptoms, compared to players not wearing headgear[117, 240]. An increased foam density and foam thickness of between 10 to 16 mm may improve headgear performance[241].

Rugby players and coaches are also not convinced that headgear assists in the prevention of concussion[242]. Finch et al[243] determined that youth rugby players felt more confident wearing headgear and therefore tended to tackle harder. It has been noted that a differential behavioural response to protective equipment in children may exist, with some children displaying increased risk behaviour and aggressive playing styles when using headgear, thereby increasing the risk of a concussive injury[23, 243-246]. Therefore, wearing headgear seems effective in preventing or reducing orofacial injuries and abrasions; however the safety and efficacy in preventing concussion injuries has not been clearly established.

Evidence for the use of mouth guards preventing concussion is inconclusive[23, 81, 219, 236]. It is postulated that custom fitted mouth guards may decrease forces transmitted to the brain through the absorption of impacts to the mandible, distraction of the tempero-mandibular joint, and increased tension of the neck muscles from biting down on the guard, which results in decreased acceleration of the cranium on the neck. It has also been suggested that strengthening and conditioning of the neck muscles, together with law changes, may also reduce the incidence of concussion[85].

The wide variety of protective equipment from headgear, mouth guards, body armour, and bracing may improve the overall safety of rugby[1]. The general consensus is that players should be

encouraged to use the available protective equipment, mostly due to its apparent ability to reduce minor injuries, if properly fitted and worn. However, it is important to recognise that studies have not conclusively found headgear and / or mouth guards to be effective in reducing concussion injuries. In addition, the attitude of the player should be considered when using protective equipment, particularly in younger players in relation to greater injury risk associated with more competitive play[23, 81, 219, 236, 243-246]. Players should be educated regarding the appropriate use, risks and benefits of protective equipment[1].

2.6.2. Technique and Training

Tackling is associated with the highest incidence of concussion injuries[7-9, 60, 67, 69-72]. A lack of skill from the tackler has been highlighted as a risk factor for catastrophic cervical injuries and concussion[68, 125, 247], and as the primary reason for a much higher rate of tackling injuries sustained amongst school rugby players[7]. It is therefore important, especially at lower levels, to teach the basics of safe and effective tackling techniques, with the primary emphasis placed on the head and neck position in the tackle. Players should be coached to place their heads in the safest area when tackling, (e.g. place the head behind the buttocks of the ball carrier) and ensure that the face is always up when performing a side-on tackle[248-250].

Approaching the tackle half-heartedly may place the tackler at greater risk of injury. Greater differential impact between the tackler and the player being tackled is a major risk factor for injury to the player with less momentum. This emphasises the need to dominate the tackle situation to minimise the risk of injury. Dominating the tackle situation requires the tackler to close down the space between himself and the attacking player while ensuring a powerful leg drive into the tackle. Shortening steps before contact, driving forcefully with the shoulder on the same side as the leading leg, and hitting into the trunk is the safest and most effective way to execute a tackle[247, 251, 252]. High speed going into the tackle, high impact force, collisions and contact with a player's head/neck were identified as significant risk factors for ball carriers and tacklers. Evasion techniques such as oblique running and forward stepping will reduce the magnitude of the collision forces, thereby decreasing the effectiveness of the tackle and will increase the safety and effectiveness of the ball carrier. Ball carriers should not run directly at defenders, as this will increase the risk of injury[249, 251, 253].

The second half of the match may be associated with the onset of fatigue and coincides with the highest incidence of concussion injuries[9, 57, 60] Further, it has been determined that there are

differences in effective tackling techniques in fatigued and non-fatigued states[254]. This highlights both the importance of conditioning, and practicing safe and effective tackling techniques under fatigued conditions.

Stricter implementation of the laws of rugby relating to collisions and tackles above the line of the shoulder and 'spearing' may reduce the incidence of head and neck injuries[255]. The risk of tackle-related injuries may be further compounded by poor player knowledge of high-risk contact situations, and a lack of training time focusing on safe tackling techniques and falling techniques [42]. In school rugby, 20% of cervical spine and concussion injuries were sustained by a substitute who was filling in for an absent player and playing outside of their usual position, or when trying a new position for the first time[30, 42]. This emphasises the importance of coaches' knowledge regarding safe tackling and falling techniques that may facilitate a reduction in the risk of concussion[42-44].

2.6.3. Education Programmes and the Role of the Coach

Education of the multidisciplinary medical team, coaches and players is essential for the prevention of concussion injuries, and to maximise player safety during training and competition[11]. Education should include the identification of concussion, management of concussion injuries and the principles of safe RTP[1, 4, 39, 40, 256-258].

A survey conducted in Townsville, Australia, indicated that rugby coaches total injury knowledge score increased in relation to the level of coaching experience, measured as the total number of seasons coached[55]. Coaches with a current first aid qualification were also more likely to identify an injury and administer early management[55]. It was also established that coaches in junior rugby union required education regarding the mechanisms of injury and procedures for early management of rugby injuries[55]. This survey did however have a small sample size of 35 coaches and may not be a true representation of all youth coaches' injury knowledge. In another study, although knowledge of concussion was not assessed, it was recognised that head and neck injuries frequently occur concurrently[259]. Senior school rugby coaches in Ireland lacked knowledge of the prevention, recognition and management of cervical injuries[259]. Further, only 50% of coaches, that being only 18 coaches, had a first aid qualification, and only 47% carried first aid equipment required to manage cervical injuries at matches. Over 50% of schools did not have cervical collars, and 83% of the schools did not have stretchers[259]. Although small surveys regarding coach numbers, the findings begin to highlight the possible need for better first aid facilities and further education of coaches.

A survey of 29 Western Cape schools showed that 45% of the schools had either no or inappropriate stretchers available, 35% did not have splints to immobilise a limb and 59% did not have cervical braces. Thirty eight percent of the schools did not have a doctor or first aid personnel

present at rugby matches, and relied on the rugby coach for medical support. Furthermore, only 62% of all first team rugby coaches had some training in first aid and the management of rugby injuries. Of the 38% of coaches that had not received first aid training, 73% provided medical support during training and matches. In addition, 80% of coaches were unaware that an unconscious player should be treated as if he has an unstable cervical injury[35]. Although this study was conducted in 1984, no study has been published since with more recent updates on either school facilities or coaches' rugby injury knowledge. The study did highlight the necessity in South Africa for both improved facilities and training of coaches in school rugby[35]. In some cases rugby may be played without any medical support, however it is also apparent that where medical personnel are present they may not be adequately trained to recognise and manage concussion and other rugby injuries[81].

The coach has an important role in the multidisciplinary team. The coach has frequent contact with the players and has the opportunity to establish trusting relationships with players. These relationships may facilitate accurate reporting of injuries or symptoms. The coach may also be able to identify subtle changes in player behaviour and demeanour, which may assist in the identification of concussion[37].

Players have indicated that they obtained information about concussion from teachers or coaches (53%), medical personnel (41%) and other players (24%)[34]. This further emphasises the importance of both player and coach education regarding concussion[46, 47, 260]. Adequate training in the recognition and correct management of a concussed player may also protect coaches from medico-legal liability[261].

The central role of the coach in injury prevention and management has led to the development of numerous educational tools, including web-based resources, educational videos and DVD's, and workshops[1, 262]. RugbySmart, a rugby injury and training education programme for coaches and managers was first introduced by the New Zealand Rugby Union[50]. This incorporated a concussion management education programme (CMEP) that included the minimum best practice for the management of suspected concussion injuries. There was a significant reduction in the number of reported concussions, as well as a decrease in the time taken for an athlete to seek medical attention following the education programme[51, 52]. The success of RugbySmart led to the development of other safety education programme in Australia (SmartRugby)[49] and South Africa (BokSmart)[48].

The South African Rugby Union established BokSmart with the primary aim to provide rugby coaches with the correct knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby in South Africa. The education

programme incorporates safe rugby techniques and basic medical and injury prevention practices. Numerous barriers to the education programme have been identified, including the demographics of facilitators and coaches, language barriers, expense, geographic location of coaches and accessibility to learning centres. One of the major challenges that limited participation in the programme was the fear of failure. Therefore an assessment for accreditation purposes was removed from the programme, and currently the only criteria for the licensing of coaches is workshop attendance. To date, not all rugby coaches in South Africa have attended the BokSmart workshops, which were initiated in 2008[48]. Formal training of coaches and referees was initiated in July 2009[263]. However, following the announcement of the new SARU regulation, making attendance of a BokSmart Safety Workshop compulsory to coach rugby from January 2011[264, 265], there was a sudden increase in coach and referee attendance at these workshops[48]. In New Zealand and Australia the completion of the RugbySmart[50] or SmartRugby[49] courses respectively are pre-requisites to attend accredited coaching courses. In addition, refresher courses are mandatory every two years to provide coaches with the latest evidence-based medicine practice regarding injury prevention and management. From January 2011, 'refresher' BokSmart courses will be mandatory for South African rugby coaches every two years[265].

Coaches are also required to be informed of the laws of rugby, and may minimise the risk of concussion injuries by ensuring that the laws are correctly implemented in the field of play. In addition, coaches have an important role in maintaining and encouraging ethical values of fair play and respect for opponents, which may decrease the risk of injury associated with illegal play[1, 33, 34, 51, 232, 266-268].

Given the importance of coaches in delivering training programmes and other safety initiatives to players, as well as their possible role in having to identify and make management decisions about a concussion injury, it is surprising that there have been very few studies assessing coaches injury prevention practices, safety promotion and general injury or concussion knowledge. Essentially there are only three studies assessing coaches concussion knowledge, all of which were coaches involved in American football[260, 266, 267]. Rugby coaches have been surveyed regarding general injury knowledge and serious cervical spine injury knowledge[36, 55, 259], but not specifically concussion injuries. Regardless of this all studies concluded that coaches, specifically youth coaches, required further education about concussion and rugby injuries.

Summary of the Literature: Prevention of Concussion

Current literature suggests that preventing a concussion may be the best way of protecting the brain from injury[1]. The evidence has shown that the use of equipment in rugby has no significant

effect on reducing concussion[23, 81, 92, 219, 236]. However, teaching safe tackling and falling techniques may reduce the risk of injury[42-44]. In addition, educational programmes for coaches may improve the coaches' ability to identify and manage a concussed player, thereby ensuring player safety[51, 52]. The evidence emphasises the central role of the rugby coach in reducing concussion injuries. The coach is instrumental in teaching the player safe rugby techniques, as well as disseminating information about concussion signs and symptoms and concussion management to the player; thereby allowing the coach and player to work together on early identification of concussion and safe RTP[1, 33, 34, 51, 232, 266-268].

2.7. SUMMARY OF THE LITERATURE: THE IDENTIFICATION, MANAGEMENT AND PREVENTION OF CONCUSSION IN RUGBY

It is therefore evident that concussion injuries are common in rugby due to the physicality and aggressive nature of this contact sport[8, 13, 14, 16-20]. Concussion injuries occur at all levels of play and across all age groups[77, 78]. A concussion is a complex pathophysiological injury involving various brain regions and neural pathways, resulting in a combination of somatic, cognitive and emotional signs, physical symptoms and behavioural changes[1]. The potential severity of a concussion injury is not only evident in cases with catastrophic outcomes, but also in studies that have identified long-term brain damage and prolonged impairment in cognitive function particularly with repeated concussion injuries[4, 5, 9, 24, 25]{#58, 26-28].

There has been much recent progress with regards to the diagnosis, grading, RTP guidelines and testing protocols for sports-related concussion[1]. The series of international consensus statements since 2001 appear to not only have consolidated expert opinion into a more unitary model, but exponentially spurred research and interest in the field[1, 4, 40]. Clear guidelines on the identification and immediate management of concussion have been published, with player safety the primary goal. The use of multiple assessment tools to aid in the diagnosis and management of the player is advocated. This is due to the complexity of the brain, whereby one instrument is unlikely to assess the numerous systems affected by a concussion injury[1, 4, 22, 39, 40]. The negative effects of premature RTP on physical symptoms and cognitive function, and the increased risk for subsequent concussion injuries have been identified[67, 77, 80, 233]. The dissemination of information, and the implementation of management guidelines and compliance with stepwise RTP protocols are current challenges in the field of sports-related concussion[1, 4, 40].

Although the risk of sport-related concussion does not outweigh the many benefits of sport participation, preventative interventions should be implemented to decrease concussion rates to the lowest possible level. The use of protective equipment has little benefit in rugby, however

research has shown that safe tackling and falling techniques can reduce the risk of injury[23, 43, 44, 81, 92 {#81, 219, 236]. Educational workshops that teach coaches about the identification and early management of a concussed player, as well as safe RTP protocols have resulted in a significant reduction in the incidence of concussion injuries[51, 52].

The rugby coach has a pivotal role in concussion identification, management and prevention, particularly in the South African context where the rugby coach is often responsible for medical emergencies at practices and matches [1, 33, 34, 51, 232, 266-268]. The study, to be discussed in Chapter Three, was designed to establish South African rugby coaches' knowledge of prevention, identification and management of concussion. The information gained from this study will also establish factors that predict South African rugby coaches' knowledge of concussion, which may inform further development and implementation of effective educational programmes for South African rugby coaches'.

CHAPTER THREE

SOUTH AFRICAN RUGBY COACHES' KNOWLEDGE OF THE PREVENTION, IDENTIFICATION AND MANAGEMENT OF CONCUSSION

INTRODUCTION

The high reported incidence[8, 18-20, 53-58] and complex clinical presentation of concussion injuries has resulted in numerous consensus statements regarding the prevention, diagnosis and management of concussion[1, 4, 39, 40, 71, 79]. These consensus statements are continually evolving, but consistently identify the importance of early and accurate identification of concussion, and the prevention of primary injury and secondary complications.

As discussed in the literature review, the rugby coach has a central role in general player safety and more specifically, in the prevention, identification and management of concussion injuries. This is particularly evident in the South African context, where training and competition are often conducted in the absence of medical professionals[35, 42].

Further, training and educational programmes for rugby coaches have been established to improve coaches' injury knowledge and rugby safety[46, 47, 49, 50, 262]. Concussion education has been successful in other rugby playing nations, with significant reductions in the number of reported concussions since initiation of these programmes[49-52]. However, in South Africa similar programmes have only recently been implemented and the efficacy of these programmes has not been determined[48]. In addition, the programmes may not be accessible to the broader rugby community, particularly for coaches in outlying rural areas where rugby is played informally. Accordingly, the purpose of this study was to determine current levels of coaches' knowledge regarding concussion, and to investigate factors, including educational programmes, that may influence concussion knowledge.

3.1. AIMS & OBJECTIVES

3.1.1. Aim

The aim of the study was to determine South African rugby coaches' knowledge of the prevention, identification and management of concussion.

3.1.1.1. Specific Objectives

1) To determine whether rugby coaches have adequate knowledge of the prevention, identification and management of concussion.
2) To determine whether rugby coaches are able to manage players with concussion safely.
3) To determine factors that may predict rugby coaches' knowledge of the prevention, identification and management of concussion. Predictive factors investigated included coaching qualifications, number of years of coaching experience, level of coaching, and course attendance.

3.2. METHODS

3.2.1. Participants and Study Design

The study had a descriptive correlational design. The study was submitted and approved by the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town (HREC REF: 114/2010) *(Appendix III).* Eight hundred and fifty-two participants were requested to volunteer for this study. Participants were recruited through electronic or written correspondence informing them of the study. All participants were required to complete an informed consent form prior to completing the questionnaire *(Appendix IV)*. The informed consent form explained the purpose and procedure of the study, how confidentiality would be ensured, and the right to withdraw from the study without reason or prejudice.

3.2.2. Sample Size Calculation

In the absence of more definitive data regarding coaches' knowledge of the diagnosis and management of concussion, the prevalence of concussion injuries was used to calculate the required sample size for this study. This was used as a proxy to ensure that the sample would include participants who had been exposed to concussion. An expected frequency of 40% was selected based on previous studies, which report the incidence of concussion injuries of 20% to 55%[8, 17-20, 31]. If the worst expected frequency was 35%, with 95% confidence intervals, the required sample size was 228. Previous questionnaire-based studies have reported response rates of 35% to 55%[35, 55, 235, 259, 266, 267, 269]. Therefore 852 volunteers were recruited for this study, based on an estimated response rate of between 25% and 30%, to ensure sufficient statistical power.

3.2.3. Inclusion Criteria

Male rugby coaches over the age of 18 years were included in the study. Participants were required to be actively engaged in rugby coaching at school, club, or provincial level.

3.2.4. Exclusion Criteria

The rugby coaches for national teams were excluded from the study, due to issues relating to confidentiality, and the lack of generalisation of data. 'Girls only' schools and women's rugby were excluded from the study, as the laws of contact differ from men's rugby and there are no statistics on concussion injuries in women's rugby. In addition, any questionnaires returned with incomplete informed consent forms were excluded from the study.

3.2.5. Recruitment

A contact list of all the schools in South Africa was obtained from the Department of Education. Similarly, contact details of rugby clubs and provincial rugby coaches were requested and obtained from the South African Rugby Union (SARU) and the respective provincial franchises. In addition, based on input from the BokSmart chief medical advisors, schools that were classified by the Department of Education as rural or farm schools were removed from the list. This was due to a lack of contact details for the schools, and a lack of knowledge of whether rugby was played in an informal, social setting compared to the structured leagues of the urban schools. The remaining sample consisted of 12875 'boys only' and co-education schools.

The schools however were not equally distributed across the South African provinces. There would have been a subsequent skewed representation had an equal number of schools been randomly selected from each province. A relative percentage per province was calculated from the 12875 schools *(Table 3.1)*. Accordingly, a specific number of schools were then randomly selected from each province to give a fair distribution across the country. From the total pool of potential participants to be recruited for the study, rugby clubs represented approximately 10% (1 264 clubs and 12 875 schools).

Figure 3.1: Political Map of South Africa Depicting the Nine Provinces

Table 3.1: Calculation of the Required Number of Schools, per Province, for Random Recruitment Process

Province	*Number of Boys & Co-Education Schools*	*Provincial Representation versus National Total (%)*	*Required number of schools for random selection/ province*
Limpopo	583	4.5	33
Eastern Cape	1871	14.5	104
Free State	1036	8	58
Gauteng	2402	18.6	133
Kwa-Zulu Natal	1195	9.2	67
Northern Cape	426	3.3	26
North West	1977	15.3	110
Mpumalanga	2290	17.7	127
Western Cape	1095	8.5	62
Total:	**12875**	**100**	**720**

As described above, a sample size of 852 volunteers was required for this study. With an average of four provincial coaches per 'rugby province' in South Africa, the potentially small sample size required that all of the 52 provincial coaches were requested to participate in this study. Eighty club rugby coaches (a 10% representation of the total number of coaches required for the study) and 720 school rugby coaches were then randomly selected to participate in the study *(Table 3.2).* All rugby clubs were allocated a number, and 80 clubs were randomly drawn from a concealed bag. Schools were selected using the same procedure. The number of schools randomly selected for each province was in accordance with Table 3.1 above.

Table 3.2: Total Number of Coaches Contacted to Volunteer to Participate in the Study

Provincial Coaches	52
Club Rugby Coaches	80
School Rugby Coaches	720
Total number of coaches:	**852**

Individual coach's details were requested from the randomly selected schools, rugby clubs, and rugby franchises. Participants were recruited through electronic or written correspondence informing them of the study and requesting voluntary participation *(Appendix IV)*. The recruitment process; from initial contact with the Department of Education, Rugby Clubs and Rugby Franchises; to the point of acquiring coaches contact details spanned five months.

3.2.6. Concussion Questionnaire

A questionnaire was designed to assess rugby coaches' knowledge of the prevention, identification and management of concussion *(Appendix V)*. The questionnaire design was based on past coach questionnaires and current concussion literature. *Each section of the questionnaire is clearly referenced and should be referred to for more information* (*Appendix V*, page 114). The questionnaire was divided into sections to assess different aspects of concussion knowledge and associated factors that may predict knowledge. Section A was descriptive, and included questions regarding the level of coaching and coaching experience. Section B assessed first aid qualifications and the level of coaching education. Section C determined the use of different training techniques that may assist to prevent concussion. Section D specifically assessed the level of concussion knowledge and the identification of concussion. Sections E, F and G investigated knowledge regarding the management of concussion, consequences of concussion and safe RTP protocols respectively.

The questionnaire was translated into Afrikaans and IsiXhosa, and was forward- and back-translated to ensure content, technical and semantic equivalence. The translators were both first language Afrikaans and IsiXhosa speaking respectively, and were high school educators of learners with English first language. In addition, the questionnaire had a Flesch Reading Ease of 55, and a Flesch-Kincaid Grade Level score of 8.8, which indicated that the text should be understandable by an average student in the 8th grade.

3.2.6.1. Validity of the Concussion Questionnaire

A panel of nine experts within the field of sports concussion reviewed the questionnaire to ensure content validity. Content validity is the degree to which an instrument explores all areas identified by the literature[276]. The validation panel included two members of BokSmart (SARU Coach Education programme), a neurologist from Impact, three sports medicine physicians from the South African Concussion Unit, a medical doctor for a Currie Cup provincial rugby team, a sports physician on the board of the South African Sports Medicine Association (SASMA) and a sports physiotherapist. The validators were requested to comment on the relevance and importance of questions, and whether the questions were clear and easy to understand. The validators were also asked to indicate whether they agreed with the correct answers and the ranking of responses that were provided. In addition, the validators were requested to give input regarding areas or questions that had not been included in the questionnaire, and that may contribute to the assessment of knowledge of concussion *(Appendix VI)*.

All nine experts from the validation panel returned the questionnaires. The majority of feedback was related to language simplification of some questions, and the inclusion of explanations for certain medical terms, and appropriate adjustments were made to the questionnaire. There was agreement that two questions regarding RTP protocols and a player being 'medically cleared' were ambiguous and potentially confusing to coaches. The questions were combined and re-worded to form question 47 in the questionnaire *(Appendix V).* One further question regarding long term consequences of concussion was vague and felt it had no real value in assessing coaches' knowledge of concussion. It was subsequently deleted from the questionnaire. Two questions regarding coaches' knowledge of the BokSmart Safety Workshop regulation for January 2011 (question number 9b) and the BokSmart Under-Age regulation (question number 9c) were added to the questionnaire. These questions were deemed pertinent to the new SARU coaching certification laws and safety laws for players. The panel of experts all indicated that the questionnaire was thorough and covered all components of concussion knowledge appropriate to rugby coaches.

3.2.6.2. Feasibility of the Concussion Questionnaire

Feasibility was established with a pilot study consisting of five rugby coaches. Participants included a junior school coach, two senior school coaches, a club rugby coach and a junior provincial rugby coach. The participants completed the questionnaire successfully, making appropriate indications for selected answers, and making multiple or numerical selections where applicable. The questionnaires and signed informed consent forms were returned electronically and via fax, indicating the coaches also understood the study procedure. Feedback from the coaches was obtained regarding comprehension and ease of completion of the questionnaire. No changes were made to the questionnaire following the feasibility study. These completed questionnaires were not included as part of the final sample of 229 questionnaires, and were therefore not included in the data analysis.

3.2.6.3. 'Adequate Concussion Knowledge'

One of the important objectives of the study was to determine whether rugby coaches had adequate knowledge of concussion. Therefore the panel of experts used to validate the questionnaire were contacted requesting their professional opinion on what would classify a coach as having '*adequate concussion knowledge*' (ACK) or '*inadequate concussion knowledge*' (ICK). The panel of experts were requested to identify specific questions from the questionnaire that comprised '*adequate knowledge*' *(Table 3.3)*.

A cut-off score for ACK, using a modified Angoff method, was established[270, 271]. The nine experts each recommended a minimum acceptable score expected of rugby coaches[272, 273]. Feedback was received from the panel and their suggestions were collated to determine a minimum ACK score of 75%. Anything less than 75% would classify that coach as having ICK. Therefore a minimum score of 107 was required to qualify a coach as having ACK *(Table 3.3)*.

Table 3.3: Questionnaire Scoring for Calculation of Coaches 'Adequate Concussion Knowledge' Score						
	Answer Options and [Score]					Max Score
Section C: Training Techniques						
Q16. Concussion most often happens during which phase of play	Scrumming [0]			Rucks [0]		1
	Mauls [0]			***Tackling [1]***		
	Lineouts [0]					
Q17. Do you teach safe tackling and falling techniques	***Yes, at every practice session [4]***			Yes, frequently during the season [3]		4
	Only in pre-season sessions [2]			No, I expect them to know this [1]		
	No [0]					
Q18. Teaching safe tackling and falling techniques can reduce the incidence of concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q19. Wearing soft-shelled rugby headgear can reduce the risk of concussion	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q20. Teaching players about the signs and symptoms, treatment and safe RTP will better aid the identification and management of concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Section D: Diagnosis of Concussion						
Q21. Concussion only occurs following a direct blow to the head	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q22. Acceleration – deceleration forces may cause concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q23. Loss of consciousness is the main diagnostic criteria for concussion	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q24. Concussion may also be termed 'mild traumatic brain injury'	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q25. From the list select any, and/or as many symptoms, which are indicative of concussion. • 18 correct symptoms at ½ mark each, max score 9 • 6 incorrect symptoms in the list, negative marking of - ½ mark per incorrect symptom selected	***Nausea***		***Headache***		***Feeling 'foggy'***	9
	Paraesthesia (tingling)		***Difficulty remembering***		***Drowsiness***	
	Sensitivity to light		***Aggressiveness***		Abdominal cramps	
	Thirst		***Vomiting***		***Sensitivity to noise***	
	Difficulty concentrating		Increased alertness		***Vacant, glassy eyes***	
	Diarrhoea		***LOC***		Heart palpitations	
	Dizziness		***Poor balance***		***Blurred vision***	
	'Just not feeling right'		***Confusion***		***Ringing***	
Q26. Radiology may be normal after a first concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q27. Routine questioning of person, time and place is a reliable test for rapid on field assessment of concussion	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q28. Have you ever heard of a SCAT/SCAT2 card	***Yes [1]***			No [0]		1
Q28a. Have you ever used a SCAT/SCAT2 card	***Yes [1]***			No [0]		1

Q28b. A Sports Concussion Assessment Tool card (SCAT) may be used to assist rapid on field assessment of concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q29. Balance tests may be used to assist rapid on field assessment of concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q30. Neuro-psychological tests alone may be used for sideline diagnosis of concussion	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Section E: Management of Concussion						
Q31. If a player is suspected of having a concussion he must leave the field of play immediately	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q32. Only a player with a 'severe' concussion, who lost consciousness, needs to leave the field	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q33. If a player left the field for concussion, but 'feels fine' within some minutes, he can safely return to the field	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q34. Choose the 2 people who have the ultimate decision on whether a player has to leave the field following a concussion	The Player [0]	The Coach [0]	The Parent [0]			2
	The Referee [1]	The Manager [0]	***Medical Staff [1]***			
Q35. A player with a suspected concussion should consult an appropriate medical doctor as soon as possible	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q36. A child or adolescent (under the age 18) is more vulnerable to concussion than an adult	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q37. A child or adolescent (under the age 18) requires a smaller impact force to sustain a concussion	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q38. The mainstay of treatment for concussion is	***Physical and Cognitive Rest [1]***	Physical Rest only [0]	Cognitive Rest only [0]	Medication for symptom relief [0]	Do not know [0]	1
Section F: Consequences of Concussion						
Q39. 2nd Impact Syndrome occurs when	A 2nd concussion occurs in the same match [0]	A 2nd concussion is sustained in the same season [0]	A 2nd concussion is sustained in a career [0]	***A 2nd blow to the head is sustained whilst a concussion has not yet resolved [1]***	All of the above [0]	1
Q40. The most serious consequence of 2nd impact syndrome is	No serious consequences [0]	Loss of consciousness [0]	3rd impact syndrome [0]	Post-concussion syndrome [0]	***Death [1]***	1
Q41. The most likely consequence for a child who suffers from more than one concussion in a season is	No serious consequences [0]	Loss of consciousness [0]	***2nd impact syndrome [1]***	Post-concussion syndrome [0]	Death [0]	1
Q42. The most likely consequence for an adult who suffers from more than one concussion in a season is	No serious consequences [0]	Loss of consciousness [0]	2nd impact syndrome [0]	***Post-concussion syndrome [1]***	Death [0]	1

Section G: Return to Play						
Q43. According to SA Rugby Concussion guidelines, if there is no access to a doctor to medically clear a player, a minimum 'stand down' period is stipulated for	1 week [0]		2 weeks [0]		***3 weeks [1]***	1
	4 weeks [0]		5 weeks [0]		Do not know [0]	
Q44. A child or adolescent (under the age 18) recovers faster from concussion and can therefore return to play sooner	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q45. A player who reports he is symptom free following concussion can return to practice that day	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q46. When a concussed player has been medically 'cleared' he can immediately resume full contact practice with his team	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q47. A player has to be examined by a medical professional, be symptom free throughout a stepwise, graded return to play protocol and be neuro-psychologically cleared before returning to match play	***Strongly Agree [5]***	Agree [4]	Do not know [3]	Disagree [2]	Strongly Disagree [1]	5
Q48. A player returns to play after a concussion and develops a headache. The management of choice would be pain-killers	Strongly Agree [1]	Agree [2]	Do not know [3]	Disagree [4]	***Strongly Disagree [5]***	5
Q49. If you were to use a Stepwise Return to Play protocol following a concussion, list these activities in the order you would have the player perform them. 1 being the first activity, through to 7, being the activity prior to match play (4 marks correct order, 1 out of order = 3 marks, 2 out of order = 2 marks, 3 out of order = 1 mark, > 3 out of order = 0 marks)	Activity				Order	4
	Tackle bags and contact allowed at full practice				***7***	
	Running and agility drills, no impact activities				***4***	
	Jogging, light running				***3***	
	Walking, stationary bicycle, swimming				***2***	
	Drills incorporating running and passing, co-ordination activities				***5***	
	Resistance training (lifting weights at the gym)				***6***	
	No activity, complete rest				***1***	
					Coach Score:	
					Max Score for Questionnaire:	**143**
					Percent %:	
					ICK < 75% ≥ ACK	**ICK / ACK**

* The correct or desired answers to score maximum points on the questionnaire, indicative of the coaches' level of concussion knowledge, are indicated in bold *Italics.*

3.2.6.3.1. Continued Education Score

A continued education score (CES) was calculated from a section of questions within the coach education section of the questionnaire to determine the level of continuing education among rugby coaches. Points were awarded for attendance at courses and workshops, online education, and access to other educational resources such as libraries, media and DVD's. The maximum continued education score was 25 points.

3.2.6.4. 'Safe Management of Concussion'

One of the important objectives of the study was to determine whether rugby coaches had sufficient knowledge of concussion to ensure player safety. Therefore the panel of experts used to validate the questionnaire were contacted requesting their professional opinion on what would classify a coach as having '*safe management of concussion*' (SMC). The panel of experts were requested to identify specific questions from the questionnaire that comprised SMC *(Table 3.4)*. The panel of experts were then required to score the SMC component of the questionnaire to establish the minimum score for SMC. Absolute standards are most appropriate for tests of competence, where the purpose is to establish that the participants know enough for a particular purpose[272]. As the standards are an expression of values, the most important contributors to their credibility are the number and nature of the experts deciding on this value. The literature recommends that a minimum of six to eight experts be consulted for this purpose[272-275]. In this study, nine experts (Section 3.2.6.1, page 54) were consulted. A modified Hofstee method was used such that the experts could specify a minimum (80%) and maximum (100%) acceptable cut-off for SMC scores[272]. When calculating the SMC score, the scoring for safety-related questions was adjusted such that each question had an equal weighting. Therefore a score of 22 was required to qualify a coach as having SMC (*Table 3.4*).

Table 3.4: Specific Questions for Calculation of Coaches 'Safe Management of Concussion' Score						
	Answer Options and [Score]					Max Score
Section C: Training Techniques						
Q17. Do you teach safe tackling and falling techniques	***Yes, at every practice session [2]***		Yes, frequently during the season [1]			2
	Only in pre-season sessions [0]		No, I expect them to know this [0]			
	No [0]					
Q18. Teaching safe tackling and falling techniques can reduce the incidence of concussion	***Strongly Agree [2]***	Agree [1]	Do not know [0]	Disagree [0]	Strongly Disagree [0]	2
Q20. Teaching players about the signs and symptoms, treatment and safe RTP will better aid the identification and management of concussion	***Strongly Agree [2]***	Agree [1]	Do not know [0]	Disagree [0]	Strongly Disagree [0]	2
Section D: Diagnosis of Concussion						
Q25. Selection of any and/or as many signs and symptoms of concussion From the coaches' original selection of Signs and Symptoms (S&S) for Concussion, they potentially scored a maximum of 9 points. For the Safety calculation they were then 'classified' according to their scores and allocated 0,1 or 2 points respectively	*A S&S score of 0 ≥ 'C' < 4.5* *C = 0 points*		*A S&S score of 4.5 ≥ 'B' < 7* *B = 1 point*		***A S&S score of 1. ≥ 'A' ≤ 9*** ***A = 2 points***	2
Section E: Management of Concussion						
Q31. If a player is suspected of having a concussion he must leave the field of play immediately	***Strongly Agree [2]***	Agree [1]	Do not know [0]	Disagree [0]	Strongly Disagree [0]	2
Q33. If a player left the field for concussion, but 'feels fine' within some minutes, he can safely return to the field	Strongly Agree [0]	Agree [0]	Do not know [0]	Disagree [1]	***Strongly Disagree [2]***	2
Q35. A player with a suspected concussion should consult an appropriate medical doctor as soon as possible	***Strongly Agree [2]***	Agree [1]	Do not know [0]	Disagree [0]	Strongly Disagree [0]	2
Q36. A child or adolescent (under the age 18) is more vulnerable to concussion than an adult	***Strongly Agree [2]***	Agree [1]	Do not know [0]	Disagree [0]	Strongly Disagree [0]	2
Section G: Return to Play						
Q43. According to SA Rugby Concussion guidelines, if there is no access to a doctor to medically clear a player, a minimum 'stand down' period is stipulated for	1 week [0]		2 weeks [0]		***3 weeks [2]***	2
	4 weeks [0]		5 weeks [0]		Do not know [0]	
Q44. A child or adolescent (under the age 18) recovers faster from concussion and can therefore return to play sooner	Strongly Agree [0]	Agree [0]	Do not know [0]	Disagree [1]	***Strongly Disagree [2]***	2
Q47. A player has to be examined by a medical professional, be symptom free throughout a stepwise, graded return to play protocol and be neuro-psychologically cleared before returning to match play	***Strongly Agree [2]***	Agree [1]	Do not know [0]	Disagree [0]	Strongly Disagree [0]	2
					Coaches Score / 22 (max):	
					Safety Score %	
* The correct or desired answers to score maximum points on the safety questions are indicted in bold *Italic*						

3.2.7. Procedure

Once the questionnaire was validated and the pilot study completed, participants were contacted through electronic or written correspondence informing them of the purpose of the study, and requesting their participation. The participants were required to give written informed consent *(Appendix IV)* before completing the concussion questionnaire *(Appendix V)*. All study information; informed consent forms and questionnaires were sent together on the first contact with the coach. This was done such that a coach who wanted to participate could do so with ease and time was not wasted with multiple communications, or the inconvenience of repeated contacts. The informed consent form and the concussion questionnaire were then returned to the investigator via email, post or fax. The questionnaire was also made available online using Survey Monkey® (www.surveymonkey.com). An independent assistant processed all returned questionnaires. The assistant confirmed that the informed consent forms were signed, and that the questionnaires were completed. The consent forms were filed separately from the questionnaires. The questionnaires were then allocated a code and handed over to the investigator. In addition, no contact details were included in the questionnaire, to further ensure confidentiality and anonymity. The questionnaires were stored in a locked filing cabinet, and only the investigator had access to the data. Coaches were given six weeks to complete the questionnaire. Two follow up contacts were made with coaches at three weeks and five weeks following the initial contact, reminding coaches of the study. Participants were encouraged to complete and return the questionnaires to ensure the highest possible response rate. A total of fifteen weeks was taken to collect the data, ensuring a sufficient sample size for significant outcomes. On completion of the questionnaire, participants were sent an information booklet about concussion as well as the SCAT2 pocket tool to assist with on field identification of concussion *(Appendix VII).*

3.2.8. Statistical Analyses

Statistical analyses were performed using Statistica software (StatSoft, Inc. 2004,STATISTICA (Data analysis software system, version 8. www.statsoft.com). Pearsons' chi-square measures of association and percentages were used for descriptive information. The descriptive data are presented as the mean and standard deviation (X ± SD). Parametric statistics were used to analyse the Likert scale questionnaire data. Although there is some controversy surrounding the preferred method of analysis for Likert scale data, current literature supports the use of parametric techniques with data that do not necessarily represent equal-interval values, particularly when the number of categories on the scale is five or more, as in this study[276]. Independent-samples *t* tests were performed to compare differences within groups. One-way analysis of variance (ANOVA) was used to determine differences between groups for questionnaire data, for example the effect of coaching level, years of coaching experience, attendance at courses and continued education on concussion knowledge and safety scores. Scheffe's *post-hoc* analyses were performed where necessary.

Multiple regression analyses were used to determine which variables were predictive of coaches' concussion knowledge and safety scores. These variables included coaching level, years of coaching experiences, first aid qualification, BokSmart certification and continued education score (CES). All variables were entered simultaneously and preliminary residual analysis was performed. Confidence intervals were 0.95 and statistical significance was accepted as $p < 0.05$.

3.2.10. Ethical Considerations

The study was performed in accordance with the principles of the Declaration of Helsinki (Seoul version, 2008). The study was submitted and approved by the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town (HREC REF: 114/2010) *(Appendix III).* All participants were required to complete an informed consent form prior to completing the questionnaire *(Appendix IV)*. The informed consent form explained the purpose and procedure of the study, how confidentiality would be ensured, and the right to withdraw from the study without reason or prejudice. All data was kept confidential and anonymous.

3.2.10.1. Risk to Participants

There was no risk to any participant, as no physical tests were carried out.

3.2.10.2. Benefits to Participants

All participants were provided with an information booklet about concussion as well as the SCAT2 pocket tool to assist with on field identification of concussion *(Appendix VII).*

3.3. RESULTS

Of the 852 questionnaires distributed, 236 were returned. Seven questionnaires were excluded from data analysis, as the questionnaires were either incomplete (n = 4) or did not have a signed informed consent form (n = 3). Therefore a total of 229 questionnaires were used for data analysis. This represents a response rate of 27.7%.

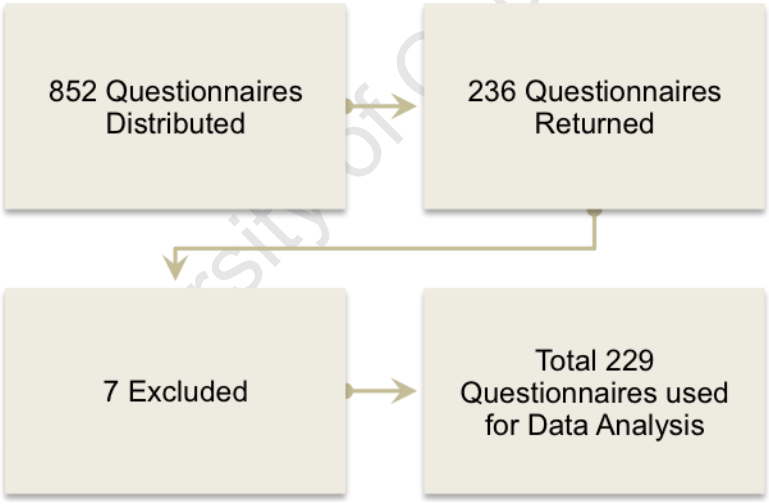

Figure 3.2: Summary of Response Rate

3.3.1. Descriptive Characteristics

3.3.1.1. Coach Demographics

The majority of participants were High School (38.4%) and Club rugby (30.6%) coaches. Only a small number of the participants were employed in full-time coaching positions (17.0%). All rugby provinces were represented in this research, with the greatest number of coaches participating from the Western Province (22.7%), Lions (19.2%), Blue Bulls (11.4%) and KwaZulu Natal (10.0%) rugby provinces. Fifty six percent of participants had ten or more years of coaching experience *(Table 3.5).* There was a significant difference between the coaching levels and years of coaching experience (χ^2 = 30.8; p = 0.009). The Junior School, High School and Club Rugby coaching levels had more coaches with two years of experience and less at 11.76%, 4.5% and 7.2% respectively compared to Provincial coaches with only 2.7%. The majority of Provincial coaches (78.3%) had more than ten years of coaching experience.

Table 3.5: Coach Demographics

	Number	*Percentage (%)*
Coaching Level		
Junior School	34	14.8
High School	88	38.4
Club Rugby	70	30.6
Provincial	37	16.2
Full Time Coaching Position		
Yes	39	17.0
No	190	83.0
Rugby Provinces represented by Coaches		
Leopards	7	3.1
Griffons	8	3.5
Western Province	52	22.7
Eastern Province	12	5.2
KwaZulu Natal	23	10.0
Lions	44	19.2
Free State	8	3.5
Boland	2	0.9
Border	2	0.9
Blue Bulls	26	11.4
Falcons	10	4.4
Griquas	10	4.4
South Western Districts	6	2.6
Pumas	19	8.3
Years of Coaching Experience		
First year	3	1.3
1 year	3	1.3
2 years	8	3.5
3 – 5 years	32	14.0
6 – 9 years	55	24.0
10 years and more	128	55.9

3.3.1.2. Coaches with Medical Support

There was a significant difference between the coaching levels and the amount of medical support. Of Junior School coaches, 41.2% were alone 80 – 100% of their practices, with no medical personnel present to assist with emergencies; while 17.7% had medical support at every practice. High School coaches had greater medical support with 40.9% of coaches reporting medical support at every practice (χ^2 = 18.2; p= 0.03*) (Table 3.6a).*

Of all the coaching levels, Junior School and Provincial coaches had the smallest percentage of coaches with consistent medical support at every practice (8.7% and 10.1% respectively). Compared to other coaching levels 52.5% of High School coaches had medical personnel present at every practice session (χ^2 = 18.2; p= 0.03*) (Table 3.6a).*

Table 3.6a: Frequency with which a coach could be responsible for medical emergencies at PRACTICES (x^2 = 18.2 p = 0.03)

	80 – 100% of the time, coach is alone with no medical support	***50 – 79% of the time***	***Less than 50% of the time***	***Never alone, medical personnel are always present***	Row Count
Junior School	14	4	10	6	34
Column %	23.3%	10.8%	15.9%	8.7%	
Row %	41.2%	11.8%	29.4%	17.7%	
High School	24	12	16	36	88
Column %	40.0%	32.4%	25.4%	52.2%	
Row %	27.3%	13.7%	18.2%	40.9%	
Club Rugby	12	14	24	20	70
Column %	20.0%	37.9%	38.1%	28.9%	
Row %	17.1%	20.0%	34.3%	28.6%	
Provincial	10	7	13	7	37
Column %	16.7%	18.9%	20.7%	10.1%	
Row %	27.0%	18.9%	35.1%	18.9%	
All Coaches	60	37	63	69	229
Column %	26.2%	16.2%	27.5%	30.1%	

The presence of medical personnel at every match was significantly better than practice; with 52.9% of Junior School, 81.8% of High School, 55.7% of Club and 59.5% of Provincial coaches having medical support at every match and therefore not having to be solely responsible for medical emergencies (χ^2 = 20.4; p = 0.01*)(Table 3.6b).*

At rugby matches 65.9% of coaches, across all coaching levels, had the support of medical personnel at every match *(Table 3.6b).*

Table 3.6b: Frequency with which a coach could be responsible for medical emergencies at MATCHES (x^2 = 20.4 p = 0.01)					
	80 – 100% of the time, coach is alone with no medical support	***50 – 79% of the time***	***Less than 50% of the time***	***Never alone, medical personnel are always present***	Row Count
Junior School	5	4	7	18	34
Column %	31.3%	25.0%	15.2%	11.9%	
Row %	14.7%	11.8%	20.6%	52.9%	
High School	2	3	11	72	88
Column %	12.5%	18.8%	23.9%	47.7%	
Row %	2.3%	3.4%	12.5%	81.8%	
Club Rugby	5	7	19	39	70
Column %	31.3%	43.8%	41.3%	25.8%	
Row %	7.1%	10.0%	27.1%	55.7%	
Provincial	4	2	9	22	37
Column %	25.0%	12.5%	19.6%	14.6%	
Row %	10.8%	5.4%	24.3%	59.5%	
All Coaches	16	16	46	151	229
Column %	7.0%	7.0%	20.1%	65.9%	

3.3.1.3. Coach Education and Dealing with a Concussed Player

Seventy two percent of coaches had a first aid qualification. Of these however only 26.1% had attended the first aid course within the last two years and 82% of the qualifications were for Level 1 or Basic Life Support. There was no significant difference between the coaching levels and the first aid qualification status of coaches (χ^2 = 4.7; p = 0.19) *(Table 3.7).*

Approximately 64% of coaches had attended a BokSmart course and were BokSmart Certified. There was a significant difference between coaching levels and the BokSmart Certification status of coaches (χ^2 = 8.9; p = 0.03). Less than half the Junior School coaches (47.1%) were BokSmart certified, whereas 81.1% of the Provincial rugby coaches had attended the course *(Table 3.7).*

Table 3.7: Rugby Coach Education and Dealing with a Concussed Player			
		Number	*Percentage (%)*
First Aid Qualification			
	Yes	165	72.1
	No	64	27.9
Of those with a First Aid Qualification, when did they do the course			
	Within the last 2 years	43	26.1
	More than 2 years ago	122	73.9
Level of First Aid Qualification			
	Basic Life Support	136	82.0
	Intermediate Life Support and above	29	18.0
BokSmart Certification			
	Yes	146	63.8
	No	83	36.2
BokSmart Certification across the Coaching Levels			
Junior School Coaches	Yes	16	47.1
	No	18	52.9
High School Coaches	Yes	56	63.6
	No	32	36.4
Club Rugby Coaches	Yes	44	62.9
	No	26	37.1
Provincial Coaches	Yes	30	81.1
	No	7	18.9

Figure 3.3 below indicates coaches' responses to how confident they felt dealing with a concussed player. It shows that 78.2% of coaches felt confident (answering with 'agree' and 'strongly agree') dealing with concussion.

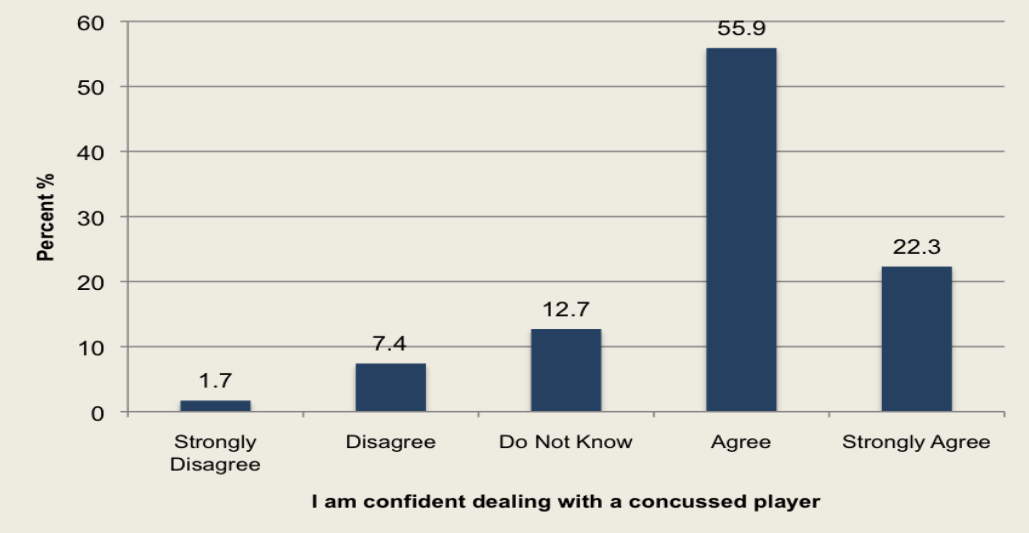

Figure 3.3: Coaches Indication of their Level of Confidence Dealing with a Concussed Player

The majority of coaches (91.3%) indicated that they believe education will aid in reducing the incidence of concussion injuries in rugby *(Figure 3.4).*

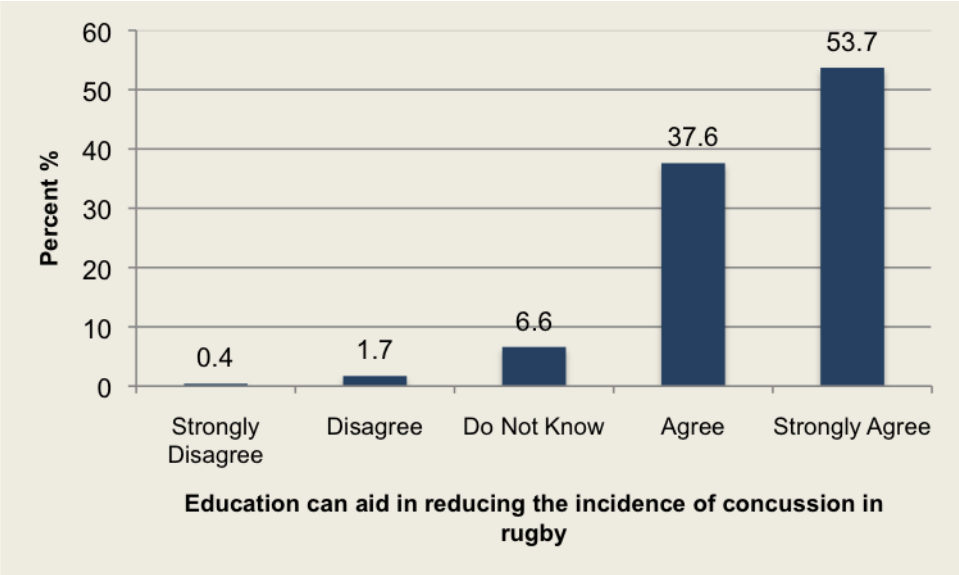

Figure 3.4: Coaches Indication of their Belief that Education can Reduce the Incidence of Concussion in Rugby

Figure 3.5 illustrates a significant relationship (F = 7.5; p = 0.00001) between a coach who stated that education will aid in the reduction of concussion injuries and has actively developed his rugby injury and safety knowledge, represented as a Continuous Education Score (CES).

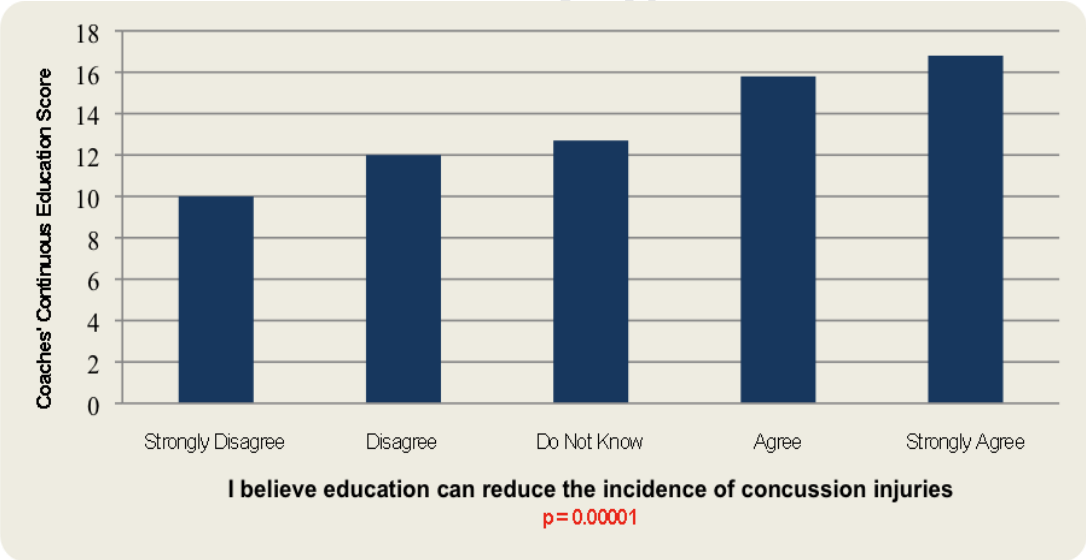

Figure 3.5: Relationship between Coaches who Believe Education can Aid in the Reduction of Concussion Injuries and their Continuous Education Score

3.3.2. Concussion Knowledge Score

The average Concussion Knowledge (CK) score was 72.2% ± 5.4%. Provincial rugby coaches had the best mean CK score (73.2% ± 4.4%), when assessing CK across the coaching levels *(Table 3.8).*

Table 3.8: Concussion Knowledge Scores

	Number Count	Mean %	Minimum %	Maximum %	Std. Dev
Total	*229*	*72.2*	*54.9*	*89.9*	*5.42*
Junior School	34	70.0	62.6	83.6	4.36
High School	88	72.3	57.3	89.9	6.06
Club Rugby	70	72.5	54.9	85.7	5.34
Provincial	37	73.2	62.9	85.0	4.41

Junior School coaches had significantly lower CK scores when compared to High School coaches (F = 2.4; p = 0.03), Club rugby coaches (p = 0.03), and Provincial coaches (p = 0.01). There were no significant differences in the years of coaching experience on coaches CK scores (F = 0.6; p = 0.72). There were no significant differences in CK scores between coaches with or without a first aid qualification [72.3% ± 5.1% vs. 71.9% ± 6.2% respectively (*t* = 0.5; p = 0.6)].

There were also no significant differences in CK scores between coaches with current (completed within the last two years) first aid qualifications, compared to coaches with outdated (completed more than two years ago) first aid qualifications [72.4% ± 6.2% vs. 73.2% ± 5.3% respectively (*t* = -0.2; p = 0.8]. However, BokSmart Certified coaches had significantly higher CK scores (73.1% ± 5.1%), compared to non-certified coaches (70.6% ± 5.6%) (*t* = 3.4; p = 0.0008).

The CK score was comprised of five sections: '*teaching safe techniques', 'concussion identification', 'management of concussion', 'consequences of concussion'*, and '*safe return to play'*. There were significant differences in the sections of the CK score between coaches with and without BokSmart certification (F = 3.8; p = 0.002). BokSmart Certified coaches scored significantly higher in the '*teaching safe techniques'* (p = 0.007), and '*concussion identification'* (p = 0.0003) sections, compared to non-BokSmart certified coaches *(Figure 3.6)*. However, there were no significant differences between BokSmart certified and non-BokSmart certified coaches in CK scores for '*management of concussion', 'consequences of concussion'*, and '*safe return to play' (Figure 3.6).*

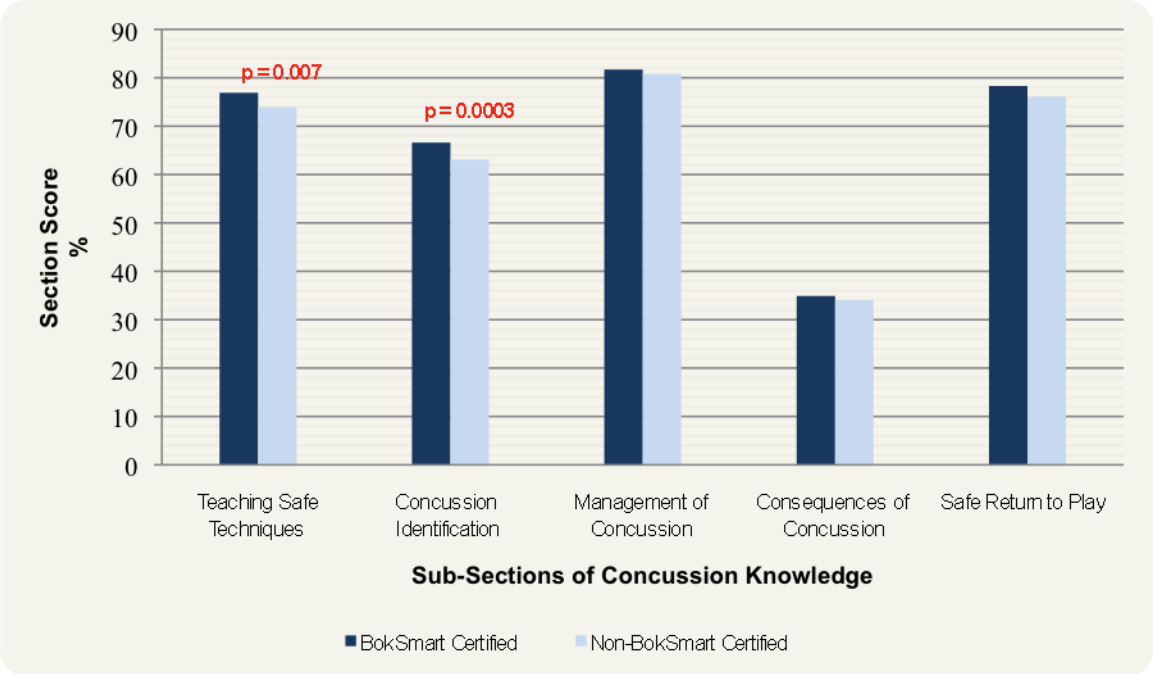

Figure 3.6: Comparison of Scores for BokSmart Certified and Non-BokSmart Certified Coaches on Specific Sections within the Concussion Knowledge Questionnaire

The confidence indicated by coaches in dealing with concussion *(Figure 3.3)* is unfounded given the lack of CK (*Figure 3.7*, F = 3.5, p = 0.008). Even coaches indicating high levels of confidence, rating 4 and 5, their mean CK scores were 72.4% ±5.1 and 73.7% ±5.4 respectively. This, as will be discussed later *(Section 3.3.2.1, page 62),* is below the 75% cut-off required for adequate concussion knowledge.

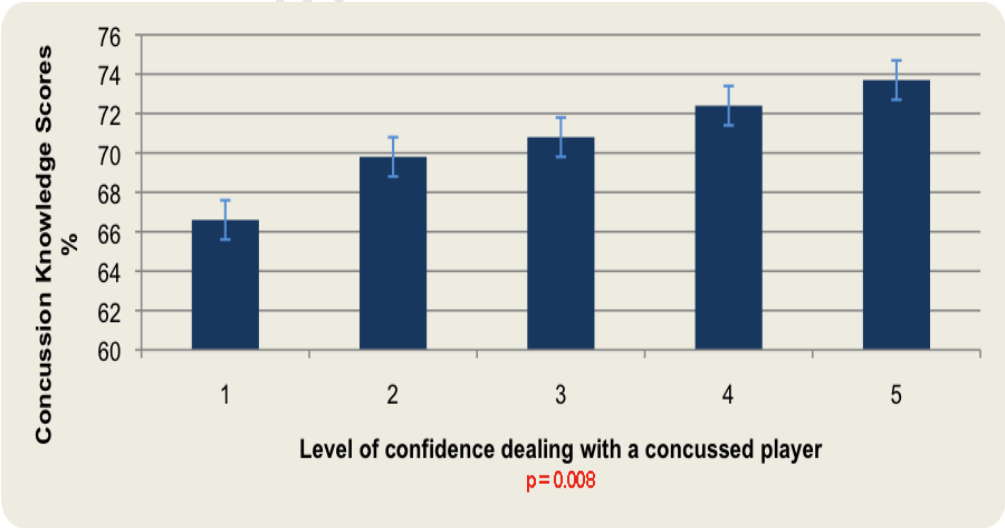

Figure 3.7: Comparison of Coaches' Levels of Confidence in Dealing with a Concussed Player and their Concussion Knowledge

There was a weak but significant positive relationship between coaches' CES and CK scores (r = 0.25; p = 0.00008) *(Figure 3.8)*. Only 6.6% of the variation between coaches CK scores is accounted for by their CES (r^2 = 0.066). Therefore, more than one independent variable may influence the CK scores. This will be further analysed using multiple regression analysis later in the results *(Section 3.3.2.2, page 63)*.

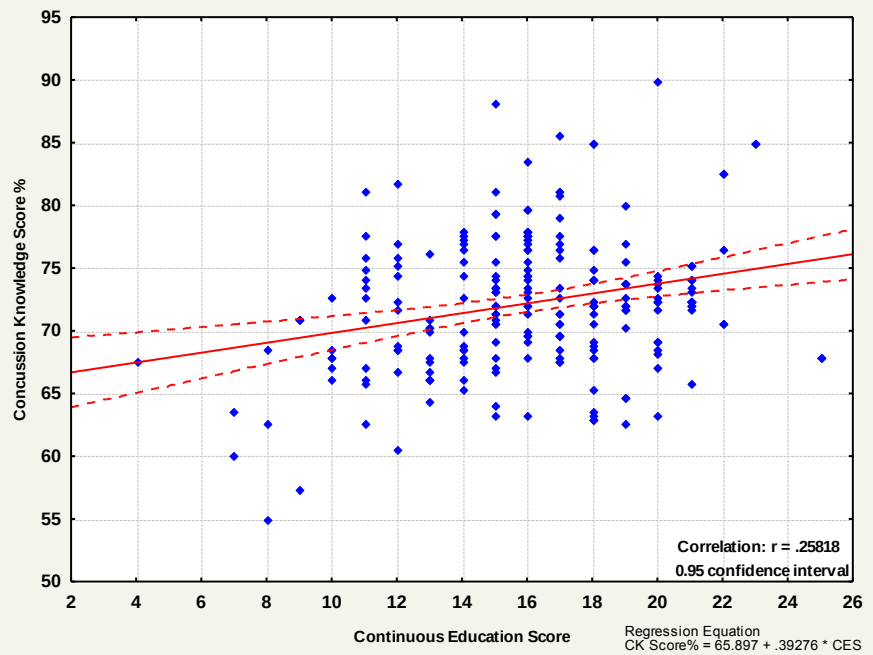

Figure 3.8: Relationship between Concussion Knowledge Scores and Continuous Education Scores

3.3.2.1. Adequate and Inadequate Concussion Knowledge

Coaches were categorised according to their CK scores as either having 'Adequate Concussion Knowledge' (ACK) if they scored ≥ 75%, or 'Inadequate Concussion Knowledge' (ICK) if they scored less than 75%. Sixty-one participants (26.6%) had ACK, and 168 participants (73.4%) had ICK. There were significant differences in CK scores across all coaching levels, with the majority of Junior School, High School, Club Rugby and Provincial coaches having ICK ($p < 0.05$). High School coaches had the greatest percentage of coaches with ACK (34.1%), followed by Club Rugby and Provincial Coaches, both with 24.3%. Of the Junior School coaches only 14.7% had ACK *(Figure 3.9)*.

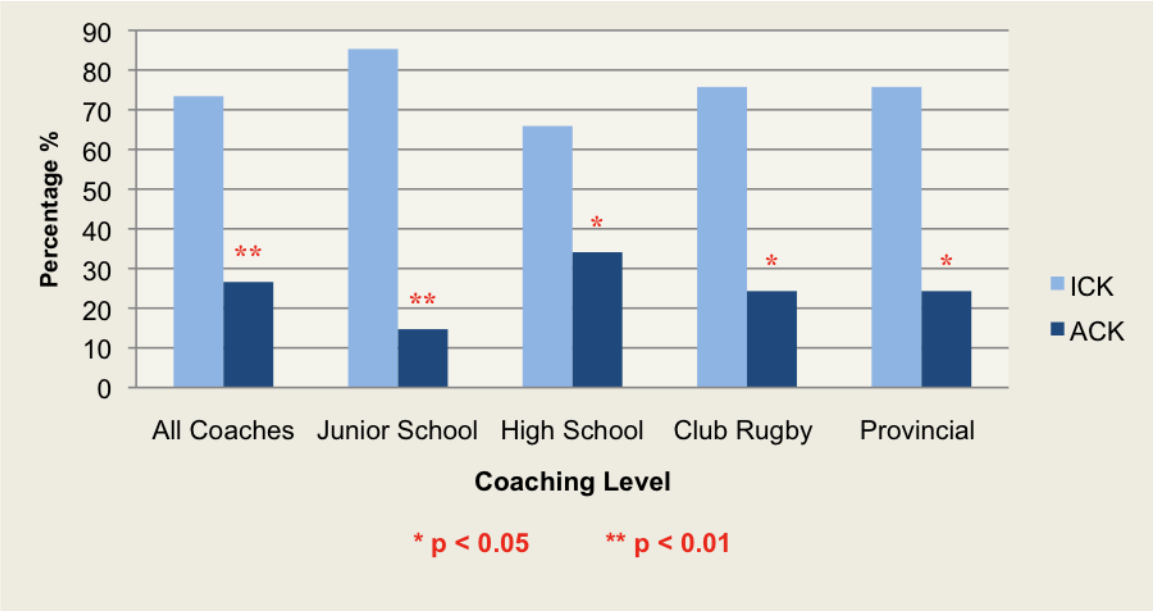

Figure 3.9: Comparison of Coaches with Inadequate (ICK) and Adequate Concussion Knowledge (ACK) across the Coaching Levels

Of coaches with a first aid qualification, there was no significant difference between those with ACK and / or ICK (χ^2 = 0.1; p = 0.75). Only 26.1% of coaches with a first aid qualification were classified as having ACK. There were no significant differences between coaches with ACK or ICK and the BokSmart certification status of coaches (χ^2 = 0.12; p = 0.73). Approximately 27% of BokSmart certified coaches had ACK, whereas 25% of non-BokSmart certified coaches had ACK.

3.3.2.2. Factors predicting concussion knowledge

The determinants of a coach's concussion knowledge was examined and a model was developed which included coaching level, years of coaching experience, first aid qualification, BokSmart certification and continued education (CES) *(Table 3.9*). The model did not fit the data well and only accounted for 10% of the variance. There were 11 coaches whose predicted scores fell more than two standard deviations away from their observed scores and these cases were removed for final analysis. Coaches' concussion knowledge may actually decrease by -0.1 with a first aid qualification, although not significantly. Coaching level and continuous education (which included attendance at a BokSmart course) may predict coaches' concussion knowledge by 0.15 (p = 0.02) and 0.19 (p = 0.04) respectively.

Table 3.9: Multiple Regression Analysis (Forward Stepwise) for Dependant Variable: Concussion Knowledge

	b*	Std.Err. of b	T (212)	p value
Intercept		1.96	33.0	0.00
Coaching Level	0.15	0.33	2.3	*0.02*
Continuous Education	0.19	0.12	2.1	*0.04*
First Aid Qualification	-0.10	0.79	-1.4	0.18
Years of Coaching Experience	0.10	0.29	1.5	0.13
BokSmart Certification	0.08	0.75	1.1	0.29
R^2 = 0.104				

3.3.3. Safe Management of Concussion

The safety score was calculated from 11 specific questions identified within the concussion questionnaire, and the required safety score was 100%. No coach scored 100%, three coaches (1.3%) scored 90%, and 13 coaches (5.7%) scored above 80% for safety. The mean safety score for all coaches was 60.9% ± 12.9%, with a maximum score of 90.0% and minimum score of 27.3%. Although there were no significant differences in SMC between the different coaching levels (F = 1.3; p = 0.23), Junior School coaches had the lowest mean score (57.6% ± 12.3%) and the Provincial rugby coaches the highest SMC (63.8% ± 13.0%)*(Table 3.10).* There were also no significant differences in safety scores and the number of years of coaching experience (F = 1.0; p = 0.414). In addition, there were no significant differences in safety scores between coaches with or without a first aid qualification [61.2% ± 12.6% vs. 60.4% ± 13.8% respectively (*t* = 0.3; p = 0.7)].

Table 3.10: Safety Scores Across Coaching Levels

	Count	Mean %	Minimum %	Maximum %	Std.Dev
Total	*229*	*60.9*	*27.3*	*90.9*	*12.9*
Junior School	34	57.6	32.8	89.9	12.3
High School	88	61.1	33.6	88.4	13.1
Club Rugby	70	61.0	27.3	86.4	12.7
Provincial	37	63.8	31.8	90.9	13.0

Analysis of the specific safety questions showed that coaches performed poorly (less than 35% selecting the correct answer) on '*children being more vulnerable to concussion than adults'*, '*children do not recover faster than adults'*, '*stand down period'* and '*stepwise RTP'*. Questions where coaches scored strongly (more than 60% selecting the correct answer) included *'leaving the field immediately for concussion', 'not allowing a player back to the field even if they feel fine after a few minutes'* and *'consulting a medical practitioner after sustaining a concussion.' (Figure 3.10)*

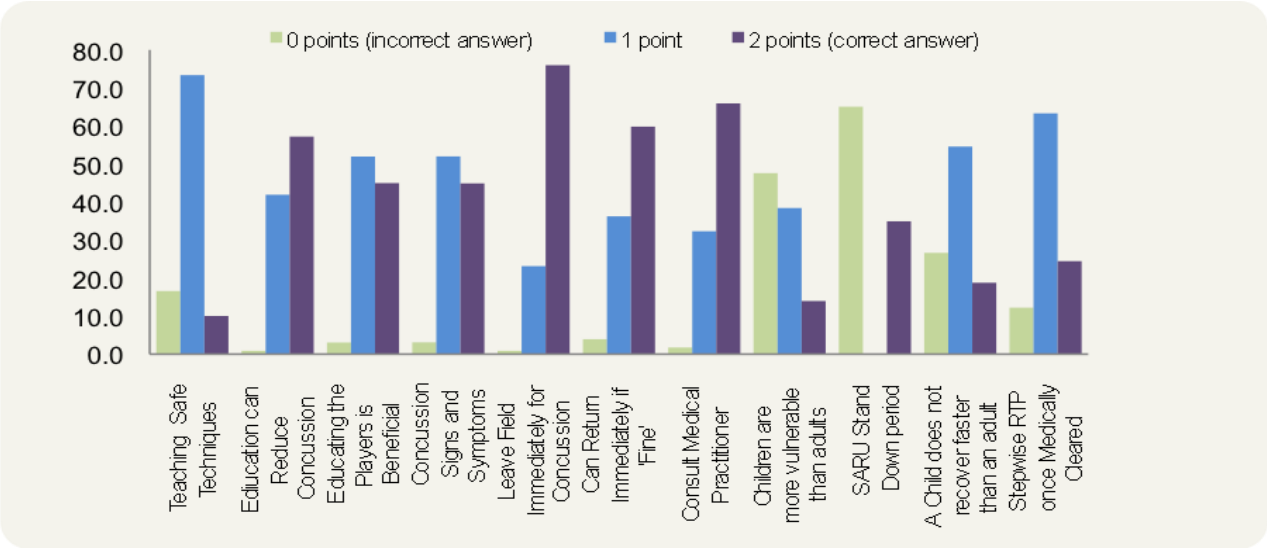

Figure 3.10: Representation of Coaches' Answers for each Safety Question

BokSmart certified coaches had significantly higher safety scores (62.9% ± 12.3%), compared to non-BokSmart certified coaches (57.6% ± 13.3%) (t = 3.03; p = 0.00274). Using cross-tabulation, significant differences in scores were seen between BokSmart certified coaches' and non-BokSmart certified coaches' questions regarding '*teaching safe techniques'* (p = 0.014), '*educating the players'* (p = 0.02), '*concussion signs and symptoms'* (p = 0.039), '*returning to the field'* (p = 0.026), and '*using a stepwise return to play'* (p = 0.0034)*(Table 3.11).*

Table 3.11: Influence of BokSmart (BS) Course on the 11 Safety Questions						
	0 (Incorrect Answer)	1	2 (Correct Answer)	Pearson Chi -square	df	p value
Teaching Safe Techniques						
BS No	25.3	62.7	12.0			
BS Yes	11.6	79.5	8.9	8.52	2	0.014
Education can Reduce the Incidence of Concussion						
BS No	1.2	45.7	53.0			
BS Yes	0.7	39.7	59.6	1.03	2	0.59
Educating the Players can be Beneficial with Concussion Injuries						
BS No	7.2	48.2	44.6			
BS Yes	0.7	54.1	45.2	7.77	2	0.02
Concussion Signs and Symptoms						
BS No	20.5	59.0	20.5			
BS Yes	18.5	45.2	36.3	6.45	2	0.039
Player to Leave the Field Immediately for Concussion						
BS No	2.4	19.3	78.3			
BS Yes	0.0	25.3	74.7	4.45	2	0.11
Player can not Return to the field, even if he 'Feels Fine' after a Few Minutes						
BS No	8.4	32.5	59.0			
BS Yes	1.4	38.4	60.3	7.22	2	0.026
All Concussed Player Should Consult a Medical Practitioner as Soon as Possible						
BS No	2.4	28.9	68.7			
BS Yes	1.4	34.2	64.4	0.94	2	0.62
Children are More Vulnerable to Concussion than Adults						
BS No	56.6	28.9	14.5			
BS Yes	42.5	43.8	13.7	5.3	2	0.07
SARU Stand Down Period is..						
BS No	69.9		30.1			
BS Yes	62.3		37.7	1.3	1	0.24
A Child Recovers Faster from Concussion than an Adult						
BS No	32.5	49.4	18.1			
BS Yes	23.3	57.5	19.2	2.37	2	0.31
Stepwise RTP Should be Implemented following Medical Clearance						
BS No	20.5	63.9	15.7			
BS Yes	7.5	63.0	29.5	11.37	2	0.0034

There was a weak but significant positive relationship between coaches' CES and safety scores (r = 0.23; p = 0.0006) *(Figure 3.11)*. Only 5% of the variation between coaches CK scores is accounted for by their CES (r^2 = 0.051). Therefore, more than one independent variable may influence the safety scores. This will be further analysed using multiple regression analysis later in the results *(Section 3.3.3.1, page 68)*.

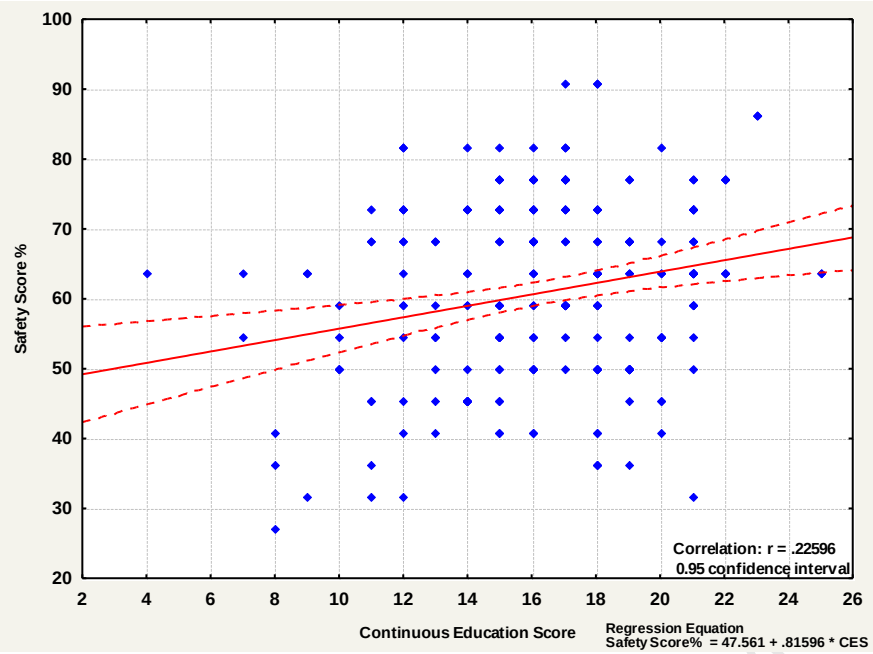

Figure 3.11: Relationship between Safety Scores and Continuous Education Scores

Given that all coaches showed poor safety knowledge specific to children and concussion injuries *(Figure 3.12);* further analysis of Junior and High School coaches' safety knowledge was performed. This was regarded as particularly relevant, in light of the fact that these coaches deal with adolescents on a daily basis, frequently without the support of medical personnel *(Table 3.6).* Only 26.5% of Junior School coaches and 10.2% of High School coaches knew that children were more vulnerable to concussion than adults. Similarly, 26.5% of Junior School coaches and 5.7% of High School coaches knew that children require a smaller impact force than adults to sustain a concussion. Further, 8.8% of Junior School coaches and 22.7% of High School coaches knew that children do not recover faster than adults following a concussion injury *(Figure 3.12).*

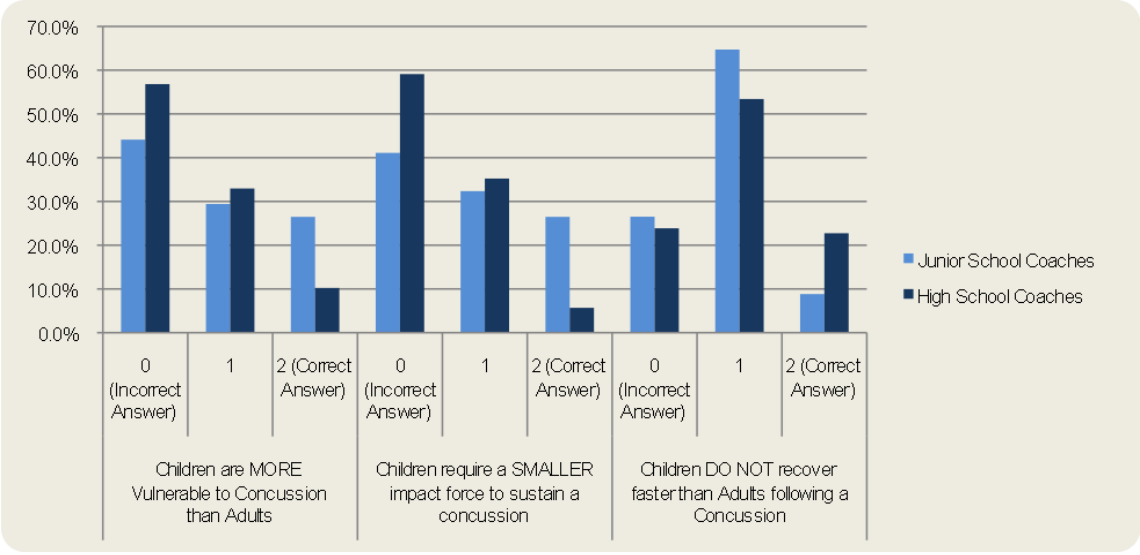

Figure 3.12: Comparison of Answers for Child Related Concussion Questions by Junior and High School Coaches

3.3.3.1. Factors predicting safety knowledge

The determinants of a coach's safety knowledge was examined and a model was developed which included coaching level, years of coaching experience, first aid qualification, BokSmart certification and continued education (CES) *(Table 3.12).* The model did not fit the data well and only accounted for 11% of the variance. There were 11 coaches whose predicted scores fell more than two standard deviations away from their observed scores and these cases were removed for final analysis. Coaches' safety knowledge may actually significantly decrease by -0.19 (p = 0.015) with a first aid qualification. Continuous education (which included attendance at a BokSmart course) and coaching level may predict coaches' safety knowledge by 0.34 (p = 0.00003) and 0.13 (p = 0.04) respectively *(Table 3.12).*

Table 3.12: Multiple Regression Analysis (Forward Stepwise) for Dependant Variable: Concussion Knowledge

	b*	Std.Err. of b	T (214)	p value
Intercept		3.9	10.8	0.00
Coaching Level	0.13	0.83	2.01	*0.04*
Continuous Education	0.34	0.26	4.27	*0.00003*
First Aid Qualification	-0.19	2.01	-2.45	*0.015*
BokSmart Certification	0.11	1.84	1.4	0.16

$R^2 = 0.112$

Summary of Results

In summary, the main findings of this study were that only 26.6% of rugby coaches had ACK. High School coaches had the greatest percentage of coaches with ACK, 34.1%. Junior School coaches had significantly (p = 0.009) lower CK scores compared with other coaching levels, not surprising therefore that Junior School coaches had the greatest percentage of coaches with ICK (85.3%; p = 0.045). Years of coaching experience, first aid qualification, and working with medical personnel had no significant effect on coaches' CK. BokSmart certified coaches had significantly higher CK scores (73.1% ±5.1), compared with non-BokSmart certified coaches (70.6% ±5.6) (*t* 3.4; p = 0.00079), however this had little influence on the coaches final classification, as only 27.4% of the BokSmart certified coaches were classified as having ACK. Correlation analyses showed weak, but significant positive relationships between CES and CK and safety scores (r = 0.25; p = 0.00008). Multiple regression analyses established that both coaching level and continued education (including BokSmart certification) might predict rugby coaches' CK.

Only 13 coaches (5.7%) had safety scores above 80%, and no coach obtained the required 100% SMC score. Coaching level, years of coaching experience, and first aid qualification status had no significant effect on SMC scores. BokSmart certified coaches had significantly higher safety scores (62.9% ±12.3), compared to non-BokSmart certified coaches (57.6% ±13.3) ($p = 0.00274$). Continued education also had a significant effect on coaches' safety knowledge ($p = 0.0001$). There was a weak but significant positive relationship between continued education and safety knowledge scores ($r = 0.22$ $p = 0.0006$). Multiple regression analyses showed that both continued education (including BokSmart certification) and coaching level might predict coaches' safety knowledge.

3.4. DISCUSSION

There is a lack of evidence regarding the role of the rugby coach in the prevention, identification and management of a concussed player. Although it is recognised that coaches have an important role in the delivery of training programmes and other safety initiatives, few studies have investigated coaches' injury prevention practices, safety promotion attitudes and ongoing role in implementing injury prevention programmes[262, 269, 277, 278].

3.4.1. Coach Demographics

This study had a relatively large sample size (n = 229), compared to previous coach survey studies by Carter et al[52] (n = 35), Guilmette et al[266] (n = 62) and Valovich McLeod et al[267] (n = 156). This study included Junior School, High School, Club and Provincial level coaches, whereas previous studies only surveyed junior level coaches in a variety of disciplines[267], or from other sports including football and netball[266, 277]. This limits comparison regarding the influence of coaching level on concussion and injury knowledge[55, 267]. The participants in this study were all rugby coaches, resulting in the development of a sports-specific questionnaire, and subsequent concussion knowledge scores. Rugby requires a distinct set of skills and techniques, with particular injury and concussion knowledge that may differ from other sporting disciplines.

It is recognised that, although the sample size was sufficient to ensure statistical power, a larger sample size would have allowed for better representation of coaching level, training and education characteristics. Unfortunately, the timing of the distribution of the questionnaires also coincided with both the start of the rugby season, and the 2010 Soccer World Cup, which may have limited participation in this study.

A further limitation of this study was that the questionnaires were self-administrated. Self-administered questionnaires are common measurement tools used to assess the characteristics of large populations[279-281]. The questionnaires were assessed for content validity and a feasibility study was conducted to ensure good comprehension and ease of completion of the questionnaire. However, this study was unable to control for the disadvantages associated with self-administered questionnaires, including inaccuracy in mailing lists; literacy issues, for example reading, writing and computer literacy; possible visual acuity and dyslexia[281]. Limited translation of the questionnaire may also have been a disadvantage, as the questionnaire was only available in three of the eleven official languages in South Africa. A self-administered questionnaire must 'stand alone' without assistance in the interpretation and understanding of the content[281]. The limitation of using closed-ended questions may lead to a lower validity when researching affective variables. The motivation of the individual who chooses to respond to the survey may differ from those who do not respond, thus biasing the estimates. Respondents may not be motivated to give accurate answers, and may rather be motivated to give answers that present themselves in a favourable light. It is also not possible to control whether respondents have gained assistance by referring to literature or colleagues when completing the questionnaire[279-281]. In addition to this bias may have been brought on by the fact that coaches who returned the questionnaire have been exposed to or have a special interest in concussion.

3.4.2. Concussion Knowledge

The majority of coaches' concussion knowledge (CK) scores were between 65% and 75% *(Section 3.3.2, page 59)*. The coaches with significantly lower mean CK scores were Junior School coaches. Further, a high proportion of coaches with less than three years of coaching experience were Junior School coaches, whereas more than 78% of the Provincial coaches had 10 years or more of coaching experience *(Section 3.3.2, page 59).* Previous studies have identified the inability of youth coaches to accurately recognise, manage and safely RTP an athlete after sports related concussion[267]. Carter et al[55] found that a coaches total injury knowledge score increased in relation to the level of coaching experience, based on total number of seasons coached. However, in this study there was no significant relationship between years of coaching experience and CK scores.

In this study, 72% of rugby coaches had a first aid qualification, with Level 1 or Basic Life Support being the most common qualification (82%). However, only 26% of the first aid qualifications were classified as 'valid', that is, completed within the past two years *(Section 3.3.1.1, page 54).* Previous studies determined that only 50% of coaches had first aid qualifications[259], and 62% of South African rugby coaches had first aid training[35]. Although this study demonstrated an improvement in the percentage of coaches with first aid training compared to previous studies, there was no significant relationship between first aid qualification status and CK scores *(Section 3.3.2, page 59).* Similarly, Valovich McLeod et al[267] found that 45% of coaches with a first aid qualification or medical training showed no improved recognition of concussion, compared to coaches without training. Marshall et al[81] stated that first aid qualifications alone may be insufficient for the adequate recognition and management of concussion and other rugby-specific injuries, emphasising the importance of sport-specific education programmes. In contrast, coaches with a current first aid qualification were more likely to identify an injury and administer early management[55]. This highlights both the importance of regularly updating first aid qualifications and the necessity for continued education[51, 52, 267]. Gianotti et al[51] and Quarrie et al[52] demonstrated the efficacy of continued education. The Concussion Management Education Programme (CMEP), a component of the RugbySmart programme in New Zealand, was assessed over a two-year period. Coaches were required to attend the course bi-annually, and concussion injuries reduced by 10.7% over the same period[51]. Further, over a four year period only eight serious head and spinal injuries were recorded, versus a predicted 18.9 injuries[52]. In addition, following the introduction of this coach education programme the spinal injury rate decreased from 2.7 injuries per 100 000 players per year to 1.3 per 100 000 players per year[52, 282]. In comparison over the same time period in Australia, where a similar coach education programme had not yet been initiated, the spinal injury rate was 3.2 injuries per 100 000 players per year[283, 284]. In the absence of evidence that other factors have had a major role, it was concluded that the RugbySmart education programme probably played a positive part in decreasing the injury risk to players[52, 282].

In this study, 63% of all coaches had received specific rugby coach education through the BokSmart programme. However, only 47% of Junior School coaches were BokSmart certified. The BokSmart certified coaches had significantly higher CK scores than non-BokSmart certified coaches *(Section 3.3.2, page 59).* Previous studies have determined that coach education programmes may facilitate the prevention of concussion injuries in rugby[51, 52, 267, 269, 285], where coaches who had received education demonstrated improved recognition of concussion[267]. It was also identified that youth coaches may require additional education about concussion injuries[267], particularly regarding the mechanisms of injury and early management strategies[55].

In addition, BokSmart certified coaches performed significantly better in specific sections of CK, including '*Teaching Safe Techniques'* and '*Identifying a Concussion'*, compared to uncertified coaches' *(Figure 3.6, page 60; and Section 3.3.3, page 64).* Previous studies identified that players' knowledge of safe tackling and falling techniques was inadequate, and that there was insufficient coaching of safety techniques during rugby training[42-44]. The BokSmart certification programme may be associated with improved knowledge of safe tackling and falling techniques, thereby facilitating a potential reduction in the risk of concussion injury[18, 23, 42-44, 51, 52, 81, 92, 219, 236]. Glang et al[286] found that youth coaches' concussion identification knowledge, based on a 16-item symptom checklist list, improved following exposure to an interactive e-learning programme. An improved ability to identify concussion may also be particularly advantageous in the South African context, where rugby coaches are often solely responsible for identifying concussion injuries and instituting appropriate medical management to ensure the safety of the player[35, 261]. Coaches are also often the primary source of player education regarding concussion injuries, which further demonstrates the importance of this component of CK[34, 37, 259].

However, all coaches performed poorly in the '*Consequences of Concussion*' section of CK *(Figure 3.6, page 60).* It may be suggested that knowledge of the consequences of concussion is outside the scope of practice of rugby coaches. However, if coaches do not fully understand the medical implications of a concussion injury, the safe management of the concussed player may be compromised[287]. There were also no significant differences in the '*Management of Concussion*' and '*Safe RTP*' CK scores between BokSmart certified and non-BokSmart certified coaches. Similarly, Glang et al[286] found smaller effect sizes on questions pertaining to '*management of a concussion*' and '*the appropriate action to take*'. These findings may therefore indicate components of CK that require greater emphasis in coach education programmes.

3.4.2.1. Adequate and Inadequate Concussion Knowledge

This was the first study that has attempted to quantify adequate concussion knowledge (ACK). Adequate concussion knowledge was classified as a minimum CK score of 75%. Using an objectively determined cut-off score of 75% as an indicator of proficiency, it was found that only 26.6% of all coaches had ACK *(Section 3.3.2.1, page 62)*[270, 271, 275]. There is a paucity of literature regarding the minimum scores for adequate knowledge in the management of life-threatening medical conditions. However, it is commonly accepted in both medical and paramedical training and assessment that a minimum score of 75% is required to ensure sufficient knowledge[288]. Interestingly, only 27.4% of the BokSmart certified coaches and 25.3% of non-BokSmart certified coaches had ACK *(Section 3.3.2.1, page 62).* It may therefore be suggested that although the BokSmart certification programme is effective in improving CK, it may not fulfil all the necessary learning requirements to ensure South African rugby coaches have adequate concussion knowledge.

Currently, BokSmart certification is acquired through attendance at a BokSmart workshop[48], which is similar to education programmes in New Zealand[50] and Australia[49]. However, educational research has shown that unless learners complete some form of assessment, the learning circle is incomplete, leading to sub-optimal retention of knowledge[289-297]. An assessment might discourage coaches from attending BokSmart workshops[48]. Interestingly, in this study only 1.8% of coaches (*Appendix VIII*) indicated that a written exam would be of concern when attending courses. The lack of assessment could potentially compromise the primary goals of the BokSmart programme.

It is recognised that the BokSmart programme is relatively new, as it was only launched in July 2009, and mandatory attendance instituted from January 2011. Furthermore, there are potential challenges specific to education within the South African context, which may influence the efficacy of the programme. Firstly, the primary language of instruction on the programme is English. Although instructors attempt to host workshops in the most common language of a province or area, using translators where possible, with eleven official languages, some coaches may be disadvantaged. In addition, the online course material and educational tools are only available in English. Secondly, the geographic location of the workshops may limit coaches' attendance due to concerns about travel, time and cost[298]. In this study, the three most common concerns about attending courses were time constraints (39,2%), cost (24.3%), and location (16.2%) (*Appendix VIII*). Finally, BokSmart like RugbySmart and SmartRugby, offer the workshops free of charge so as not to discriminate against coaches from different socio-economic backgrounds. It could be argued that if participants were required to pay for the workshop, there may be an increased perception of importance and value attributed to the workshop, with a resultant increased gain in knowledge. These are important points to consider when assessing the administrative challenges of the BokSmart programme.

3.4.3. Safe Management of Concussion

This was the first study to quantify the required level of knowledge for the safe management of a concussed player. As there was no evidence to support a scoring system for safety, reference was made to other methods of setting standards for tests[272]. A modified Hofstee method was used so that the expert panel could specify a minimum (80%) and maximum (100%) acceptable cut-off for SMC scores *(Section 3.2.6.4, page 50)*[272]. In this study, none of the 229 participating coaches obtained a safety score equivalent to the required maximum (100%). Only 5.7% of coaches scored above the minimum requirement (80%). The mean safety score for all coaches was 60.9% ± 12.9%, with a maximum score of 90.0% and minimum score of 27.3% *(Section 3.3.3, page 64).* These results highlight the discrepancies between the actual and expected safety standards of rugby coaches.

The higher score required for SMC compared with CK was based on experts concerns of the life threatening ramifications should a coach lack specific safety knowledge *(Section 3.2.6.4, page 50).* The SMC score was comprised of 11 specific safety-related questions identified within the 36 questions that comprised the CK score. The lower SMC scores (60.9% ±12.9%), compared to CK scores (72.2% ± 5.4%), may be indicative of problems relating to knowledge and confidence regarding specific actions to ensure player safety. Examples include removing a player from the field (question 31); not allowing a player back on to the field (question 33); referring the player to a doctor (question 35); knowing and understanding a minimum stand down period (question 43); and the implementation of a safe stepwise RTP protocol (question 47)*(Table 3.4, page 51).* Further, the higher CK scores may also reflect the inclusion of general and descriptive concussion questions *(Table 3.3, page 47).*

In this study, there were no significant differences in safety scores between coaches with or without a first aid qualification *(Section 3.3.3, page 64).* Carter et al[55] found that rugby coaches with a first aid qualification were more likely to recognise and manage an injury. However, although first aid training for coaches may be beneficial in the management of peripheral and spinal musculoskeletal injuries[55, 259, 266], the training may be insufficient for the safe and accurate identification and management of concussion injuries[81].

BokSmart certified coaches had significantly higher safety scores (62.9% ± 12.3%), compared to non-BokSmart certified coaches (57.6% ± 13.3%)*(Section 3.3.3, page 64).* It is evident that the BokSmart programme improved safety knowledge. This is consistent with findings from earlier studies conducted in other countries, which evaluated the effectiveness of coach education on concussion knowledge[51, 52, 55, 267, 269, 285]. As previously discussed, the BokSmart course content and method of delivery may need to be reviewed to ensure optimal learning. BokSmart certified coaches were also better able to identify a concussion *(Table 3.11, page 66).* However all coaches lacked knowledge in areas pertinent to the actions that should be taken to ensure player safety *(Table 3.11, page 66).* It may be recommended that the BokSmart programme place further emphasis on the principles of safe management of concussion, however evaluating the content, delivery and assessment of the BokSmart programme was beyond the scope of this study.

In this study, coaches demonstrated a high level of awareness of the importance of continuing education regarding concussion for both coaches and players, and that education may facilitate the safe management of concussion injuries *(Section 3.3.3, page 64).* The now mandatory BokSmart certification aligns the South African programme with other international coach education and injury prevention programmes[48-50, 169{#187, 269, 277, 285, 286]. Although there is evidence to support the efficacy of mandatory education programmes[51, 52, 258, 269, 282], current literature recommends that programmes be updated regularly[49, 50]; use refresher courses to emphasise key safety aspects[49]; include a grading of complexity of courses for coaches to progress through[49, 50]; and be responsive towards the diverse backgrounds and needs of coaches[286, 292, 299, 300].

Furthermore, although it is well-documented that children are more vulnerable to concussion and have a slower recovery compared to adults[20, 23, 77, 78, 116, 120]; and that Second Impact Syndrome occurs predominantly in children[23, 72, 126]; Junior School and High School coaches had poor knowledge of concussion injuries in children. The incidence of concussion among South African schoolboy rugby players ranges from 22% to 55%[20], which is substantially higher than in adult rugby players[8, 17-19,77, 78]. It is evident that considerable education is required to ensure coaches implement safe training techniques, are aware of precautions and contraindications when managing children with concussion, and use a more conservative RTP strategy.

3.4.4. Factors that Predict Coaches' Knowledge of the Prevention, Identification and Management of Concussion

Coaching level and continued education, including BokSmart certification, were predictive of both coaches' CK *(Section 3.3.2.2, page 63)* and coaches' SMC *(Section 3.3.3.1, page 68).* Although previous studies have identified poor concussion knowledge in youth coaches[55, 63, 259, 267], the influence of coaching level on knowledge has not been explored. Due to the sample distribution, Junior School coaches represented a smaller sample (n = 34) compared to the other coaching levels *(Table 3.5, page 55).* This could have potentially skewed the analysis, and may not be a true representation of the Junior School coaching population of South Africa. With a greater sample size and more even distribution across all coaching levels, a different result may have been obtained. However, the potential clinical significance of this finding cannot be disregarded, particularly as junior rugby players are at greater risk of concussion and its consequences.

Previous studies have also identified coach education as a predictor of concussion knowledge[260, 267]. The development of educational resources for coaches may increase concussion reporting, thereby facilitating a reduction in the number of symptomatic athletes playing sport. This may ultimately reduce the risk of re-injury and the development of complications associated with concussion[267, 301]. The findings of this study are in agreement with previous studies that support the necessity for continued education to ensure player safety[34, 42, 55, 116, 266, 267, 269, 285].

3.5. CONCLUSION

In conclusion, this study demonstrated that rugby coaches have inadequate concussion knowledge (CK), and insufficient knowledge to ensure the safe management of concussed players (SMC). Continued education was an important predictor of concussion knowledge. The BokSmart certification programme was influential in improving coaches' concussion knowledge. However, it is recommended that further studies review the learning outcomes and assessment methods of the BokSmart programme to maximise the efficacy of the programme in improving player safety.

CHAPTER FOUR

SUMMARY AND CONCLUSION

The high concussion injury rates in rugby have been well-documented[8, 18-20, 53-58]. The accurate identification[1, 11, 13, 19, 29-31, 40] and correct management[1, 34, 37, 46, 47, 261, 262] of a concussion injury is essential to ensure player safety[9, 26-28,31, 34]. Coaches may be required to identify and manage a concussed player in the absence of medical professionals, may educate players regarding concussion, and may assist in injury prevention through teaching safe techniques for training and competition[34, 46, 47]. Previous studies have identified that the risk of concussion may be reduced through coach education, and the subsequent implementation of skills training and education of players[51, 52].

There is a paucity of literature on the assessment of rugby coaches' concussion knowledge[52,260, 266, 267], and no study has been conducted within the South African context. Specific differences were observed between this study and previous studies in coach demographics[52,260, 266, 267], sporting disciplines[257,263,264] and scoring systems[266, 267, 286].

The overall aim of this study was to determine South African rugby coaches' knowledge of the prevention, identification and management of concussion. Based on the evidence provided in this thesis, the study objectives, as described in Section 3.1.1.1, page 51, may be answered as follows:

> *To determine whether rugby coaches have adequate knowledge of the prevention, identification and management of concussion.*

In this study, 73.4% of coaches had inadequate concussion knowledge. Further, BokSmart certified coaches had significantly higher CK scores compared with non-BokSmart certified coaches, only 27% of certified coaches had adequate concussion knowledge. Although the BokSmart programme appeared to be beneficial in increasing coaches' CK, the efficacy of the programme may be improved through adjustments in course content, teaching methods, and accessibility.

To determine whether rugby coaches have sufficient knowledge for the safe management of concussion.

None of the coaches participating in this study obtained safety scores equivalent to the required maximum (100%), and only 5.7% of coaches scored above the minimum requirement of 80%. There were no significant differences in safety scores between coaches with or without a first aid qualification. Although BokSmart certified coaches had significantly higher safety scores compared to non-certified coaches, all coaches lacked knowledge pertinent to ensuring player safety. It may be recommended that the BokSmart programme place further emphasis on the principles of safe management of concussion.

To determine factors that may predict rugby coaches' knowledge of the prevention, identification and management of concussion.

Coaching level and continued education, including BokSmart certification, were predictive of both concussion and safety knowledge. An important implication from these findings is that youth coaches in particular may benefit from extensive education and training on concussion. Further, despite the BokSmart programme being in its infancy, the evidence presented in this study suggests that further investment in coach education and training is warranted.

Based on the findings of this study it is recommended that the BokSmart course content and method of delivery be reviewed to facilitate maximum efficacy within a diverse South African context, thereby ensuring player safety.

CHAPTER FIVE

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APPENDICES

Appendix I: Sports Concussion Assessment Tool2 (SCAT2)

Sports Concussion Assessment Tool 2 (SCAT2)
Permission for reproduction obtained from Dr P McCrory, SCAT2 has no copyright restrictions[1]

SCAT2

Sport Concussion Assessment Tool 2

Name

Sport/team

Date/time of injury

Date/time of assessment

Age Gender M F

Years of education completed

Examiner

What is the SCAT2?[1]

This tool represents a standardized method of evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older. It supersedes the original SCAT published in 2005[2]. This tool also enables the calculation of the Standardized Assessment of Concussion (SAC)[3,4] score and the Maddocks questions[5] for sideline concussion assessment.

Instructions for using the SCAT2

The SCAT2 is designed for the use of medical and health professionals. Preseason baseline testing with the SCAT2 can be helpful for interpreting post-injury test scores. Words in Italics throughout the SCAT2 are the instructions given to the athlete by the tester.

This tool may be freely copied for distribtion to individuals, teams, groups and organizations.

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific symptoms (like those listed below) and often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (such as headache), or
- Physical signs (such as unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour.

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle.

Symptom Evaluation

How do you feel?

You should score yourself on the following symptoms, based on how you feel now.

	none	mild		moderate			severe
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)
Symptom severity score
(Add all scores in table, maximum possible: 22 x 6 = 132)

Do the symptoms get worse with physical activity? Y N
Do the symptoms get worse with mental activity? Y N

Overall rating

If you know the athlete well prior to the injury, how different is the athlete acting compared to his / her usual self? Please circle one response.

no different	very different	unsure

SCAT2 SPORT CONCUSSION ASSESMENT TOOL 2 | **PAGE 1**

Cognitive & Physical Evaluation

1 Symptom score (from page 1)

22 **minus** number of symptoms ____ of 22

2 Physical signs score

Was there loss of consciousness or unresponsiveness? Y N
If yes, how long? ____ minutes
Was there a balance problem/unsteadiness? Y N

Physical signs score (1 point for each negative response) ____ of 2

3 Glasgow coma scale (GCS)

Best eye response (E)

No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4

Best verbal response (V)

No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5

Best motor response (M)

No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6

Glasgow Coma score (E + V + M) ____ of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

4 Sideline Assessment – Maddocks Score

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

At what venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1

Maddocks score ____ of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not included in SCAT 2 summary score for serial testing.

5 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1

Orientation score ____ of 5

Immediate memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. Score 1 pt. for each correct response. Total score equals sum across all 3 trials. Do not inform the athlete that delayed recall will be tested.

List	Trial 1	Trial 2	Trial 3	Alternative word list		
elbow	0 1	0 1	0 1	candle	baby	finger
apple	0 1	0 1	0 1	paper	monkey	penny
carpet	0 1	0 1	0 1	sugar	perfume	blanket
saddle	0 1	0 1	0 1	sandwich	sunset	lemon
bubble	0 1	0 1	0 1	wagon	iron	insect
Total						

Immediate memory score ____ of 15

Concentration

Digits Backward:

"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."

If correct, go to next string length. If incorrect, read trial 2. One point possible for each string length. Stop after incorrect on both trials. The digits should be read at the rate of one per second.

		Alternative digit lists		
4-9-3	0 1	6-2-9	5-2-6	4-1-5
3-8-1-4	0 1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0 1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0 1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6

Months in Reverse Order:

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November ... Go ahead"

1 pt. for entire sequence correct

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan 0 1

Concentration score ____ of 5

[1] This tool has been developed by a group of international experts at the 3rd International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2008. The full details of the conference outcomes and the authors of the tool are published in British Journal of Sports Medicine, 2009, volume 43, supplement 1.
The outcome paper will also be simultaneously co-published in the May 2009 issues of Clinical Journal of Sports Medicine, Physical Medicine & Rehabilitation, Journal of Athletic Training, Journal of Clinical Neuroscience, Journal of Science & Medicine in Sport, Neurosurgery, Scandinavian Journal of Science & Medicine in Sport and the Journal of Clinical Sports Medicine.

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[5] Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clin J Sport Med. 1995;5(1):32–3

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6 Balance examination

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[6]. A stopwatch or watch with a second hand is required for this testing.

Balance testing

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:
"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:
"If you were to kick a ball, which foot would you use? [This will be the dominant foot] *Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

(c) Tandem stance:
"Now stand heel-to-toe with your ***non-dominant foot*** *in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Balance testing – types of errors
1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10.** If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects that are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

Which foot was tested: ☐ Left ☐ Right
(i.e. which is the **non-dominant** foot)

Condition	Total errors
Double Leg Stance (feet together)	of 10
Single leg stance (non-dominant foot)	of 10
Tandem stance (non-dominant foot at back)	of 10
Balance examination score (30 **minus** total errors)	of 30

7 Coordination examination

Upper limb coordination

Finger-to-nose (FTN) task: *"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended). When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose as quickly and as accurately as possible."*

Which arm was tested: ☐ Left ☐ Right

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Athletes fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. Failure should be scored as 0.

Coordination score of 1

8 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Delayed recall

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Circle each word correctly recalled. Total score equals number of words recalled.

List	Alternative word list		
elbow	candle	baby	finger
apple	paper	monkey	penny
carpet	sugar	perfume	blanket
saddle	sandwich	sunset	lemon
bubble	wagon	iron	insect

Delayed recall score of 5

Overall score

Test domain	Score
Symptom score	of 22
Physical signs score	of 2
Glasgow Coma score (E + V + M)	of 15
Balance examination score	of 30
Coordination score	of 1
Subtotal	**of 70**
Orientation score	of 5
Immediate memory score	of 5
Concentration score	of 15
Delayed recall score	of 5
SAC subtotal	**of 30**
SCAT2 total	**of 100**
Maddocks Score	**of 5**

Definitive normative data for a SCAT2 "cut-off" score is not available at this time and will be developed in prospective studies. Embedded within the SCAT2 is the SAC score that can be utilized separately in concussion management. The scoring system also takes on particular clinical significance during serial assessment where it can be used to document either a decline or an improvement in neurological functioning.

Scoring data from the SCAT2 or SAC should not be used as a stand alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion.

Athlete Information

Any athlete suspected of having a concussion should be removed from play, and then seek medical evaluation.

Signs to watch for

Problems could arise over the first 24-48 hours. You should not be left alone and must go to a hospital at once if you:

- Have a headache that gets worse
- Are very drowsy or can't be awakened (woken up)
- Can't recognize people or places
- Have repeated vomiting
- Behave unusually or seem confused; are very irritable
- Have seizures (arms and legs jerk uncontrollably)
- Have weak or numb arms or legs
- Are unsteady on your feet; have slurred speech

Remember, it is better to be safe.
Consult your doctor after a suspected concussion.

Return to play

Athletes should not be returned to play the same day of injury. When returning athletes to play, they should follow a stepwise symptom-limited program, with stages of progression. For example:

1. rest until asymptomatic (physical and mental rest)
2. light aerobic exercise (e.g. stationary cycle)
3. sport-specific exercise
4. non-contact training drills (start light resistance training)
5. full contact training after medical clearance
6. return to competition (game play)

There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage 1 if symptoms recur. Resistance training should only be added in the later stages.
Medical clearance should be given before return to play.

Tool	Test domain	Time	Score			
		Date tested				
		Days post injury				
SCAT2	Symptom score					
	Physical signs score					
	Glasgow Coma score (E + V + M)					
	Balance examination score					
	Coordination score					
SAC	Orientation score					
	Immediate memory score					
	Concentration score					
	Delayed recall score					
	SAC Score					
Total	**SCAT2**					
Symptom severity score (max possible 132)						
Return to play			☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N	☐ Y ☐ N

Additional comments

Concussion injury advice (To be given to concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. It is expected that recovery will be rapid, but the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please telephone the clinic or the nearest hospital emergency department immediately.

Other important points:

- **Rest and avoid strenuous activity for at least 24 hours**
- **No alcohol**
- **No sleeping tablets**
- **Use paracetamol or codeine for headache. Do not use aspirin or anti-inflammatory medication**
- **Do not drive until medically cleared**
- **Do not train or play sport until medically cleared**

Clinic phone number

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

Contact details or stamp

Appendix II: Balance Error Scoring System (BESS)[184]

The Balance Error Scoring System (BESS)

Obtain Preseason Baseline Score; Compare with Post-Concussion Score[33-34]

The Balance Error Scoring System[33-34] provides a portable, cost-effective and objective method of assessing static **postural stability**. The BESS can be used to assess the effects of mild head injury on static postural stability. Information obtained from this clinical balance tool can be used to assist clinicians in making return to play decisions following mild head injury. The BESS can be performed in nearly any environment and takes approximately 10 minutes to conduct.

The balance-testing regime consists three stances on two different surfaces. The three stances are **double leg stance**, **single leg stance** and **tandem stance**. The two different surfaces include both a **firm** (ground) and **foam** surface. **Athletes' stance should consist of the hands on the iliac crests, eyes closed and a consistent foot position depending on the stance**. Shoes should not be worn.

In the **double leg stance**, the feet are flat on the testing surface approximately pelvic width apart.

In the **single leg stance** position, the athlete is to stand on the non-dominant leg with the contralateral limb held in approximately 20° of hip flexion, 45° of knee flexion and neutral position in the frontal plane.

In the **tandem stance** testing position, one foot is placed in front of the other with heel of the anterior foot touching the toe of the posterior foot. The athlete's non-dominant leg is in the posterior position. Leg dominance should be determined by the athlete's kicking preference.

Administering the BESS: Establish baseline score prior to the start of the athletic season. After a concussive injury, re-assess the athlete and compare to baseline score. Only consider return to activity if scores are comparable to baseline score. Use with Standardized Symptom Scale Checklist.

Scoring the BESS: Each of the trials is **20 seconds.** Count the number of errors (deviations) from the proper stance. The examiner should begin counting errors only after the individual has assumed the proper testing position.


Double Leg Stance
Firm Surface


Single Leg Stance
Firm Surface


Tandem Stance
Firm Surface


Double Leg Stance
Foam Surface


Single Leg Stance
Foam Surface


Tandem Stance
Foam Surface

Errors:
- **Moving the hands off the hips**
- **Opening the eyes**
- **Step, stumble or fall**
- **Abduction or flexion of the hip beyond 30°**
- **Lifting the forefoot or heel off of the testing surface**
- **Remaining out of the proper testing position for greater than 5 seconds**

The maximum total number of errors for any single condition is 10.

If a subject commits multiple errors simultaneously, only one error is recorded.

B.E.S.S. SCORECARD		
Count Number of Errors max of 10 each stance/surface	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dominant foot in back)		
TOTAL SCORES: total each column		
B.E.S.S. TOTAL: (Firm+Foam total)		

Airex™ Foam Balance Pads available at **www.power-systems.com** or through most sporting goods stores.

Appendix III: Ethics Approval Letter

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6626 • **Facsimile** [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

07 April 2010

REC REF: 114/2010

Dr T Burgess & Ms R Parker
Health & Rehab

Dear Dr Burgess & Ms Parker

PROJECT TITLE: FACTORS THAT PREDICT SOUTH AFRICAN RUGBY COACHES' KNOWLEDGE OF THE PREVENTION, DIAGNOSIS AND MANAGEMENT OF CONCUSSION.

Thank you for submitting your study to the Research Ethics Committee for review.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 16th April 2011.

We acknowledge that the following student is also involved in this study:

1. Kathryn Thomas

Please submit an annual progress report if the research continues beyond the expiry date. Please submit a brief summary of findings if you complete the study within the approval period so that we can close our file.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

S Thomas

Yours sincerely

signature removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix IV: Letter to coaches and Informed Consent

School of Health and Rehabilitation Sciences

Faculty of Health Sciences

Divisions of Communications Sciences and Disorders, Nursing and Midwifery, Occupational Therapy, Physiotherapy

F45 Old Main Building, Groote Schurz Hospital,

Observatory 7925

Tel: +27 (0) 21 406 6401 Fax: +27 (0) 21 406 6323

Dear Coach

I am a Masters student at the University of Cape Town, Division of Physiotherapy and am conducting a study on South African rugby coaches' knowledge of the prevention, identification and management of concussion. The study has been given ethics approval by the Research Ethics Committee (Ref# 114/2010). The knowledge gained from this study will ascertain the knowledge of the prevention, diagnosis and management of concussion of South African rugby coaches and could highlight any future needs or changes required in coaching workshops or more stringent regulation of coaches 'licenses'.

Although the risk of concussion in rugby does not outweigh the many benefits of sports participation, preventative measures, like safe playing techniques and education, should be practiced to decrease rugby concussion rates to the lowest possible level. After sustaining a concussion the ability to treat or reduce the effects are minimal, added to which the mismanagement of a concussed player can have prolonged and serious consequences. Unfortunately in South Africa doctors and emergency personnel are not always present at practices and matches, often leaving the coach as the sole 'medical officer'. Given this situation it would be beneficial that the coach be fully capable of identifying a concussed player and making the right decisions to ensure the wellbeing of the player and any management outcomes that follow. Prevention of concussion through safer playing techniques and education, may well become key for progress in this field.

Rugby coaches across the country from schools, clubs and provincial teams have been randomly selected to participate in this study. Your voluntary participation in this study will require you to sign an informed consent form and complete the attached questionnaire. The questionnaire is designed to firstly determine your coaching experience and level of coaching education, followed by establishing any training techniques and player education. Finally, the questionnaire will investigate your knowledge on the diagnosis of concussion, concussion consequences, management of a concussed player and return to play protocols.

It is estimated that it will take you **approximately 20 minutes to complete the questionnaire**. The original questionnaire sent to you is in English. Should you wish to complete it in Afrikaans or Xhosa, please email me your request. On completion you will be required to email, post or fax the completed questionnaire, with the signed informed consent, back to me. If you choose to complete it online, the informed consent is part of the survey and no paper work is therefore required. There are no risks associated with taking part in this study. All questionnaires will be kept locked

away and confidential, as well as coded to ensure anonymity. There is also no monetary remuneration for taking part in the study. You will be sent a coaches booklet with information regarding the latest protocols on concussion in sport and a handy concussion pocket guide to assist you with on-field assessment and diagnosis of a concussed player.

This study is being be supervised by Dr Burgess and Ms Parker. Should you have any questions regarding the study prior to volunteering to participate, please feel free to contact me.

Thanking you in advance for your enthusiasm to support research in the field of rugby.

Kind regards

Kathryn Thomas (BSc Physiotherapy)

NB: Should you have other rugby coaches working with you (assistants or additional teams) that would be interested in participating in the research, please include them by either making additional copies of the questionnaire and informed consent for them to complete, or advise me such that I can contact them directly.

Details to return the completed questionnaire:

Email: rugbyresearch2010@gmail.com

OR

Post: 88 Salisbury Avenue, Westville, 3629, KZN

OR

Fax: 0866 705887

Informed Consent

Study: South African rugby coaches' knowledge of the prevention, identification and management of concussion

Participation in the study is voluntary. You will be required to sign this informed consent and complete the attached questionnaire. On completion both the informed consent form and questionnaire need to be emailed, posted or faxed back to me. All questionnaires will be kept confidential and locked away. In addition to that each questionnaire will be allocated a code, thereby keeping the respondent anonymous.

Potential risk to participant:

There will be no risk to any subject, as no physical tests will be carried out. The questionnaire will be coded such that they remain anonymous and kept in the strictest confidence.

Anticipated benefit to participant:

All participants will be provided with information pamphlets on concussion, including a useful pocket booklet to aid their on-field assessment and diagnosis of concussion. Unfortunately no remuneration is available for participation in this study.

Questions or Concerns:

If at any time you have any questions about the study please feel free to contact any of the individuals listed below. You are assured that all enquiries will remain confidential.

Researcher: Kathryn Thomas 0828861954 rugbyresearch2010@gmail.com

Supervisor: Theresa Burgess 012 4066171 theresa.burgess@uct.ac.za

Co-Supervisor: Romy Parker 021 4066571 romy.parker@uct.ac.za

Ethics Committee: Professor Marc Blockman
Chairperson, Faculty of Health Sciences Research and Ethics Committee
Tel: 021 406 6492
E-mail: marc.blockman@uct.ac.za

By placing your signature below it confirms that you have had adequate time to read through and have understood the consent form and that you are willing to participate in this study.

	Print Name	Signature	Date
Coach / Participant			
Witness			
Researcher			

Appendix V: Questionnaire

For Office use Only	Questionnaire Code:

Rugby Coach Questionnaire

Thank you for taking the time to complete this questionnaire, which will greatly add to the body of knowledge and literature about Rugby coaches and the management of Concussion.

Each questionnaire will be coded, therefore ensuring confidentiality and anonymity.

Please read each question carefully

Note: References have been provided to indicate the evidence-base for inclusion of specific sections/questions into the concussion knowledge questionnaire.

How to answer:

(1) Please tick √ to indicate your answer, in the same box as the answer you choose.

Or

(2) If you are completing this questionnaire on your computer, simply open it, work through the questionnaire selecting your answers, save the changes and email back to me. Please indicate your answer by highlighting it OR indicate your selection by making your answer a specific font colour (for example all your answers will be in red)

SECTION A: COACH EXPERIENCE[1-6]

1. What is your current rugby coaching position?

Junior School	Schools Provincial Team
High School	Provincial u19 Team
Junior Club Rugby	Provincial u21 Team
Senior Club Rugby	Provincial Team
Other, please specify	

1a. Is this coaching position a full time job?

Yes	No

1b. Are the players..

Amateurs	Semi-Professionals	Professionals
Informal / Social		

2a. What is the age group of the players you coach?

Under 10 year olds	10 – 12 year olds	13 – 15 year olds
16 – 18 year olds	Adults (over 18 years old)	

2b. Which team do you coach?

First XV	A
Second XV	B
Third XV	C
Fourth XV	D
Fifth XV	E
Other, please specify	

3. In which 'rugby province' do you coach?

Leopards	Lions	Falcons
Griffons	Free State	Griquas
Western Province	Boland	South Western Districts
Eastern Province	Border	Pumas
KwaZulu Natal	Blue Bulls	

4. How many years have you coached rugby?

This is my first year	1 year	2 years
3 – 5 years	6 – 9 years	10 years and more

5a. Are you in a coaching position whereby you are the only 'senior' person present at **rugby practices**, making you responsible for any medical emergency?

Yes, 80 – 100% of the time	50 – 80% of the time	Less than 50% of the time
No, never		

5b. Are you in a coaching position whereby you are the only 'senior' person present at **rugby matches**, making you responsible for any medical emergency?

Yes, 80 – 100% of the time	50 – 80% of the time	Less than 50% of the time
No, never		

6. If you have indicated that you **do have** a medical team working with your rugby team, what does this medical team consist of?

Medical Doctor - GP	Sports Physician	Biokineticist
Chiropractor	Physiotherapist	Masseur
Psychologist	Fitness Instructor	Orthopaedic surgeon
Dietician	Boksmart Rugby Medic	First Aider
Other, please specify		

SECTION B: COACH EDUCATION[7-16]

7. Do you have a first aid qualification?

Yes	No

7a. If *YES*, when did you attend the first aid course?

Last year	Within the last 2 years
2 – 5 years ago	More than 5 years ago

7b. If *YES*, at what level

1	2	3	4	5
Basic Life Support	Intermediate Life Support		Advanced Life Support	

8. Do you know about the BokSmart program?

Yes	No

9. Have you done the BokSmart Rugby Safety Certification Program (or your provincial equivalent, for example SharkSmart)?

Yes	No

9a. If *YES*, please supply your BokSmart Certification number…

BK:

9b. Are you aware of the BokSmart Rugby Safety Workshop regulations that are in effect from 1 January 2011?

Yes	No

9c. Are you aware of the current BokSmart "Under Age Rugby" regulations that are in effect from 1 April 2010?

Yes	No

10. Do you use the BokSmart Website to learn more about rugby coaching, safe techniques, rules and medical management?

Never	Once a year	Once a quarter	Every month	Every week

11. The majority of my knowledge about concussion was learnt through….

Internet	Media: TV	Media: Print	Media: DVD
Library	Courses/Workshops	Fellow Coaches	Medical Staff
Other, please specify..			

12. At present I am confident managing a concussed player

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

13. Education about concussion identification, management and prevention can reduce the incidence of concussion.

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

14. My current concerns about attending rugby courses/workshops are (you may select more than one)

Cost	Language barrier	Location, travelling away from home
Time constraints	Fear of Failure	Concerns about written exam
Courses are not productive, a waste of my time	I do not need further courses /education at the moment	

15. Are you aware that the BokSmart Rugby Safety Certification program is a free service and that you are not required to write an exam?

Yes	No

SECTION C: TRAINING TECHNIQUES[17-24]

16. Concussion most often happens during which phase of play?

Scrumming	Rucks	Mauls
Tackling	Lineouts	

17. Do you teach safe tackling and falling techniques?

Yes, at every practice session	Yes, frequently throughout the season	Only in pre-season practice sessions	No, I expect them to know this	No

18. Teaching safe tackling and falling techniques can reduce the incidence of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

19. Wearing the soft-shelled rugby headgear can reduce the risk of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

20. Teaching players about signs and symptoms, treatment and safe return to play will aid in better identification and management of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

SECTION D: DIAGNOSIS OF CONCUSSION[1, 2, 25-30]

21. Concussion only occurs following a direct blow to the head

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

22. Acceleration – deceleration forces (a type of whiplash or head jolt whilst being tackled) may cause concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

23. Loss of consciousness is the main diagnostic criteria for concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

24. Concussion may also be termed "mild traumatic brain injury"

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

25. From the list below select any and/or as many symptoms which are indicative of concussion

Nausea	Headache	'Feeling foggy'
Paraesthesia (tingling)	Difficulty remembering	Drowsiness
Sensitivity to light	Aggressiveness	Abdominal cramps
Thirst	Vomiting	Sensitivity to noise
Difficulty concentrating	Increased alertness	Vacant, glassy eyes
Diarrhea	Loss of consciousness	Heart Palpitations
Dizziness	Poor balance	Blurred vision
'Just not feeling right'	Confusion	Ringing

26. Radiology (MRI, CT scan, X-ray) may be normal after a first concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

27. Routine questioning of person, time and place (what is your name? what day is it? where are you?) is a reliable test for rapid on-field assessment of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

28. Have you ever heard of a SCAT (Sports Concussion Assessment Tool) card?

Yes	No

28a. Have you ever used a SCAT card?

Yes	No

28b. A Sports Concussion Assessment Tool card (SCAT/SCAT2 card) or BokSmart Concussion guide tool may be used to assist rapid on-field assessment of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

29. Balance Tests may be used to assist rapid on-field assessment of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

30. Neuro-psychological tests (computer tests to assess brain function) alone may be used for sideline diagnosis of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

Section E: Management of Concussion[1, 2, 11, 12, 25, 26, 31-35]

31. If a player is suspected of having sustained a concussion he must leave the field of play immediately

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

32. Only a player with a 'severe' concussion, who lost consciousness, needs to leave the field immediately

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

33. If a player left the field for concussion but 'he feels fine' within some minutes, he may safely return to the field of play

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

34. Choose **2** people who have the ultimate decision on whether a player has to leave the field following a concussion?

The Player	The Coach	The Parent
The Referee	The Manager	Medical Staff

35. Any player with a suspected concussion should consult an appropriate medical doctor as soon as possible

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

36. A child or adolescent (under the age of 18) is more vulnerable to concussion than an adult

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

37. A child or adolescent (under the age of 18) requires a smaller impact force to sustain the same concussion as an adult

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

38. The mainstay of treatment for concussion is

Physical and Cognitive (rest from any studying, or mental activity which requires thought and information processing) rest	Physical rest only	Cognitive rest only	Medication for symptom relief	Do not know

SECTION F: CONSEQUENCES OF CONCUSSION[25, 36-45]

39. 2nd Impact Syndrome occurs when

A 2nd concussion is sustained in the same match	A 2nd concussion is sustained in the same season	A 2nd concussion is sustained in a career	A 2nd blow to the head is sustained whilst a concussion has not yet resolved	All of the above

40. The **most serious** consequence of 2nd Impact Syndrome is

No serious consequences	Loss of consciousness	3rd impact syndrome	Post Concussion Syndrome	Death

41. The most likely consequence for a **child** (under the age of 18) who suffers from more than one concussion in a season is

No serious consequences	Loss of consciousness	2nd impact syndrome	Post Concussion Syndrome (prolonged presence of concussion symptoms)	Death

42. The most likely consequence for an **adult** player who suffers from more than one concussion in a season is

No serious consequences	Loss of consciousness	2nd impact syndrome	Post Concussion Syndrome	Death

SECTION G: RETURN TO PLAY[9, 25, 31, 36, 46-53]

43. According to the South African Rugby Concussion Guidelines, if a player does not have access to a doctor to be medically cleared following concussion, a minimum 'stand down' period is stipulated for

1 week	2 weeks	3 weeks
4 weeks	5 weeks	Do not know

44. A child or adolescent recovers faster from concussion than an adult and can therefore return to play sooner

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

45. A player who reports to his coach that he is symptom free following a concussion can return to practice that day

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

46. When a concussed player has been medically 'cleared' to return to play he can immediately resume full contact practice with his team

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

47. A player has to be examined by a medical professional and be symptom free throughout a step-wise and graded return-to-play exercise progression protocol and be neuro-psychologically (brain function) cleared before returning to match play

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

48. A player returns to play after a concussion and develops a headache. The management of choice would be pain-killers

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree

49. If you were to use a Stepwise Return to Play Protocol following concussion – list these activities in the order you would have the player perform them. (1 being the first activity performed and 7 the final activity prior to full game play)

Tackle bags and contact allowed at full practice	
Running and agility drills, no impact activities	
Jogging, light running	
Walking, stationary bicycle, swimming	
Drills incorporating running and passing, co-ordination activities	
Resistance training (eg: lifting weights at the gym)	
No activity, complete physical and cognitive rest	

Thank you so much for your time and completing this questionnaire !!

Please return the questionnaire, with the signed (you may type your name should you be completing this electronically) informed consent form, by:

Post: Kathryn Thomas, 88 Salisbury Avenue, Westville 3629, KZN

or

Email: rugbyresearch2010@gmail.com

or

Fax: 0866 705887

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Appendix VI: Letter to Validators

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Dear *(insert individuals name)*

Request for Assistance: Validation of Rugby Concussion Questionnaire

I am an MPhil (Sports Physiotherapy) student at the University of Cape Town, and am writing to you to request assistance with the validation of a concussion questionnaire.

The correct diagnosis, management and return to play protocol for concussion are essential to ensure player safety and to prevent the risk of associated complications. Research conducted in other rugby playing nations has highlighted the fact that rugby coaches' knowledge about concussion is limited and has such resulted in the implementation of programmes and courses to address this. In South Africa the coaches are frequently the only 'senior' person present at practices and matches indirectly making them responsible for dealing with any medical emergency. At present there is no literature documenting South African rugby coaches' knowledge of concussion diagnosis and management. This is cause for concern, particularly with regards to player safety, medico-legal ramifications and the future reputation of the sport. Accordingly, I propose to investigate South African rugby coaches' knowledge of the prevention, diagnosis and management of concussion.

I have developed a questionnaire to assess rugby coaches' knowledge of prevention, diagnosis, management and return to play protocols for concussion and potentially establish any correlations with the coaches' experience and education on rugby. In addition, the questionnaire aims to test the coaches understanding of the dangers and consequences of concussion.

As a recognised *(insert individuals specific expertise)* and an expert in the field of rugby and concussion, I therefore wish to request your assistance with the validation of the content of the concussion questionnaire. Please could you review the questionnaire in order to ensure that the questions are clear and easy to understand, and that the questions adequately assess knowledge of the diagnosis, management, and understanding of the consequences of concussion?

I have attached the questionnaire, with the desired answers indicated as well as allocated a comment section per question. Your feedback will be greatly appreciated.

If possible, please could you return any feedback before *(insert date)* 2010. Please contact me should you have further questions or should you be unable to assist with the validation process.

My contact details are as follows:

Kathryn Thomas:

kittyjoythomas@gmail.com

Mobile: 082 8861954

Thank you for your time and supporting research in the field of rugby.

Kind regards

Kathryn Thomas

Thesis supervisors: Dr Burgess theresa.burgess@uct.ac.za

Mr Parker romy.parker@uct.ac.za

Appendix VII: Coaches Information Booklet and Pocket SCAT2

What is Concussion?

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical force. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilized in defining the nature of a concussive injury include:

1. Concussion may be caused by a direct blow to the head, face, neck or elsewhere on the body with an 'impulsive' force transmitted to the head.
2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
3. Concussion may result in neuropathologic change, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness (LOC). Resolution of the clinical and cognitive symptoms typically follows a sequential course; however it is important to note that in a small percentage of cases, postconcussive symptoms can be prolonged.
5. No abnormality on standard structural neuroimaging studies is seen in concussion.

What are the signs and symptoms to look for in a player that may have a concussion?

Symptoms and Signs of Concussion				
Symptoms	*Physical Signs*	*Behavioural Changes*	*Cognitive Impairment*	*Sleep Disturbance*
Somatic Eg: headache Cognitive Eg: feeling 'foggy' Emotional Eg: lability	LOC Dizziness Amnesia Photophobia Nausea Numbness / Tingling Vomiting Vacant stare Glassy eyes	Irritability Mood Swings Aggressiveness	Poor concentration Problems remembering Feeling 'slowed down' Slowed reaction time Balance problems	Drowsiness Fatigue Insomnia Difficulty getting to sleep

What should I do at a practice or match if someone is hurt and suspected of a concussion on the field?

"If in doubt – sit out"

On-field:

The aim of immediate management is to stabilise the head-injured player and administer basic first aid[99]. This applies especially in all cases where there has been loss of consciousness, the player is confused or has any suggestion of associated neck injury (neck pain, numbness or limb paraesthesiae). In more subtle cases, a validated brief on-field neuropsychological test can be administered using the Sport Concussion Assessment Tool 2 (SCAT2). SCAT2 enables the calculation of the Standardized Assessment of Concussion (SAC) score and incorporates Maddock's questions. The standard approach of asking orientation item questions of time, place and person are unreliable, as this component of cognitive function may be preserved in concussion. The concussed player must be removed from the field of play or practice session immediately.

Sideline Evaluation:

It should be emphasised that the concussed player must be assessed by a medical doctor as soon as possible following injury. The main aims of the field side assessment are to confirm the diagnosis of concussion, perform an initial (baseline) symptom analysis and to determine if there are urgent indications for referral to hospital. Following this assessment, the team physician must decide if there is any indication to refer to hospital or whether the player may be adequately managed at home. Home supervision requires a responsible adult to be present as well as a set of guidelines.

Hospital referral:

If the player has been unconscious for any period of time, has deteriorating drowsiness, recurrent vomiting, unusual or aggressive behaviour or focal neurological signs, it is recommended that the player be referred to a tertiary care hospital and either a Computed Tomographic (CT) or Magnetic Resonance Image (MRI) scan be performed.

SCAT2 Pocket Version to assist On-Field assessment of concussion

Pocket SCAT2

Concussion should be suspected in the presence of **any one or more** of the following: symptoms (such as headache), or physical signs (such as unsteadiness), or impaired brain function (e.g. confusion) or abnormal behaviour.

1. Symptoms

Presence of any of the following signs & symptoms may suggest a concussion.

- Loss of consciousness
- Seizure or convulsion
- Amnesia
- Headache
- "Pressure in head"
- Neck Pain
- Nausea or vomiting
- Dizziness
- Blurred vision
- Balance problems
- Sensitivity to light
- Sensitivity to noise
- Feeling slowed down
- Feeling like "in a fog"
- "Don't feel right"
- Difficulty concentrating
- Difficulty remembering
- Fatigue or low energy
- Confusion
- Drowsiness
- More emotional
- Irritability
- Sadness
- Nervous or anxious

2. Memory function

Failure to answer all questions correctly may suggest a concussion.

"At what venue are we at today?"
"Which half is it now?"
"Who scored last in this game?"
"What team did you play last week/game?"
"Did your team win the last game?"

3. Balance testing

Instructions for tandem stance

*"Now stand heel-to-toe with your **non-dominant** foot in back. Your weight should be evenly distributed across both feet. You should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Observe the athlete for 20 seconds. If they make more than 5 errors (such as lift their hands off their hips; open their eyes; lift their forefoot or heel; step, stumble, or fall; or remain out of the start position for more that 5 seconds) then this may suggest a concussion.

Any athlete with a suspected concussion should be IMMEDIATELY REMOVED FROM PLAY, urgently assessed medically, should not be left alone and should not drive a motor vehicle.

INDICATIONS FOR URGENT REFERRAL TO HOSPITAL FOR SPECIAL INVESTIGATION AND ADMISSION.
Any player who has or develops the following: • Fractured skull • Penetrating skull trauma • Deterioration in conscious state following injury • Focal neurological signs • Confusion or impairment of consciousness > 30 minutes • Loss of consciousness > 5 minutes • Persistent vomiting or increasing headache post injury • Any convulsive movements • More than one episode of concussive injury in a match or training session • Where there is assessment difficulty (e.g.: an intoxicated patient) • All children with head injuries • High-risk patients (e.g. haemophilia, anticoagulant use) • Inadequate post injury supervision • High-risk injury mechanism (e.g.: high velocity impact, missile injury)

PATIENT DISCHARGE INFORMATION FOR HOME CARE FOR 48 HOURS AFTER INJURY
Patient Information - Important Reminders for the First 48 Hours A normal X-ray, CT or MRI scan does NOT exclude concussion. You may be referred home after being assessed. In this case: • Always make sure that you are in the presence of a responsible adult for 48 hours. • Record and monitor the symptoms of concussion including headache, nausea, dizziness, fatigue, sleep disturbances, memory lapses, mood swings, poor concentration or any other feeling that concerns you. • Complete rest & sleep will help recovery. Do not: • Drive a motor vehicle or motor cycle if symptomatic. • Consume alcohol • Take excessive amounts of painkillers (follow doctor's orders) • Place yourself in an environment of loud noise and excessive light • Study • Work at the computer, use playstation/videogames, send text messages • Exercise until re-evaluation by a doctor Contact your nearest Emergency Department immediately if: • Any of the symptoms deteriorate • The headache becomes severe or does not respond to mild analgesics (e.g. Panado) • You have a seizure (fit) • You experience excessive irritability • You experience visual disturbances • You experience balance problems • You or anyone else is concerned about your condition Decisions regarding returning to sport will be made taking into consideration your individual circumstances including medical history, previous head injuries and current symptoms. You must receive clearance from a doctor before returning to sport.

When can a player come back to sport after a concussion?

The 'treatment' for concussion is complete rest. This means physical rest and cognitive rest – so your player must reduce all work/school work, reduce the length of their day, move meetings or examinations, not SMS or watch TV, play video games or participate in any activity requiring mental stimulation. Once all symptoms have resolved, along with the return of normal cognitive function and postural control which will be examined and cleared by a doctor or medical professional. The player can then start the Stepwise return to play protocol.

IRB Medical Regulation on Concussion
10.1.1 A Player who has suffered concussion shall not participate in any Match or training session for a minimum period of three weeks from the time of injury, and may then only do so when symptom free and declared fit after proper medical examination. Such declaration must be recorded in a written report prepared by the person who carried out the medical examination of the Player. 10.1.2 Subject to sub-clause 10.1.3 below, the three-week period may be reduced only if the Player is symptom free and declared fit to play after appropriate assessment by a properly qualified and recognised neurological specialist. Such declaration must be recorded in a written report prepared by the properly qualified and recognised neurological specialist who carried out the assessment of the Player. 10.1.3 In age grade rugby the three-week minimum period shall be mandatory. It is the responsibility of coaches and club administrators, in conjunction with medical practitioners to ensure that these requirements are closely observed. If referees are doubtful as to the ability of a player to continue in the game they should apply the provisions of Law 3.9, which requires the player to leave the field.

Graduated Stepwise Return-to-Play			
Rehabilitation Stage		***Functional Exercise at Each Stage of Rehabilitation***	***Objective of Each Stage***
1.	No activity	Complete physical and cognitive rest	Recovery
2.	Light aerobic exercise	Walking, swimming, or stationary bicycle, keeping intensity to < 70% of maximum predicted heart rate, no resistance training	Increase heart rate
3.	Sport-specific exercise	Skating drills in ice hockey, running drills in soccer and rugby for example. No contact, no head impact activities	Add movement
4.	Non-contact training drills	Progression to more complex training drills, agility drills, eg: passing drills in rugby, may start progressive resistance training	Exercise, coordination and cognitive load
5.	Full-contact practice	Following medical clearance, participation in normal training activities	Restore athlete's confidence, coaching staff assesses functional skills
6.	Return to play	Normal game play	
The player can proceed in a stepwise progression to the next level after 24 hours, provided he/she is asymptomatic. If any post-concussion symptoms develop, the player should rest for 24 hours and then revert back to the previous asymptomatic level.			

Prevention is the Best Protection

The best way to manage concussion is to prevent it!! Using safe tackling and falling techniques have been proven to reduce the rate on concussion injuries, at the same time improve the effectiveness of play. It is recommended that time is spent in training and practice sessions to teach these techniques, even to those whom you may expect to know this !! Use the BokSmart website to learn more at www.BokSmart.com

Appendix VIII: Additional Results

Results Appendix 1: Additional Demographic Data		
	Count	Percent %
Composition of Medical Personnel at Practice and Matches		
General Practitioner	41	8.9
Sports Physician	12	2.6
Biokinetist	52	11.3
Chiropractor	0	0
Physiotherapist	51	11.1
Masseur	4	0.9
Psychologist	19	4.1
Fitness Instructor	34	7.4
Orthopedic Surgeon	4	0.9
Dietician	2	0.4
BokSmart Medic	68	14.8
Paramedic / First Aider	174	37.7
Means most frequently used medium for learning about Concussion in Rugby		
Internet	34	8.1
TV	25	5.9
Print	36	8.6
DVD	11	2.6
Library	2	0.5
Courses and Workshops	119	28.4
Fellow Coaches	52	12.4
Medical Staff	126	30.0
Other: Personal Experience	10	2.4
Other: I was a rugby player	2	0.5
Other: Sports Science Degree	2	0.5
Concerns about attending Rugby Safety Workshops and Courses		
Cost	93	24.3
Language Barrier	12	3.1
Location	62	16.2
Time Constraints	150	39.2
Fear of Failure	6	1.6
Concerns about a Written Exam	7	1.8
Courses are a waste of time and not constructive	40	10.4
I don't need courses, I know everything about Rugby Safety	13	3.4

Results Appendix 2: Summary of Results for Concussion Knowledge Questions					
Questions:	**Answers: Count (N) and Percent %**				
Section C: Training Techniques					
Q16. Concussion most often happens during which phase of play	*Tackle*	Other			
	201 (n)	28 (n)			
	87.8 (%)	12.2 (%)			
Q17. Do you teach safe tackling and falling techniques	*Yes, at every practice session*	Yes, frequently during the season	Only in pre-season sessions	No, I expect them to know this	No
	23	168	32	4	2
	10	73.4	14	1.7	0.9
Q18. Teaching safe tackling and falling techniques can reduce the incidence of concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	131	96	2	0	0
	57.2	41.9	0.9	0	0
Q19. Wearing soft-shelled rugby headgear can reduce the risk of concussion	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	47	106	15	54	*7*
	20.5	46.3	6.6	23.6	*3.1*
Q20. Teaching players about the signs and symptoms, treatment and safe RTP will better aid the identification and management of concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	103	119	4	3	0
	45	52	1.7	1.3	0
Section D: Identification of Concussion					
Q21. Concussion only occurs following a direct blow to the head	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	24	87	11	94	*13*
	10.5	38	4.8	41	*5.7*
Q22. Acceleration – deceleration forces may cause concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	61	147	17	2	2
	26.6	64.2	7.4	0.9	0.9
Q23. Loss of consciousness is the main diagnostic criteria for concussion	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	17	90	12	86	*24*
	7.4	39.3	5.3	37.6	*10.5*
Q24. Concussion may also be termed 'mild traumatic brain injury'	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	29	162	34	4	0
	12.7	70.7	1408	1.7	0
Q25. From the list select any, and/or as many symptoms, which are indicative of concussion. (Max 9 marks)	$0 < x \leq 2$	$2 < x \leq 4$	$4 < x \leq 6$	$6 < x \leq 8$	*$8 < x \leq 9$*
	7	37	99	74	*12*
	3.1	16.2	43.2	32.3	*5.2*
Q26. Radiology may be normal after a first concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	23	105	66	34	1
	10	45.9	28.8	14.8	0.4
Q27. Routine questioning of person, time and place is a reliable test for rapid on field assessment of concussion	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	57	135	6	26	*5*
	24.9	59	2.6	11.4	*2.2*
Q28. Have you ever heard of a SCAT/SCAT2 card	*Yes*	No			
	128	101			
	55.9	44.1			

Q28a. Have you ever used a SCAT/SCAT2 card	*Yes*	No			
	37	192			
	16.2	83.8			
Q28b. A Sports Concussion Assessment Tool card (SCAT) may be used to assist rapid on field assessment of concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	80	99	49	0	1
	34.9	43.2	21.4	0	0.4
Q29. Balance tests may be used to assist rapid on field assessment of concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	17	133	51	22	6
	7.4	58.1	22.3	9.6	2.6
Q30. Neuro-psychological tests alone may be used for sideline diagnosis of concussion	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	11	79	68	68	*3*
	4.8	34.5	29.7	29.7	*1.3*
Section E: Management of Concussion					
Q31. If a player is suspected of having a concussion he must leave the field of play immediately	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	174	53	0	1	1
	76	23.1	0	0.4	0.4
Q32. Only a player with a 'severe' concussion, who lost consciousness, needs to leave the field	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	27	15	3	71	*113*
	11.8	6.6	1.3	31	*49.3*
Q33. If a player left the field for concussion, but 'feels fine' within some minutes, he can safely return to the field	Strongly Agree	Agree	Do Not Know	Disagree	*Strongly Disagree*
	5	2	3	83	*136*
	2.2	0.9	1.3	36.2	*59.4*
Q34. Choose the 2 people who have the ultimate decision on whether a player has to leave the field following a concussion	*Referee & Medical Staff*	Referee or Medical Staff	Neither		
	120	109	0		
	52.4	47.6	0		
Q35. A player with a suspected concussion should consult an appropriate medical doctor as soon as possible	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	150	74	0	4	1
	65.5	32.3	0	1.7	0.4
Q36. A child or adolescent (under the age 18) is more vulnerable to concussion than an adult	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	32	88	64	30	15
	14	38.4	27.9	13.1	6.6
Q37. A child or adolescent (under the age 18) requires a smaller impact force to sustain a concussion	*Strongly Agree*	Agree	Do Not Know	Disagree	Strongly Disagree
	29	81	79	30	10
	12.7	35.4	34.5	13.1	4.4
Q38. The mainstay of treatment for concussion is	*Physical and Cognitive Rest*	Physical Rest Only	Cognitive Rest Only	Medication for Symptom Relief	Do Not Know
	145			84	
	63.3			36.7	
Section F: Consequences of Concussion					

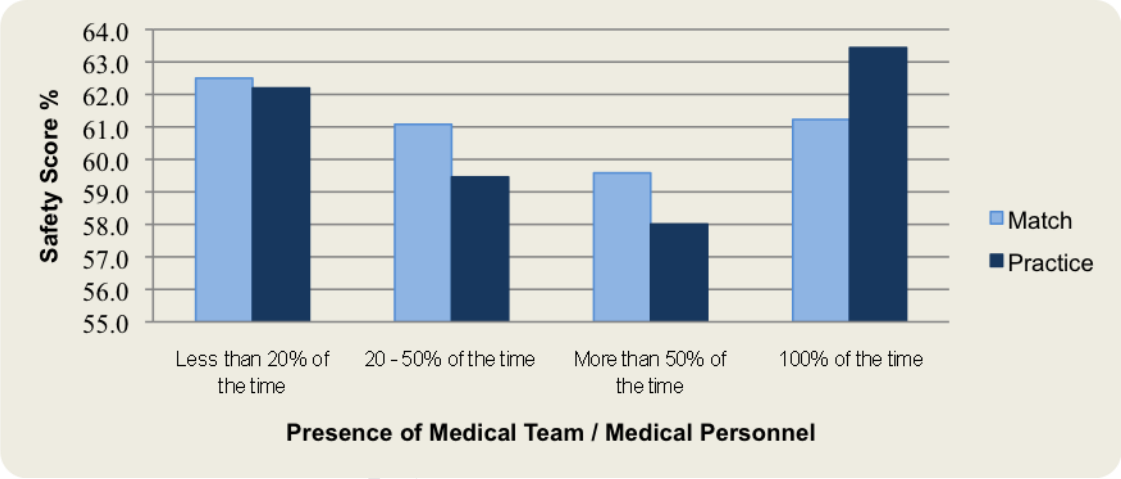
Q39. 2nd Impact Syndrome occurs when	A 2nd concussion sustained in same match	A 2nd concussion sustained in same season	A 2nd concussion sustained in a career	*A 2nd blow to the head sustained whilst prev. concussion not yet resolved* *80* *34.9*	All of the above
Q40. The most serious consequence of 2nd impact syndrome is	No serious consequences	Loss of Consciousness	3rd impact syndrome	Post concussion syndrome	*Death* *97* *42.4*
Q41. The most likely consequence for a child who suffers from more than one concussion in a season is	No serious consequences	Loss of Consciousness	*2nd impact syndrome* *18* *7.9*	Post concussion syndrome	Death
Q42. The most likely consequence for an adult who suffers from more than one concussion in a season is	No serious consequences	Loss of Consciousness	2nd impact syndrome	*Post concussion syndrome* *120* *52.4*	Death
Section G: Return To Play					
Q43. According to SA Rugby Concussion guidelines, if there is no access to a doctor to medically clear a player, a minimum 'stand down' period is stipulated for	*3 weeks* *80* *34.9*	Other 149 65.1			
Q44. A child or adolescent (under the age 18) recovers faster from concussion and can therefore return to play sooner	Strongly Agree 2 0.9	Agree 10 4.4	Do Not Know 49 21.4	Disagree 125 54.6	*Strongly Disagree* *43* *18.8*
Q45. A player who reports he is symptom free following concussion can return to practice that day	Strongly Agree 3 1.3	Agree 17 7.4	Do Not Know 6 2.6	Disagree 135 59	*Strongly Disagree* *68* *29.7*
Q46. When a concussed player has been medically 'cleared' he can immediately resume full contact practice with his team	Strongly Agree 9 3.9	Agree 55 24	Do Not Know 9 3.9	Disagree 129 56.3	*Strongly Disagree* *27* *11.8*
Q47. A player has to be examined by a medical professional, be symptom free throughout a stepwise, graded return to play protocol and be neuro-psychologically cleared before returning to match play	*Strongly Agree* *56* *24.5*	Agree 144 62.9	Do Not Know 14 6.1	Disagree 13 5.7	Strongly Disagree 2 0.9
Q48. A player returns to play after a concussion and develops a headache. The management of choice would be pain-killers	Strongly Agree 1 0.4	Agree 3 1.3	Do Not Know 15 6.6	Disagree 114 49.8	*Strongly Disagree* *96* *41.9*
Q49. If you were to use a Stepwise Return to Play	*Correct Order*	One out of Order	Two out of Order	Three out of Order	Four or more out of Order

protocol following a concussion, list these activities in the order you would have the player perform them. 1 being the first activity, through to 7, being the activity prior to match play	*95*	95	18	14	7
	41.5	41.5	7.9	6.1	3.1

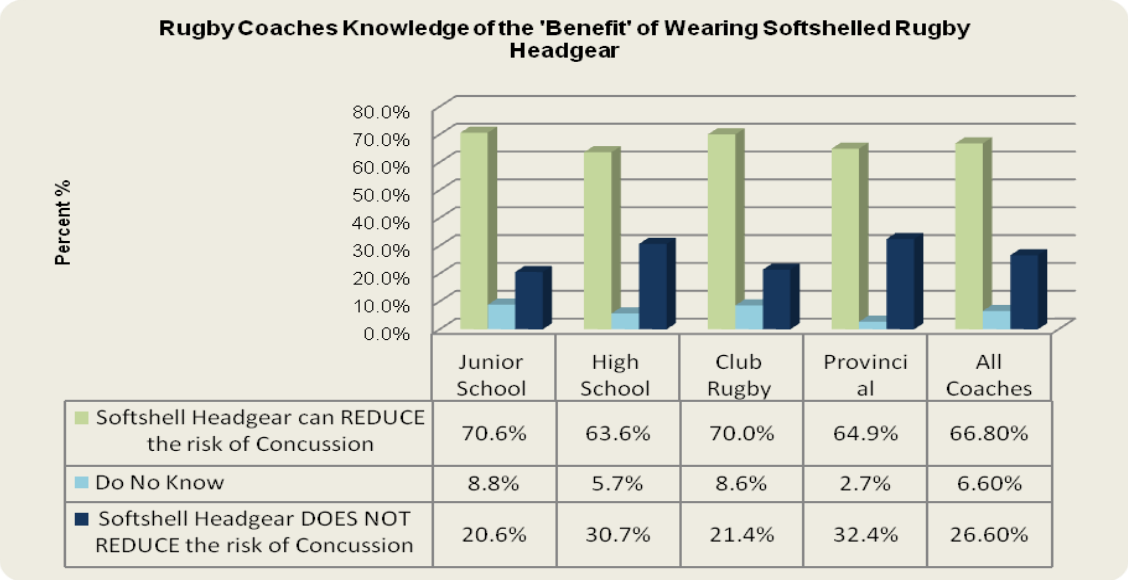
* *Italics* indicates the Correct or Desired Answer

Fifty five percent of the coaches reported that they rely on their medical staff to learn about concussion injuries. There was no significant difference on safety scores between coaches who have a medical team or medical personnel present at all practices (p = 0.07) and matches (p=0.8) to those that only have medical personnel present 50% of the time of less.

Figure: The Presence of Medical Personnel at Practices and Matches and their influence on Coaches' Safety Scores



The use of soft-shell headgear in rugby, to prevent or reduce the risk of concussion, is controversial. In all 66.8% of coaches believe soft-shell headgear can reduce concussion risk. Specifically in schoolboy rugby where the use of soft-shell headgear is strongly encouraged for head protection, 70.6% and 63.6% of Junior and High school coaches respectively believe that the headgear can reduce concussion risk.



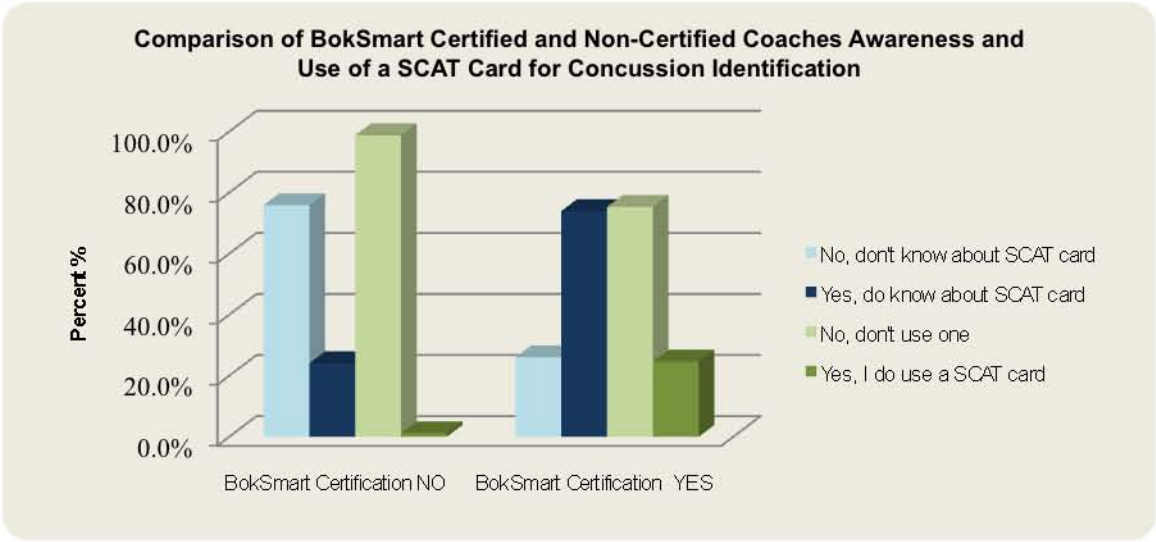
The table below indicates the coaches' responses to the reliability of using routine questioning in diagnosing a concussion injury. One can see a highly significant difference (p = 0.00008) between coaches selecting the correct (*strongly disagree*) and the incorrect *(strongly agree)* answers, regardless of BokSmart certification

Results Appendix 3: Routine Questioning of Person, Time and Place is a Reliable Test for Identifying Concussion

	Strongly Agree	Agree	Do Not Know	*Disagree	*Strongly Disagree
All Coaches					
Count	57	135	6	*26*	*5*
%	24.9	59	2.6	*11.4*	*2.2*
Non-BokSmart Certified					
Count	10	48	4	*15*	*5*
Column %	17.9	35.6	66.7	*57.7*	*100.0*
Row %	12.0	57.8	4.8	*18.1*	*6.0*
BokSmart Certified					
Count	46	87	2	*11*	*0*
Column %	82.1	64.4	33.3	*42.3*	*0.0*
Row %	31.5	59.6	1.4	*7.5*	*0.0*

Pearson Chi-Square 26.4 df=5 p=0.00008
**Italics indicates the correct answer*

The awareness of a SCAT or SCAT2 card and what it is used for was greatly improved following BokSmart certification. Twenty six percent of coaches without a BokSmart certification knew about the SCAT card, however 74.0% of coaches were aware of this tool following attendance at a BokSmart workshop. However of those BokSmart certified coaches that are aware of the SCAT card, only 24.7% use it to aid their concussion identification.


Comparison of BokSmart Certified and Non-Certified Coaches Awareness and Use of a SCAT Card for Concussion Identification
Percent %
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
BokSmart Certification NO
BokSmart Certification YES
No, don't know about SCAT card
Yes, do know about SCAT card
No, don't use one
Yes, I do use a SCAT card