

**SOUTH AFRICAN PHYSIOTHERAPISTS'
KNOWLEDGE OF THE PREVENTION,
DIAGNOSIS AND MANAGEMENT OF SPORTS-
RELATED CONCUSSION**

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TABLE OF CONTENTS

DECLARATION	i
ACKNOWLEDGEMENTS.....	ii
TABLE OF CONTENTS	iii
LIST OF TABLES.....	vi
LIST OF FIGURES	vii
LIST OF ABBREVIATIONS	viii
GLOSSARY OF TERMS.....	ix
ABSTRACT	x
CHAPTER ONE: INTRODUCTION AND SCOPE OF THESIS	1
1.1. Introduction	1
1.2. Aim and objectives	2
1.2.1. Aim	2
1.2.2. Specific objectives	2
1.2.3. Significance of the dissertation	3
1.3. Plan of development.....	3
CHAPTER TWO: A REVIEW OF THE DIAGNOSIS, MANAGEMENT AND PREVENTION OF SPORTS-RELATED CONCUSSION	4
2.1. Introduction	4
2.2. Epidemiology of sports-related concussion.....	6
2.2.1. Summary of literature: Epidemiology of concussion	10
2.3. Concussion	10
2.3.1. Definition of concussion	11
2.3.1.1. Grading of concussion	13
2.3.2. Signs and symptoms of concussion.....	17
2.3.3. Pathophysiology of concussion	18
2.3.4. Complications of concussion	21
2.3.5. Concussion risk factors	24
2.3.6. Summary of literature: Concussion in sport	27
2.4. Evaluating the concussed athlete	27
2.4.1. On-field or sideline evaluation of acute concussion	28
2.4.2. Clinical assessment	32
2.4.3. Follow up assessment and concussion investigations.....	34
2.4.3.1. Objective balance assessment	35
2.4.3.2. Neuropsychological assessment	36
2.4.4. Summary of literature: Evaluating a concussed athlete.....	38
2.5. Concussion management	39
2.5.1. Pharmacological therapy	40
2.5.2. Return to play	40
2.5.2.1. Return to Play Protocol	42
2.5.3. Summary of literature: Management of concussion.....	44

2.6. Prevention of concussion and its sequelae	44
2.6.1. Protective gear	44
2.6.2. Pre-participation evaluation	45
2.6.3. Concussion education and the role of the physiotherapist	45
2.6.4. Summary of literature: Prevention of concussion	49
2.7. Summary of literature: Diagnosis, management and prevention of concussion	50
CHAPTER THREE: SOUTH AFRICAN PHYSIOTHERAPISTS' KNOWLEDGE OF THE PREVENTION, DIAGNOSIS AND MANAGEMENT OF SPORTS-RELATED CONCUSSION	51
3.1. Introduction	51
3.2. Methodology	52
3.2.1. Study design	52
3.2.2. Participants	52
3.2.3. Recruitment	53
3.2.4. Sample size calculation	53
3.3. Procedure	53
3.3.1. Concussion questionnaire	54
3.3.1.1. Validity of the concussion questionnaire	55
3.3.1.2. Feasibility of the concussion questionnaire	55
3.3.2. Data analysis	56
3.3.2.1. Adequate concussion knowledge	56
3.3.2.2. Continued education score	59
3.3.3. Statistical analyses	59
3.3.4. Ethical considerations	60
3.3.4.1. Risk to participants	60
3.3.4.2. Benefits to participants	60
3.4. Results	61
3.4.1. Socio-demographic characteristics	61
3.4.2. Academic experience	62
3.4.3. Clinical experience	64
3.4.4. Concussion knowledge scores	68
3.4.5. Adequate and inadequate concussion knowledge	70
3.4.6. Factors associated with adequate concussion knowledge	71
3.4.6.1. Socio-demographic characteristics	71
3.4.6.2. Academic experience	71
3.4.6.3. Clinical experience	72
3.4.7. Summary of results	74
3.5. Discussion	75
3.5.1. Study sample	75
3.5.2. Concussion knowledge scores	76
3.5.2.1. Level of qualification and continuing education	77
3.5.2.2. Sports physiotherapy experience and current practice	79
3.5.2.3. Confidence in dealing with concussion	81
3.5.3. Concussion sub-section knowledge	81
3.5.4. Limitations	83
3.5.5. Clinical implications	84
CHAPTER FOUR: SUMMARY AND CONCLUSION	86

CHAPTER FIVE: REFERENCES	89
APPENDIX I.....	101
APPENDIX II.....	104
APPENDIX III.....	107
APPENDIX IV	120
APPENDIX V	122
APPENDIX VI	135

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LIST OF TABLES

Table 2. 1: Concussion grading scales	15
Table 2. 2: Signs and symptoms of concussion	17
Table 2. 3: Indications for urgent hospital referral	29
Table 2. 4: Maddocks questions	30
Table 2. 5: Patient discharge information for 48 hours after injury.....	34
Table 2. 6: Graduated return to play	43
Table 3.1: Selected questions and scoring for the calculation of adequate concussion knowledge scores.....	57
Table 3. 2: Calculation of continued education scores (CES)	59
Table 3.3: Socio-demographic characteristics of the sample (n=213)	62
Table 3.4: Academic experience of the sample (n=213)	63
Table 3.5: Clinical experience of the sample (n=213).....	65
Table 3.6: Sports physiotherapy experience of the sample (n=213).....	66
Table 3.7: On-field physiotherapists' experiences and responsibilities (n=213).....	67
Table 3.8: Total concussion knowledge sub-section scores (n=213).....	68
Table 3.9: Concussion knowledge sub-sections scores (n=213).....	70
Table 3.10: Associations between postgraduate education and adequate/inadequate concussion knowledge (n=118)	72
Table 3.11: Associations between first aid qualification and adequate/inadequate concussion knowledge (n = 154).....	72
Table 3.12: Associations between confidence in managing concussion and adequate/inadequate concussion knowledge (n=213)	73
Table 3.13: Associations between on-field physiotherapy experience and adequate/inadequate concussion knowledge (n=149)	73
Table 3.14: Associations between sports physiotherapy experience and adequate/inadequate concussion knowledge (n=213)	74

LIST OF FIGURES

Figure 2.1: SCAT2 Pocket version to assist on-field assessment of concussion	32
Figure 3.1: Summary of response rate.....	61
Figure 3.2: Concussion knowledge sub-section scores in physiotherapists that were confident in managing a concussed athlete and physiotherapists that were not confident in managing a concussed athlete (n=213).....	69
Figure 3.3: Adequate and inadequate concussion knowledge scores for the different sections of the concussion knowledge questionnaire (n=213)	71

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LIST OF ABBREVIATIONS

AAN	American Academy of Neurology
ACK	Adequate concussion knowledge
ADHD	Attention deficit hyperactivity disorder
ATP	Adenosine Triphosphate
BESS	Balance error scoring system
CES	Continued education score
CISG	Concussion in sport group
CK	Concussion knowledge
fMRI	Functional magnetic resonance imaging
HPCSA	Health Professional Council of South Africa
ICK	Inadequate concussion knowledge
LOC	Loss of consciousness
OMTPG	Orthopaedic Manipulative Therapy Physiotherapy Group
PCS	Post-concussion syndrome
PTA	Post-traumatic amnesia
RTP	Return to play
SAC	Standardised assessment of concussion
SASP	South African Society of Physiotherapy
SCAT	Standardised concussion assessment tool
SIS	Second impact syndrome
SPG	Sport Physiotherapy Group

GLOSSARY OF TERMS

Biokineticist	A specialised exercise therapist that functions in professional alliance to health and medicine, recognised and registered with the Health Professionals Council of South Africa.
Concussion	Defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces ¹⁻⁷ .
Loss of consciousness	A dramatic alteration of mental state that involves complete or near-complete lack of responsiveness to external stimuli ⁸ .
Neuropsychological	Referring to the interaction between the nervous system and cognitive function, the influence of one function on the other ³³ .
Post-concussion syndrome	The prolonged presence of a cluster of symptoms, following a concussive blow to the head, lasting for days or weeks ^{9,10} .
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 ^{7,11-13} .
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 ¹⁴ .

ABSTRACT

Background: Concussion is a growing global health concern. Due to the lack of uniformity surrounding the definition of concussion and management guidelines, concussion injuries are considered to be one of the most challenging topics in sports medicine. There is no single biological marker that exists to diagnose concussion. Therefore, concussion is often underreported and undetected. The physiotherapist is often responsible for field-side care, and required to deliver emergency care, leaving the physiotherapist as the sole 'medical officer' managing these cases. Physiotherapists' knowledge and prioritisation of clinical information has an essential role in the diagnosis and management of concussion. Studies have highlighted the need to bridge the gap between concussion education and clinical practice to reduce the incidence of concussion, improve its diagnosis and management and provide a safe environment for athletes.

Aim: To determine South African physiotherapists' knowledge of the prevention, diagnosis and management of sports-related concussion.

Specific Objectives: a) To determine physiotherapists' level of knowledge of the prevention, diagnosis and management of sports-related concussion. b) To determine whether physiotherapists have adequate knowledge of the prevention, diagnosis and management of sports-related concussion. c) To determine factors that may influence physiotherapists' knowledge of the prevention, diagnosis and management of sports-related concussion.

Methods: This study had a descriptive, correlational design. Physiotherapists that were members of the Orthopaedic Manipulative Physiotherapists Group (OMPTG) (n=1339) or the Sports Physiotherapists Group (n=639) of the South African Society of Physiotherapy were requested to volunteer for the study. A questionnaire was developed to assess physiotherapists' knowledge of the prevention, diagnosis and management of concussion. The questionnaire was validated by a panel of experts. The questionnaire was made available via the online SurveyMonkey® tool (www.surveymonkey.com).

Physiotherapists were required to provide informed consent prior to completing the online survey. The questionnaire was comprised of seven sections, and determined: demographic information; clinical experience; educational background; physiotherapists' knowledge of the diagnosis, management and consequences of concussion; and physiotherapists' knowledge of return to play decisions. Responses to the questionnaire were scored as either correct or incorrect with one mark allocated for each correct answer. Percentages were calculated for each subsection and for the total questionnaire to determine physiotherapists' level of knowledge regarding concussion. In addition, the panel of experts that validated the questionnaire were asked to identify specific questions that comprised "adequate concussion knowledge" or "inadequate concussion knowledge". Responses to these questions were then used to calculate percentage scores to establish adequate or inadequate concussion knowledge. Seventy five percent was regarded as the minimum required score for adequate concussion knowledge.

Results: The study yielded a response rate of 16.5%. Concussion knowledge scores ranged from 16.7% to 86.1%, with a mean concussion knowledge score of $64.9\% \pm 11.5\%$. Twenty one percent of physiotherapists in this study were classified as having adequate concussion knowledge. Those physiotherapists that felt confident in managing concussion scored significantly higher in the consequences of concussion knowledge section ($43.5\% \pm 23.8\%$ vs. $36.4\% \pm 20.7\%$); and management of concussion knowledge section ($68.5\% \pm 16.2\%$ vs. $63.6\% \pm 16.4\%$) compared to physiotherapists that did not feel not confident in managing concussion.

Conclusion: Only 20.7% of physiotherapists were classified as having adequate sports-related concussion knowledge. This is concerning, particularly as physiotherapists are often the only health care professionals providing on-field medical support. Based on the findings of this study, educational interventions are required to improve physiotherapists' sports-related concussion knowledge and to ensure appropriate on-field management of concussed players, thereby facilitating player safety.

CHAPTER ONE: INTRODUCTION AND SCOPE OF THESIS

1.1. Introduction

Concussion is a common occurrence in contact sports such as boxing and the martial arts, or results from high velocity collisions or falls in rugby, soccer and ice hockey^{15,16}. The incidence of concussion ranges from 0.25 to 5 per 1000 player hours of exposure¹⁷. An estimated 300 000 traumatic brain injuries occur annually in the United States of America^{7,18-20}, of which approximately 20% are sports-related concussions²⁰⁻²². In South Africa, head and neck injuries account for the largest proportion of catastrophic injuries recorded in rugby players²³. The prevalence of concussion in South African schoolboy rugby players was reported to be as high as 50%²⁴.

Concussion may be defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces^{2,4,25,26}. Concussion results in a graded set of clinical symptoms that may include loss of consciousness (LOC). The symptoms manifesting from a concussion may persist for days to weeks^{12,24}. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however in some instances, post concussive symptoms may be prolonged and may result in serious complications, including death^{2,17,26}. Concussions are difficult to diagnose^{16,19,27,28}. The clinician has to rely on gross clinical symptoms that may or may not be present, as well as the athlete's potential unwillingness to admit to clinical symptoms^{28,29}. The grading of concussion severity is controversial. Currently there are 16 different concussion guidelines, of which the Cantu and Colorado guidelines are most commonly used³⁰. Research highlights the lack of consistency regarding the definition and management guidelines of concussion, as well as a lack of objective measures of concussion signs and symptoms²⁹.

In sports medicine there is interaction amongst a diverse group of specialties, such as coaches, athletes, and the multi-disciplinary healthcare team. When providing on-field medical services, health professionals are often required to make informed decisions regarding the athlete's status in high-pressure situations³¹.

The physiotherapist has a central role in general player safety and more specifically, in the prevention, diagnosis and management of concussion. Physiotherapists' knowledge and prioritisation of clinical information is essential to the efficient diagnosis and management of concussion³². The athlete's timely return to sport may prevent the onset of a catastrophic injury from a recurrent concussive blow^{21,33}. A recent cross-sectional cohort study of physiotherapists in New Zealand highlighted the need for education regarding the key signs and symptoms in the identification of concussion³⁴.

The recent implementation of the BokSmart programme, a rugby safety programme in South Africa, has placed emphasis on educational programmes and training of the multidisciplinary team, including physiotherapists, involved in the South African rugby setting, with the primary focus on improving player safety²³. However, there is a lack of evidence regarding physiotherapists' current levels of knowledge of concussion. Therefore, the principle aim of this thesis was to determine South African physiotherapists' knowledge of the prevention, diagnosis and management of concussion.

1.2. Aim and objectives

1.2.1. Aim

The aim of the study was to determine South African physiotherapist's knowledge of the prevention, diagnosis and management of sports-related concussion.

1.2.2. Specific objectives

The study was conducted among South African physiotherapists involved in assessing and treating sports injuries, to determine:

1. The level of knowledge of the prevention, diagnosis and management of sports-related concussion.
2. Whether physiotherapists have adequate knowledge of the prevention, diagnosis and management of sports-related concussion.

3. Factors associated with knowledge of prevention, diagnosis and management of sports-related concussion including level of qualification, number of years in physiotherapy practice, sports physiotherapy experience, current practice with a sports team, and continuing education.

1.2.3. Significance of the dissertation

Physiotherapists' knowledge of sports-related concussion has not been established. The findings of this study will provide information on the current levels of knowledge of South African physiotherapists involved in sport regarding the prevention, diagnosis and management of concussion. The information generated will highlight current gaps in the knowledge of these physiotherapists regarding concussion. This information may assist in curriculum development for undergraduate physiotherapy training, and may improve the content of sports physiotherapy or sports-related concussion workshops.

1.3. Plan of development

In preparation for the study, a comprehensive review of the literature pertaining to concussion assessment, management and return to sport will be presented (Chapter 2). This will be followed by a description of the study designed to answer the stated research question (Chapter 3). The summary and conclusion section including recommendations for further research will complete this thesis (Chapter 4).

CHAPTER TWO: A REVIEW OF THE DIAGNOSIS, MANAGEMENT AND PREVENTION OF SPORTS-RELATED CONCUSSION

2.1. Introduction

Concussion is derived from the Latin word *concussus* meaning “to shake violently”^{35-37,35-37}. Historically concussion has been a common injury in contact sports and is one of the most common head injuries¹³. Recently sports-related concussion has received growing attention in both the lay media and medical literature^{9,17,38,39}. The inconsistencies with respect to the definition of concussion, diagnostic measures and management of sports-related concussion is disconcerting given the high incidence of injury^{21,40}. Literature continually highlights the lack of a universally accepted definition of concussion. Sports medical professionals unanimously agree that the rate of concussion in sport is higher than the incidence of reported concussions⁴¹. Reported concussion incidence rates may underestimate the extent of the problem due to possible ignorance surrounding the nature of concussion or an athlete’s common tendency to underreport their injuries^{8,42}. Using a large sample of high school athletes McCrea et al⁴¹ found that nearly 53% of concussed athletes did not report their concussion injury to any medical staff; mostly as a result of a poor comprehension of the possible sequelae of concussion.

Sport has become more popular and participation in high school and higher education sports continue to increase²². In the United States of America it was reported that a minimum of 1.25 million athletes compete in contact sports at a high school level⁴³. The increased popularity of traditionally male-dominated contact sports such as rugby and boxing has been attributed to the recent inclusion of female participation. In 2001 South Africa held an official launch to promote Rugby Union for women⁴². At the same time legislation passed in South African sport permitted the participation of women in boxing⁴². This growth in contact sport participation in South Africa has followed the worldwide trend in sport. These factors indicate a significant increase in the number of individuals participating in sport.

Sports-related injury incidence studies found concussion to be a common occurrence in contact sport. Given the significant increase in athletic participation in contact sport, this may suggest an increased risk of athletes sustaining sports-related concussions. McCrea et al³⁴ found high underreporting of concussion warranted concussion education of all role players in sport.

A review of previous concussion studies showed a lack of consensus of concussion guidelines and protocols^{17,39}. Eckner and Kutcher⁴⁴ discussed the shift of focus of initial concussion evaluation from severity grading to injury detection, and return to play decisions becoming individualized. The topic of concussion in sports medicine is surrounded by uncertainty and controversy⁴³. This has led experts in the field of concussion to convene three conferences over the past eight years to address the key issues in the understanding and management of concussion in sport^{2,45}. These conferences have led to three international concussion in sport statements, the first being the Vienna statement in 2001, followed by the Prague statement of 2004 and the most recently the Zurich statement of 2008². The growing body of research in sport-related concussion has provided key role players in sport, such as medical professionals as well as the general public, with increased information on the diagnosis and management of concussion^{38,46}. This increases the responsibility of these role players in sport to promote a safer playing environment at all levels of competition to minimise the incidence of injuries^{38,46}. However, Ferrara et al³⁹ have highlighted that the impact of recent concussion research developments and continuing education on medical personnel is unclear.

In South Africa, the physiotherapist may often be the only medically qualified person present at sporting events or practices, thereby bearing the responsibility of the diagnosis and management of, among others, concussed athletes. The efficient management and timely return to play of the athlete may have a vital role in the athletes' recovery, as well as their long term well being. Bridging the gap between research and clinical practice will help reduce the incidence and severity of sport-related concussion⁴⁶.

This literature review will focus on sport-related concussion. The review will outline concussion diagnosis, management and prevention in sport; and also discuss the central role of the physiotherapist in the management of a concussed player and their role in the prevention of concussion injuries. Data were sourced from PubMed, Google scholar, EBSCO, Ovid online databases. Keywords used in the search included *“concussion”, “sports-related concussion”, “head injury”, “concussion in children”, “physiotherapists’ role in concussion”, “concussion diagnosis”, “concussion pathophysiology”, “concussion investigations”, “management of concussion”, “risks and complications of concussion”, “physical therapists management of sport injuries” and “physiotherapists’ knowledge of concussion”*.

2.2. Epidemiology of sports-related concussion

Concussion is one of the most common clinical problems sustained in sport⁷. Concussions are common in many sports and recreational activities, especially those involving body contact, collisions or high speed with direct blows to the head⁴¹; as well as in non-contact sports resulting from acceleration, deceleration, and rotational forces^{7,47}. The risk of injury stems from the nature of the game¹⁵. The current trend of thinking amongst medical professionals is that concussion occurs in all sports but with varying frequencies¹⁵. The increased attention to concussion in recent literature may suggest a rise in concussion incidence. Sports-related concussion has been recognised as a global public health concern^{9,16,41,48,49}. The early retirement of several high profile athletes as a result of recurrent concussions has highlighted the complex nature and long-term sequelae of concussion^{17,41,46,50}.

Concussion injuries have been recognised as one of the greatest challenges in sports medicine as many are unreported due to the subtlety of the presentation of the injury with substantial underreporting of concussion injuries^{44,51}. McCrea et al⁴¹ showed 36% of concussed high school athletes did not recognise they had sustained a concussion injury. Concussion is an injury that may occur in any sport or physical activity. In any contact sport it has been presumed that the risk of concussion is directly proportional to playing time²⁵. Concussion has most often been associated with sports such as boxing, hockey and football¹⁵.

The collision sports of football and hockey have more acute traumatic injuries than sports such as swimming^{14,15}. Football, ice hockey, soccer and rugby are the sports with the highest prevalence of concussion^{15,52}. Studies in the early 1980's reported concussion rates in high school football as high as 20% annually; whereas the National Athletic Trainers Association (NATA) reported concussion incidence rates in the USA to be 2.8% and 3.6% in studies in 1986 to 1988 and 1995 to 1997 respectively¹⁹. By the late 1990's concussion studies amongst the higher education football population reported incidence rates ranging from 4% to 4.8% annually¹⁹. In 2000, Guskiewicz et al¹⁹ reported an overall concussion rate of 5.3% in higher education football athletes. These findings were slightly higher than the annual reported incidence reported in the 1990's; however, the incidence recorded was lower than the 12% incidence rate reported by the National Football League¹⁹.

Competitive athletes have a higher risk of injury due to the common behavior of ignoring symptoms to return to sport⁵³. Delaney et al⁵⁴ found that only 23% and 20%, of the 70% and 63% of soccer and football players respectively that reported symptoms of concussion, had actually realised they had sustained a concussion injury. McCrea et al⁴¹ found that 40% of higher education athletes believed that they were concussed but deliberately did not report this for fear of exclusion from the game. These similar findings of underreporting of concussion incidence may suggest an athlete's strong desire to compete and the tendency of the sporting population to downplay the seriousness of concussion injuries. Broglio et al⁵⁵ reported that based on their estimates of unreported concussions experienced by adolescent athletes in Italian football annually, nearly 2.1 million concussions will occur and more than half of those injuries will not be reported. Of the approximate 300 000 sports-related concussion injuries reported in the United States of America annually^{22,29,33,56-59}, 34% of athletes had been diagnosed with one concussion, and 20% of athletes were reported to have experienced multiple concussions^{30,32}. Therefore the rather alarming predicted estimate of concussion incidence highlight the seriousness of sports-related concussion.

It was estimated that 3.6% to 8.6% of the 44 million student athletes in the United States of America sustain sports-related concussion^{18,60,61}. Concussion injuries have also been reported to account for the greatest proportion of all injury types in youth ice hockey^{54,62}.

The National Collegiate Athletic Association (NCAA) found that in the 2002 to 2003 season the most prevalent concussion injuries in collegiate sports in the United States of America occurred in ice hockey (12.2%), American football (8%) and soccer (4.8%)¹⁶. A systematic review of the incidence of sports-related concussion by Koh⁶³ found that ice hockey showed the highest incidence when compared to participation in American football, ice hockey, rugby and soccer by male high school athletes, and identified the need for future epidemiology studies regarding concussion incidence in female athletes. Similarly Echlin⁶⁴ reported that ice hockey has been a major cause of concussion in Canada. A study using the NCAA injury surveillance system data recorded over three years found that concussion injuries accounted for 6.2% of sports-related injuries⁹. Koh⁶³ explained that the increased concussion incidence in ice hockey and American football athletes maybe due to over-reliance on the full protective equipment that athletes are required to use.

Rugby Union is the most widely played of the rugby football sports⁶⁵. It also has the highest rate of serious injuries; with Rugby Union having the highest rate of concussion compared to Rugby League, American Football, and soccer. Concussive insults accounted for 4.8% of injuries sustained in the English premiership from 2002 to 2004; one of the three most common injuries sustained along with thigh haematomas (8.8%) and hamstring strains (6.2%)⁶⁵. A review of studies on the incidence of concussion in rugby union showed a varying incidence from 0.1 per 100 player seasons to 11.5 per 100 player seasons. McIntosh et al⁶⁶ reported the rate of concussion injuries in youth rugby union as 6.9 per 1000 hours for games played; with 1.6 per 1000 hours resulting in a player missing a game the following week. In Australia, common sports such as Australian Football League (AFL), rugby league and rugby union have among the highest reported incidences of concussion of 5.9 to 9.8 concussive injuries per 1000 player hours, which equates to an average of approximately five injuries per team per season⁴⁵. A prospective study on the Australian Wallabies rugby union players from 1994 to 2000 showed that concussion injuries comprised 19.4% of total injuries⁶⁷.

In 2001, Marshall and Spencert⁴⁷ found the incidence rate for concussion in a high school rugby population was 3.8 per 1000 athlete-exposures. However, in comparison to 10 other concussion incidence studies across the same population, the authors found previous studies underestimated the true incidence of concussion by varying degrees which may be due to different methods of defining concussion⁴⁷.

Sports-related concussion studies in South Africa focus mainly on the game of Rugby Union. In South African rugby, head and neck injuries account for the largest proportion of catastrophic injuries with concussion being cited as one of the top three most common injuries^{23,24}. A South African study found concussion was the most common injury at the 1999 Super 12 rugby competition, with a 20% incidence of injury²⁴. An epidemiological study of the 2008 rugby season of the Super 14¹ and Vodacom Cup² league showed that concussion was one of five most commonly reported injuries at 9.7%⁶⁵. Fuller et al⁶⁵ found no significant increase in the risk of injury to players by implementing the International Rugby Board Experimental Law Variations. In contrast, a systematic review of concussion incidence in sport observed that the rules, techniques and strategies of the game may predispose an athlete to concussion⁶³. However Koh⁶³ reviewed literature across different samples involving a variety of eight contact sports played at a varying level of competition.

A concussion study on a sample of high school rugby athletes reported a concussion incidence of 21.5%⁶⁸; whereas another study reported the prevalence of concussion as high as 50% in schoolboy rugby players²⁴. Shuttleworth-Edwards et al⁶⁸ found variable incidences of concussion for the adult population in South African Rugby Union from 23% at provincial level; to 3% and 5% at university and club level respectively. Findings of this study by Shuttleworth-Edwards et al⁶⁸ implied the reported incidence of concussion to be inappropriately low in the absence of a controlled concussion management programme, and raised concerns regarding medical management of their sample population of rugby players.

¹ Rugby union competition in the Southern hemisphere with participation of 14 regional teams with elite national player representation.

² Rugby union competition within South Africa with participation of regional teams with elite provincial and national player representation.

However the improved identification of concussion and provision of an appropriate injury management strategy reduces the athlete's risk of serious complications and promotes a safe playing environment^{69,70}.

2.2.1. Summary of literature: Epidemiology of concussion

Concussion injuries are a common occurrence in various sporting codes at all levels of competition^{22,44}. The incidence of concussion in sport involving frequent forceful contact, such as hockey and boxing, is higher than in sports where contact between athletes is less frequent⁶³. These epidemiologic studies have emphasised the high incidence of concussion, and the related importance and difficulty of the accurate identification and management of concussion⁷¹. There is a general consensus that the rate of concussion in sport is higher than the incidence of recorded injuries^{41,56}. Concussion management guidelines are essential to maintain a balance between competitiveness in sport and ensuring a safe environment for participation³². One of the difficulties highlighted by the authors of the several concussion epidemiology studies reviewed is that there is no universally accepted reporting system for concussion¹⁹. The following sections will discuss the definition of concussion further.

2.3. Concussion

It was only in the 1990's that a heightened awareness surrounding concussion was created. Concussion has been recognised as potentially career-ending in sport. Concussion remains a clinical diagnosis based on a constellation of symptoms. At a community level of rugby in New Zealand, a definitive concussion diagnosis was based upon being "*knocked out*", which has subsequently been recognised as having little diagnostic value⁴. There is further difficulty diagnosing concussion due to some signs and symptoms presenting several hours or days post-injury²⁶. The following section will discuss the controversy surrounding the understanding and diagnosis of concussion, as well as the possible risks and sequelae that may stem from a concussive insult.

2.3.1. Definition of concussion

Concussion may often be misdiagnosed or underreported, possibly as a consequence of the various definitions used. Guilmette et al⁷² found that many youth sport coaches had many misconceptions regarding concussion with 42% believing that a loss of consciousness (LOC) was required to sustain a concussion injury^{55,72}. Concerns surrounding the management of sports-related concussion as a consequence of disagreement in the terminology of traumatic brain injury led to Kelly and Rosenberg³² to review all available concussion evidence between 1966 and 1996. Based on the strengths of the evidence collated, concussion was defined as *“a trauma induced alteration in mental status that may or may not include the loss of consciousness (LOC)”*^{25,32}. The definitions for concussion generally focus on the signs and symptoms at the time of the injury¹⁵. An international agreement has led to a shift in concussion diagnosis from the dramatic presentation of LOC to a multi-faceted approach based on clinical signs, physical presentation and cognitive impairments. This approach recognises that concussion injuries may manifest differently in different individuals^{2,39}.

Amnesia, LOC and confusion have become hallmark signs and symptoms for sideline diagnosis^{2,17,20,22,43,47,63,73,74}. These have been used as acute markers of injury for the basis of the identification and management of concussion^{17,21}. One of the most common misunderstandings is the presence of LOC for the diagnosis of concussion^{26,28,55}. A concussion study by the NCAA showed that 98.6% of concussions were mild and 77.8% of concussions were not associated with LOC or amnesia⁷³. The severity of the concussion did not correlate with loss of consciousness and therefore should not be defined by LOC alone¹⁷. At the Prague conference in 2004, the limitation of using LOC as a primary measure in the assessment of concussion was acknowledged²⁶.

In 2008, the most recent conference regarding concussion in sport was held in Zurich². The Zurich consensus statement unanimously agreed upon the definition for concussion and highlighted the separation from a mild traumatic brain injury (mTBI) emphasising that these terms should not be used interchangeably².

Concussion and mTBI are indistinguishable on clinical presentation; however in the case of concussion no abnormality is seen with standard neuroimaging⁷⁴. The definition of concussion has been broadened to include any trauma-induced alteration in mental state²³. According to the Concussion in Sport Group (CISG), concussion may be defined as a *“complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces”*^{1-4,26,28,75}.

There are several common clinical, pathological and biomechanical features that may be used in defining the nature of concussion. Concussion may be caused by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force to the head^{2,76}. This may result in a rapid onset of short-lived impairment of neurological function that resolves spontaneously^{26,28}. Concussion injuries may also cause neuropathological changes. Recent definitions assume a neurophysiological rather than neuroanatomical basis⁶, as concussions are typically associated with normal structural neuroimaging investigations^{2,7,17,45}. Similarly, the acute clinical symptoms reflect a functional disturbance rather than a structural disturbance. Clinical and cognitive symptoms may resolve following a sequential course; however in some instances, post-concussive symptoms may be prolonged^{1,9}. The duration of symptoms may vary from several minutes to days or weeks or longer^{12,17}.

Collins and Hawn⁹ discussed that to date there are no individual signs or symptoms proven to directly correlate with the severity of concussion. However recent data indicates that amnesia is the most predictive symptom of concussion injury severity and duration, which contradicts the older traditional concussion grading scales that rely heavily on LOC to determine the severity of an injury¹⁷. Erlanger et al⁷⁷ found concussed athletes with post-traumatic amnesia (PTA) reported significantly more symptoms, a longer duration of symptoms, and more significant impairments on neurocognitive testing; whereas LOC predicted neither the severity of injury nor the duration of symptoms.

The validity of LOC as a primary indicator of the severity of concussion has therefore been questioned in recent research^{18,31,36,50,78}. Studies have found LOC not to be a single valid marker of injury severity or neuropsychological performance⁷⁶.

A retrospective study of concussion severity of trauma patients by Lovell et al⁹ found no significant differences in severity of concussion outcome between patients experiencing no LOC, definite LOC, and uncertain LOC. Recent work by Collins et al⁴⁸ found no differences in acute recovery in concussion from those experiencing brief LOC and no LOC in a sample of high school and higher education athletes. Several other studies have also shown that there is no relation between LOC and the severity or outcome of concussion^{18,48,56}. However, evidence suggests the nature, and duration of the post-concussive symptoms may be of greater importance than the presence and duration of amnesia alone^{3,26}. However, the Prague statement also recognised that there is limited evidence to suggest that the number and duration of acute concussion signs and symptoms correlate with concussion injury severity²⁶.

Despite attempts to develop a consensus statement regarding concussion injuries there remains a debate as to which factors are most critical in determining the severity of concussion, the expected recovery of an athlete, and when it is safe for an athlete to return to sport⁴⁰. One of the methods used to determine recovery trajectories and criteria for return to sport is grading of the concussion^{19,21}. This is an area of further controversy as studies have suggested that key role players, such as medical personnel and coaches, use the grading scale that best suits their needs and not necessarily the best medical management for the athlete²⁴. Methods proposed for the grading of concussion will now be discussed.

2.3.1.1. Grading of concussion

The concussion grading scales remain controversial and are based largely on expert opinion. An early concussion grading system developed by the American Academy of Neurology (AAN) used acute injury characteristics, such as LOC or duration of symptoms, to classify concussion injuries^{49,53,70}. In 1986, Cantu⁷⁹, a neurosurgeon and team physician published an on-field grading system. Cantu combined elements of various definitions of concussion and used both the duration of LOC and PTA for the Cantu grading of concussion.

In 1991 Kelly et al⁷⁶ proposed another classification of concussion, namely the Colorado guidelines, with any concussive insult presenting with LOC classified as severe. The guidelines developed by the AAN and Cantu are the most widely used concussion grading scales^{30,78}.

Over several years, prospective studies demonstrating a correlation between the duration of post-concussive symptoms, PTA, and abnormal neuropsychological tests led to Cantu creating an evidence-based concussion grading scale³⁵. Both the Cantu and AAN grading scales take into account the nature and duration of the key symptoms (Table 2.1), classifying concussion injuries as grade 1 (mild), grade 2 (moderate) or grade 3 (severe). Each grade has an associated period of time in which the symptoms should resolve before the athlete returns to sport. The Cantu and AAN guidelines take the athlete's history of concussion into consideration, especially in the same season, in determining the safe return of the athlete to play⁷⁸. The Cantu guidelines distinguish between extended and brief LOC, and place an emphasis on the duration of PTA. In comparison the AAN guidelines highlight the qualitative importance of LOC^{36,49,78}. The Colorado guidelines also rely heavily on LOC to determine the severity of injury and subsequent return to play^{30,45}.

Table 2. 1: Concussion grading scales^{9,52,80,81}

	Grade 1 (Mild)	Grade 2 (Moderate)	Grade 3 (Severe)
Cantu (1986)	No LOC PTA or post-concussion signs or symptoms lasting less than 30 minutes	LOC lasting less than one minute, PTA or post- concussion sign or symptoms that last longer than 30 minutes but less than 24 hours	LOC lasting more than one minute or PTA lasting longer than 24 hours or post- concussion sign or symptoms that last longer than 7 days
Colorado medical society grading system (1991)	Confusion without amnesia No LOC	Confusion with amnesia No LOC	LOC
American Academy of Neurology (1997)	Transient confusion No LOC Symptoms lasting less than 15 minutes	Transient confusion No LOC Symptoms lasting longer than 15 minutes	Any LOC, brief or prolonged

LOC- Loss of consciousness

PTA- Post-traumatic amnesia

There has been much debate as to whether concussion should be graded according to the duration of symptoms, or according to the presence or absence of symptoms¹⁶. In 1999 Ferrera et al³⁹ found that 28% of athletic trainers used the Colorado guidelines, with nearly 20% of the sample not using any type of concussion grading scale guidelines and the remainder using the AAN, Cantu or other guidelines. These findings reinforce those of previous studies showing that no single grading scale is preferred when concussion is being diagnosed^{16,28,46,58,59,75,77}. By 2001, at least 25 different grading scales had been published^{26,76,78}. It is apparent that many concussion grading scales have been developed based on anecdotal evidence rather than scientific evidence, with self-reported symptoms referenced by many grading concussion scales²¹. Despite studies reporting that the majority of concussions involve neither LOC nor amnesia⁵⁶, many concussion guidelines focus on LOC and PTA at the time of injury and for a brief period thereafter^{9,36,56,58,75}.

In 2001, the first International Symposium on Concussion in Sport was held in Vienna³ and the Concussion in Sport Group (CISG) recognised the strengths and weaknesses of the several grading scales. However, no single grading system was endorsed at this meeting^{3,19,28,81,13,19,28,81}. The CISG recommended that there should be combined measures of recovery to determine the injury severity, reiterating the management of concussion be individualised in each case^{26,28}. The group of experts in sports-related concussion drafted a consensus statement at the First International Symposium on Concussion in Sport in Vienna in 2001, and revised the statement at the Second Symposium in Prague in 2004.

One of the key developments at the Prague symposium was the replacement of grading scales with a “*simple*” and “*complex*” classification, return-to-play criteria were revised, and neurocognitive testing was endorsed as the cornerstone for concussion management^{26,40,75,77}. A simple concussion resolves within seven to 10 days and does not require formal neurological testing; whereas a complex concussion presents with prolonged symptoms or neurocognitive impairments^{7,14,28,40,73,82,83,14,28,40,73,82,83}. The complex concussion requires formal neurocognitive testing. An athlete that has sustained more than one concussion is automatically classified as having sustained a complex concussion²⁶ and there is no definite recovery period available.

However the most recent Zurich consensus statement in 2008 provided unanimous agreement of the CISG to abandon the simple versus complex grading system of concussion^{2,53}. The panel felt that the simple and complex terminology of classification of concussion did not fully describe the scope of the injury. The panel also reinforced the concept that the majority of concussions resolve within a short period of time, between seven to 10 days⁸⁴ with the time frame for recovery in children and adolescents being longer⁷. This underpins a paradigm shift from traditional concussion grading scales to individualised care^{2,17,34,68}.

Despite attempts to develop a consensus statement, concussion remains a complex and a poorly understood sports-related injury. A review of concussion grading guidelines concluded that the subtle cognitive and behavioural changes that should be detected from closely monitoring an athlete were being overlooked³².

Diagnosis of concussion is largely reliant on the self-report of symptoms by athletes to medical personnel who are responsible for the evaluation and management of the concussed athlete. The specific signs and symptoms, which need to be evaluated in the diagnosis and management of concussion, will now be discussed.

2.3.2. Signs and symptoms of concussion

The seemingly simple task of properly identifying and managing concussion is one of the greatest challenges facing sports clinicians^{15,19,28,36}. The symptoms are global and transient in nature, and the subtlety of the symptoms and pathology makes diagnosis challenging^{44,50,85}. It was found that the majority of Italian football medical staff based their diagnosis of concussion on clinical examination⁵⁵. Despite this finding, the study failed to establish the concussion knowledge of the respondents, raising concerns regarding the competence of medical staff in treating sports-related concussion. The diagnosis of concussion involves the assessment of a range of aspects, including physical, cognitive and emotional symptoms; and sleep disturbances (Table 2.2), with some symptoms more obvious than others¹⁹.

Table 2. 2: Signs and symptoms of concussion^{23, 24}

Physical	Cognitive	Emotional	Sleep
Headache	Poor concentration	Depression	Drowsiness
Dizziness	Difficulty remembering	Irritability	Insomnia
Blurred Vision	Feeling “foggy”	Mood swings	Difficulty getting to sleep
Photophobia	Feeling “slowed down”	Aggressiveness	Sleeping more
Nausea			
Numbness/tingling			
Vomiting			
Fatigue			
Phonophobia			
Balance problems			

The hallmarks signs of concussion are confusion and amnesia^{50,76,78}, with headache being the most commonly reported symptom in 80% of concussive injuries^{17,19,56,86}. Other common symptoms of concussion include dizziness, nausea, fatigue, balance problems, attention and concentration difficulties, sleep disturbances, and feeling “foggy”^{12,15-18,36,54,79}. The diagnosis of concussion may be based upon one or more of these symptoms². The athlete may report a feeling of being stunned or seeing bright lights, light-headedness, vertigo, tinnitus or blurred vision^{2,36,87}. A study of concussions sustained by high school and higher education football players showed that LOC and amnesia presented in 9% and 27% of all cases respectively^{19,46,19,47}. Other symptoms such as headache (86%), dizziness (67%), confusion (59%), and blurred vision (35.5%) were much more common^{19,46}. Notebart and Guskiewicz⁵⁸ concurred with these findings, as clinicians reported evaluating few concussed athletes with LOC and amnesia.

The symptoms manifesting from a concussion may persist for days to weeks. Resolution of the clinical and cognitive symptoms typically follows a sequential course, whereby clinical signs often resolve before cognitive signs and symptoms resolve^{2,13}.

Even when initial symptoms of concussion resolve quickly, the athlete may experience delayed onset of further symptoms^{15,19}. In rare cases the symptoms of concussion disappear then reappear with dramatic sequelae. Due to most cases of concussion lacking the dramatic presentation of LOC^{54,58}, many of these injuries are not reported and may be subsequently mismanaged^{29,88}. Consequently, the International Rugby Board (IRB) adopted a rule that in the event a player is unaware of what has happened, even if it is momentarily at the time of the injury, this would be deemed as a consistent sign that the athlete is or has sustained a concussion injury⁸⁷. The multiple signs and symptoms associated with concussion provide the clinician with some indication of the complex pathophysiology underlying the condition^{2,17,26}. The pathophysiology of concussion will now be discussed further.

2.3.3. Pathophysiology of concussion

The precise pathophysiology of concussion is unknown^{24,45}. The current consensus is that concussion reflects a functional disturbance of the brain rather than a structural one^{45,89}.

Concussion may be defined as a “*transient neurological dysfunction as a result of a biomechanical force*”⁹⁰. Under normal conditions, cerebral blood flow is tightly coupled to neuronal activity and cerebral glucose metabolism^{69,90}. Recent studies have shown that a cascade of neurochemical changes in the brain occurs when a moderate to severe brain injury is sustained^{24,59}. The assumption is that similar changes occur in concussion^{26,56}.

Giza and Hovda⁹⁰ explained the metabolic mismatch between the energy production and demands in experimentally simulated concussions in rodent studies^{8,9,54}. At a neurophysiological level, the forces associated with concussion result in the stretching and shearing of axons. There is an abrupt release of neurotransmitters and ion fluxes that occur immediately after a concussion injury. The axonal stretching causes the pathological release of excess neurotransmitters such as glutamate to the N-methyl-D-aspartate (NMDA) receptors leading to further neuronal depolarization^{24,53,90}. In addition, there is disruption of the neuronal membranes and the opening of the voltage dependent potassium ion (K^+) channels⁹⁰.

The ionic flux causes acute and subacute changes in cellular physiology^{24,53}. Acutely, the sodium-potassium (Na^+K^+) pump works overtime in an effort to restore the neuronal membrane potential. There is a marked increase in extracellular potassium ions (K^+), as well as the release of excitatory amino acids (EEA) that exacerbates the K^+ flux. The massive influx of K^+ results in hyperglycolysis^{8,56,90}. The Na^+K^+ pump requires more adenosine phosphate (ATP) to restore the ionic homeostasis. This increase in energy demand is accompanied by decreased cerebral blood flow that is not well understood. The disparity between the glucose supply and demand results in a cellular energy crisis^{8,24,56}. The resulting energy crisis is proposed to account for the symptoms and behavioural changes associated with a concussion injury⁸.

Normally after a mild insult to the brain, excessive extracellular K^+ is taken up by the surrounding glial cells, maintaining the physiological K^+ levels. However, after a larger insult, such as brain trauma or ischaemia, the neuronal depolarisation continues and further EEA's are released due to the increase in extracellular K^+ . There is also further opening of EEA channels and a greater K^+ flux.

This period of massive excitation is followed by relative neuronal suppression called spreading depression. This may manifest in a concussed athlete as early loss of consciousness, amnesia or other cognitive dysfunction⁹⁰.

After an experimental concussive injury, acute abnormalities include ionic fluxes, hyperglycolysis, indiscriminate glutamate release, lactate accumulation and axonal injury⁹⁰. There is increased lactate production due to the accelerated glycolysis, as well as impaired oxidative metabolism. The acute physiological response is followed by an increase in intracellular calcium, mitochondrial dysfunction, impaired oxidative metabolism, decreased glycolysis, and decreased cerebral blood flow and neurotransmitter disturbances. It is during this post injury period that cellular metabolism has already been stretched to its limits. It is suggested that it is during this period that concussed athletes could be more vulnerable to sustain a repeated concussion⁹⁰. The neurophysiology following the initial concussion, depending on the severity, begins to return to normal within a few days to weeks. The energy crisis and ionic imbalances begin to resolve and metabolism returns to normal.

The physiological response to a concussion in children may differ from the adult brain. Studies have shown that although most cognitive deficits resolve by three months post-injury, a subgroup of children continued to demonstrate persistent behavioral problems, as well as difficulties with attention and memory¹⁴. The reason for these findings are unclear and poorly understood. This may be due to factors in the developing brain such as biomechanical differences, thinner cranial bones and a greater head-to-body ratio which provide less protection to the developing cortex; thinner myelination which may make the axons more susceptible to damage from stretching^{91,92}; greater brain/water volume and the blood-brain barrier properties which may increase the susceptibility of the developing brain to cerebral oedema³⁵. These differences may cause the younger athlete to be more vulnerable to severe injury^{43,73}. The major concern in the management of concussion is the possible onset of serious sequelae from the concussive insult. This will be discussed in the following section.

2.3.4. Complications of concussion

As will be discussed later in this review, concussion may resolve within days or weeks, provided the correct management of the athlete is implemented from the time of injury. In some instances the initial signs and symptoms of concussion disappear then reappear with dramatic consequences¹⁵. Recovery from post-concussive symptoms may be delayed and more serious sequelae, including death may result following either an undiagnosed concussion or an athlete's premature return to sport²⁴.

Impact convulsions or concussion convulsions are immediate sequelae of concussion^{24,93}. These convulsions are not common and have a recorded incidence of one case per 70 concussions in Australian Rules football⁹³. Although reported in other contact sports, the overall incidence rate of concussion convulsions has yet to be established. Convulsions characteristically occur within two seconds of impact. Typically following impact there is brief tonic stiffening followed by a clonic or myoclonic phase, which may last a few minutes^{89,93}. Convulsions are not necessarily associated with structural brain damage and the absence of long-term cognitive damage is indicative of the benign nature of these occurrences^{24,93}. The discussion in the literature may be supported by the findings in a large-scale retrospective study in Australian Football on the absence of adverse clinical, cognitive or neuroimaging outcomes observed at the time of injury or on long-term follow up⁸⁹.

Damage to cerebral arteries or veins may be, but are not usually, associated with concussion injuries²⁴. Bleeding of these vessels may lead to epidural, subdural or intracerebral haematomas causing raised intracranial pressure. Neurological deterioration subsequent to a concussion is highly suggestive of an intracranial haematoma^{24,91}. Signs of neurological deterioration include worsening headaches, lethargy and confusion^{24,91}. These symptoms need to be identified immediately as this condition requires surgical intervention. The initial presentation of a concussed athlete may overlap with that of an athlete that may have sustained an intracranial bleed. Therefore this stresses the need for continual monitoring of a head injured athlete in the first 48 to 72 hours after an injury²⁴.

Second impact syndrome (SIS) or diffuse cerebral swelling is a rare but well recognised complication of concussion injuries that occurs mainly in children and teenagers^{2,24,43}. Second impact syndrome is thought to occur if an athlete prematurely returns to sport while still experiencing persistent post-concussion symptoms from an initial concussion, and then sustains a second concussion while still being symptomatic^{7,9,11,12,37,41,70}. Most documented cases of second impact syndrome stem from a player either not reporting an initial concussion, or an athlete being poorly assessed and managed^{41,41}. At least 17 deaths related to second impact syndrome were reported in the literature between 1992 and 1997^{43,94}. It is proposed that the physiological effects of the initial concussion may not have resolved and the brain oedema may still be present due to the biochemical 'mismatch' from the previous blow^{13,27,53}. This leads to an increased vulnerability to injury, and a second blow may result in further catastrophic swelling. The pathophysiology of this syndrome is thought to include cerebrovascular congestion or the loss of cerebrovascular autoregulation with subsequent vascular engorgement^{24,54}. This results in cardiorespiratory failure and possible death^{23,24}. The SIS cases reported in the literature were mostly sustained by athletes between the ages of 13 to 18 years old⁹⁴. A possible explanation for the higher incidence of SIS in this age group may be the pathophysiology of the younger brain resulting in greater vulnerability to injury in comparison to adults (as discussed in Section 2.2.3)⁹⁴.

Post-concussion syndrome (PCS) includes a range of non-specific cognitive, emotional or somatic symptoms that may occur following a concussion^{9,10,79}. As mentioned in Section 2.3.2, these symptoms include headaches, dizziness, vertigo, memory loss, blurred vision, noise and light sensitivity, difficulty concentrating, fatigue, depression, sleep disturbances, poor coordination and irritability^{52,59,76,91}. Symptoms and signs associated with PCS are typically temporary, and resolve spontaneously and uneventfully within 10 to 14 days of injury⁹⁵. However, there is wide intra-individual and inter-individual variability in the process of recovery from concussion injuries⁴⁵. After repeated concussions the likelihood of serious sequelae may increase, the symptoms may be more significant, and may resolve at a slower rate^{56,96}.

There is a growing body of research that suggests that young athletes are more susceptible to sustaining a head injury⁹². This may be due to a number of important anatomical, physiological and behavioural differences between adults and younger athletes. The most common cognitive sequelae of a concussion injury, namely poor concentration, reduced speed of information processing and impaired execution of function, are the same for younger athletes as for adults⁹². Field et al⁴⁹ found high school athletes who sustained a concussion had prolonged memory dysfunction when compared with athletes in higher education who sustained a concussion. Similarly Moser and Schatz⁵⁴ observed mild enduring neuropsychological effects and decreased mental speed in the youth population who experienced two concussions or more. However, in contrast Barth et al⁹⁷⁹⁷ who noted a recovery from a concussive insult in higher education athletes within five to 10 days. Perhaps the findings by Moser and Schatz⁵⁴ differs from those previous studies as their sample included athletes across a multitude of sports and comprised of adolescents as well as young adults.

As discussed in Section 2.3.3, the resilience of the brain to biomechanical forces differs between adults and young athletes. A two to three fold greater impact force is required to produce clinical symptoms in younger athletes compared to adults^{7,92}. It was reported that despite normal neuropsychological testing, young athletes might still suffer from various post-concussive behavioural sequelae⁹². Therefore concussion may have a negative impact on the educational and social aspects in young athletes such as attending school⁹².

At the third concussion conference in Zurich, 2008 the CISG expert panel unanimously agreed that young athletes below the age of 10 should be evaluated and managed for concussion differently to adults. It was reported that young athletes report different concussion symptoms compared to adults, and therefore a concussion symptom checklist should be age appropriate². In these cases, the parent and patient's input, as well as the teacher and school's input may be required. Any cognitive tests should be developmentally sensitive until the late teen years due to the ongoing cognitive maturation that occurs during this period². Comparison of the young athlete's neuropsychological test results to test norms or population norms are limited due to the continuous cognitive development in the young athlete².

Neuropsychologists maybe required to assess concussed youth athletes due to the need for a modified assessment strategy as other factors such as learning disorders and attention deficit hyperactivity disorder (ADHD) needs to be taken into consideration². To minimise the exacerbation of any post-concussion symptoms activities need to be modified⁹². In conclusion, a more conservative concussion management approach is followed for children due to the different physiological responses and longer recovery period post injury^{2,54}.

The cumulative effect of long term exposure to recurrent concussive blows may also lead to chronic encephalopathy²⁴. There is concern that each bout of concussion may result in residual brain damage. This is most evident in boxers where the degree of cognitive dysfunction has shown to be directly related to the number of concussive blows²⁴. Cognitive deficits have also been identified in retired football players²⁴. There is a need for future research to establish what degree of head injury causes chronic encephalopathy and the period the residual effects may last²⁴. In order to monitor for these changes, the athlete's cognitive function should be documented periodically and cognitive deficits noted to record changes over time^{2,15}. The wide intra-individual and inter-individual variability in concussion suggests a myriad of factors increase risk for the injury. Risk factors for concussion will now be discussed further.

2.3.5. Concussion risk factors

There is increasing evidence that athletes with a history of concussion experience more persistent post-concussion symptoms and are at a greater risk for future injury^{7,18,19,50,70,78,98}. An athlete that has sustained a single concussion is four to six times more likely to sustain a subsequent concussion^{17,24,25,32,35-37,56,81,94}. Whereas Guskiewicz et al^{17,20} found that higher education football players that sustained three or more concussions were at a greater risk of sustaining a concussion in the same season. Zemper²⁵ found the risk of sustaining a repeat concussive insult to be 5.8 times higher for those male football players with a concussion history, however the number of repeat concussions sustained was not recorded.

Despite the findings not being a fair representation of the general population, Zemper²⁵ argued that based on the pathophysiological mechanism of concussion presumably being the same for everyone, it would be reasonable to conclude that the intrinsic risk of sustaining a second concussion of 5.8 would be similar in the general population. Whereas Johnston et al⁷⁸ presumed that in any contact sport the risk of concussion to be directly proportional to the amount of playing time. Thereby proposing that the risk of repeat concussion may reflect the cumulative amount of exposure in sport.

Not only does a previous concussion increase risk of sustaining a further concussion, a previous concussion is also associated with worse symptoms in subsequent concussions. Guskiewicz²⁰ proposed that an athlete with a concussion history may take longer to recover from subsequent concussions. A study of high school and higher education athletes showed that those athletes who had suffered three or more concussions had more severe on-field presentation, and were more vulnerable to subsequent injury, compared to those athletes with no concussion history^{17,20,79}. Athletes with a multiple concussion history have reported significantly more symptoms on a self-report scale compared to those athletes with one or no concussion history^{8,35,77,80}. A study on young athletes carefully matched on important demographic variables found participants with a history of multiple concussions were six times more likely to experience PTA, and eight times more likely to report five or more symptoms of mental disturbances⁸¹.

Iverson et al⁸² showed that high school athletes with a history of three or more concussions presented with more symptoms and poorer memory performance on neurocognitive testing, compared to athletes with no concussion history^{17,20,79}. In the sample a decrease in memory was recorded in those with a concussion history as compared to those athletes without a history of concussion two days after the concussive insult. However at day five post-concussion, Iverson noted no significant difference in neurocognitive performance between the groups. These findings were consistent with those by Collins et al⁹⁹, subjects reported experiencing a greater number of post-concussion symptoms and performed more poorly on two cognitive tests when compared to those higher education football athletes with no history of concussion. Moser et al⁸³ observed similar findings in the cognitive performance of high school athletes with a history of two or more concussions.

The findings of these studies suggest that a history of previous concussion may be associated with a prolonged recovery after a subsequent concussion.

Macciocchi et al⁸¹ found no cumulative effects in football players who sustained two concussions more than two weeks apart. However, in a study evaluating the cognitive performance of jockeys after sustaining a concussion, those jockeys with a history of previous concussion performed worse in cognitive tests after a three month recovery period⁴⁰. These findings suggest that a history of concussion may place an athlete at risk of developing long term complications associated with post-concussion syndrome²⁰. The small sample size in the study by Macciocchi et al⁸¹ was identified as a possible limitation to finding statistical significance. Insufficient sample size is a common weakness of the literature reporting on the effects of recurrent concussion injuries raised by Collins and Hawn⁹ in a discussion on the lack of reliable prospective research of cumulative concussive injury.

Gaetz et al²⁰ found that junior ice hockey players with a history of three or more concussions reported a greater number of post-concussive symptoms, compared to athletes without a history of concussion. Similarly Collins et al⁹ found in the high school athletic population there was found to be a more severe on-field presentation after sustaining more than three concussive insults. However, Covassin et al²⁰ showed that concussed athletes still exhibited neurocognitive impairments in reaction time and verbal memory despite the concussion group of athletes showing no significant difference in concussion symptoms. A possible explanation for this discrepancy is the likelihood of athletes not being fully aware of the symptoms of concussion and therefore not reporting it to a sport medical professional. The post-concussive neurocognitive impairment commonly reported to occur includes visual motor reaction time, memory and attention⁴⁰.

Histories of headaches, learning disabilities, as well as psychiatric disorders such as anxiety, are risk factors for prolonged recovery from a concussion⁵³. Collins et al⁷⁹ found that athletes with a history of learning disabilities are more vulnerable to post-concussive neurocognitive impairments.

Findings from neuroimaging studies using functional magnetic resonance imaging (fMRI) are suggestive that mental health issues, such as depression, as well as increasing the risk of more severe symptoms, are long term consequences of sports related concussion^{2,53,84}.

2.3.6. Summary of literature: Concussion in sport

Concussion may occur in any activity¹⁵. However, in sport, there is an inherent risk of sustaining a concussion^{15,32}. Collectively, the incidence of concussion has been well documented illustrating high rates of occurrence. There is growing emphasis in the literature on increasing the objectivity of concussion assessment. Recently, progressive effort have been made in developing a consensus on concussion in sport addressing this major health concern with the aim of facilitating improved diagnosis. The understanding of the potential complications and risk factors for concussion, as discussed in the above literature, highlights the importance of the effective management of a concussed athlete. The following sections of this review will describe the evaluation and management of the concussed athlete.

2.4. Evaluating the concussed athlete

Since the first reported case of concussion, the method of managing this injury has been a debated topic amongst medical professionals⁷⁸. In a review of concussion assessment literature, Eckner and Kutchner⁴⁴ reported that the current mainstay of concussion evaluation included symptom assessment, neurological examination, and cognitive testing. The recent international concussion consensus statement emphasised a multi-faceted approach for concussion evaluation and management². The management of concussion may be divided into three broad sections, namely immediate, early and late management²⁴.

The diagnosis of acute concussion requires a comprehensive assessment, including clinical symptoms, physical signs, behaviour, balance, cognition and sleep^{2,24}. A detailed pre-season evaluation inclusive of concussion history forms an integral part of the evaluation of the concussed athlete.

The diagnosis of concussion may include one or more of the following signs and symptoms (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). If the athlete displays or reports any of the above components, a concussion is suspected and the appropriate management protocol should be followed⁸. 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^{9,71}.

2.4.1. On-field or sideline evaluation of acute concussion

One of the most critical roles of medical personnel is a proper evaluation of potential head and cervical spine injuries. Basic principles of first aid apply at this stage including cervical spine protection, followed by airway, breathing and circulation evaluation and management^{2,5,9,24,27,88}. When the athlete presents with a prolonged period of loss of consciousness all cervical spine injury precautions should be adopted and careful removal from the field of play to an emergency facility^{2,5,24,29,87,88}. Particular attention should be given to exclude a cervical spine injury and to stabilise the head injured player with urgent referral should any of the indicators in Table 2.3 be met²⁴.

Table 2. 3: Indications for urgent hospital referral^{24,52,75}

Any player should be referred to hospital urgently if they develop any of the following:	
1.	Fractured skull
1.	Penetrating skull trauma
2.	Deterioration in conscious state following injury
3.	Focal neurological signs
4.	Confusion or impairment of consciousness > 30min
5.	LOC > 5min
6.	Persistent vomiting or increasing headache post injury
7.	Any convulsive movements post injury
8.	More than one episode of concussive injury in a match or training session
9.	Where there is assessment difficulty, for example an intoxicated athlete
10.	Children with head injuries
11.	High risk patients, for example haemophilia, anti-coagulant use
12.	Inadequate post injury supervision
13.	High risk injury mechanism, for example high velocity impact

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In the more subtle cases, a brief validated on-field neuropsychological test, such as Maddock's questions (Table 2.4), to assess recent memory may be indicated^{2,9,26,28,29,57,85}. Maddock's questions are a validated tool for brief on-field neuropsychological testing to assess recent memory and orientation immediately after a concussion^{24,86,91}. Brief neuropsychological tests used in the acute assessment of concussion to evaluate memory function and attention have been shown to be practical and effective^{2,3}. The standard approach of asking orientation item questions, time, place and person, have been shown to be unreliable as this component of cognitive function may be preserved in a concussion^{5,24}. However, prospective studies have shown that Maddock's questions which include assessment of recent memory are more sensitive in differentiating between concussed and non-concussed athletes^{14,24}. It should be recognised that the appearance of concussion symptoms may be delayed for several hours following the concussive insult⁸⁹.

Table 2. 4: Maddocks questions^{24,100}

Maddocks questions	
1.	Which ground are we at?
2.	Which team are we playing today?
3.	Who is your opponent at present?
4.	Which quarter is it?
5.	How far into the quarter is it?
6.	Which side scored the last goal?
7.	Which team did we play last week?
8.	Did we win last week?

Any athlete suspected of sustaining a concussion should be removed immediately from activity^{28,70,89}. The overall consensus by authors is the concussed athlete must be removed from the field of play or practice session immediately. The overall approach should be: “*when in doubt, sit them out*”^{26,35}. The priority of sideline management is to confirm the diagnosis of concussion and perform a baseline symptom and cognitive function evaluation^{2,14,26,87}. It should be emphasised that following the injury, the concussed player must be assessed by a medical doctor as soon as possible^{24,29,88}. This should be performed in a quiet medical room where a thorough history and neurological examination is performed. In accordance with the Zurich concussion guidelines, any athlete that shows any features of concussion, should be assessed using a brief neuropsychological concussion tool^{2,24,73,89}. In addition, a concussion evaluation should include neurological assessment and cognitive testing using tools such as the Standardised Assessment of Concussion (SAC) or Standardised Concussion Assessment Tool (SCAT2).

Although Maddock’s questions have been found to be an effective assessment strategy, Broglio et al⁹² showed that the SAC tool provided the clinician with the most information regarding memory acquisition and global cognitive ability in an acute concussion. McCrea et al^{9,93} found the SAC to accurately identify concussed athletes from controls within 24 of concussion. The SAC tool is feasible for use in the sideline setting and measures four neurological domains sensitive to change following a concussion injury. These domains include orientation, immediate memory, concentration, delayed recall, as well as neurological screening^{7,29,93}.

The standard questioning utilised in the SAC tool requires the concussed athlete to provide the day of the week, month, date, year and time of day within one hour. Concentration is tested by having the athlete repeat in reverse order, numbers that increase in length from three to six numbers, as well as reciting the months of the year in reverse order. A five-word list is read to the athlete for immediate recall to assess immediate memory. Delayed recall of the original five-word list is the final component of the SAC test. This gives a numerical scoring with a maximum of 30⁷. Barr and McCrea⁹³, using a test-retest paradigm in their study of high school and university soccer athletes, found the SAC tool to be a reliable and valid measure of early cognitive changes following a concussion. However, the Standardised Concussion Assessment Tool (SCAT) is a more practical alternative to the SAC.

The Standardised Concussion Assessment Tool 2 (SCAT2) (Figure 2.1) was developed as a part of the consensus statement at Zurich, 2008^{2,44,45}. The SCAT2 was developed by combining existing concussion assessment tools^{7,94}. Although not yet validated, the SCAT2 is a practical assessment tool, internationally applied and user friendly⁸⁹. The use of SCAT2 is encouraged to promote consistency with concussion evaluation^{24,33,89}. Patricios et al¹⁰¹ reported that physicians in South Africa have implemented the use of the SCAT2 at all levels of sport since 2009. This brief sideline assessment provides a gross characterisation of the athlete's level of cognitive function. However, athletes should not return to play solely based on the results of the brief sideline assessment alone^{48,49}. These abbreviated testing paradigms have been designed for rapid sideline concussion assessment and are not meant to replace comprehensive neuropsychological tests². Further clinical evaluation of an acute concussion injury will be discussed now.

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.

<ul style="list-style-type: none"> ▪ 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 	<ul style="list-style-type: none"> ▪ 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
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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 than 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 *

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2.4.2. Clinical assessment

If the concussed athlete has suffered any period of LOC, has deteriorating drowsiness, recurrent vomiting, or has unusual or aggressive behavior, they should be referred to a tertiary hospital, querying the risk of a possible intracranial lesion. An athlete may be evaluated in the emergency room or doctor's office as point of first contact². A key feature is to determine the need for emergency neuroimaging to exclude a more severe brain injury that may involve a structural abnormality. Further investigations such as brain imaging by either computer tomographic (CT) or magnetic resonance imaging (MRI) should be performed². Functional magnetic resonance imaging (fMRI) provides additional information on the pathophysiological mechanisms^{2,6,24}. It demonstrates patterns that correlate with symptom severity and recovery in concussion. This is not a part of routine assessment, although it may provide additional information regarding the pathological mechanism².

This line of research may help establish the link between clinical indicators of concussion and changes in brain physiology. The availability of fMRI is currently not sufficiently widespread to facilitate clinical use⁶. If neuroimaging investigations are clear and the athlete's condition continues to improve over a two hour observation period they may be discharged. The athlete should be discharged in the care of a responsible adult that has possession of a concussion information booklet (Table 2.5)²⁴. The follow up evaluation prior to return to play of an athlete will now be discussed.

University of Cape Town

Table 2. 5: Patient discharge information for 48 hours after injury^{24*}

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.

**Table reproduced with permission from Dr Patricios*

2.4.3. Follow up assessment and concussion investigations

The follow-up assessment of a concussed athlete should preferably be performed by a medical doctor with experience in concussion management using the recommended guidelines. The modern concussion management protocol requires return to play decisions to be made after serial medical evaluations, and may include multi-disciplinary skills of neurologists, neurosurgeons, neuropsychologists, physiotherapists and biokineticists^{40,89}.

Return to play decisions should not be made at the sideline assessment and/or emergency room evaluations, as serial evaluations are required to determine whether the athlete has fully recovered from concussion and is safely able to return to play^{54,88}. This is best evaluated by a combination of clinical assessment with neuropsychological tests^{2,44}.

Clinical assessment should include evaluation of the following parameters: the history of the specific head injury, and history of previous concussions or associated injuries (for example, neck or maxillofacial injuries). Symptoms at the time of injury (particularly amnesia which is of prognostic value), and current symptoms⁸. 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 and maxillofacial structures, should be addressed²⁴.

A range of additional investigations may be used to assist with the diagnosis of concussion. Utilising all available resources is the safest approach to facilitate decisions regarding an athlete's safe return to play⁴⁸⁵⁹. Neuroimaging forms an integral tool in concussion evaluation as previously discussed in Section 2.4.3. Other current mainstays of concussion evaluation, including a neurological assessment, will be discussed in the following section.

2.4.3.1. Objective balance assessment

There have been reports of motor function and coordination deficits following sports-related concussion⁷. McCrea et al⁸ found balance scores to be significantly lower in concussed athletes when compared with a control group. Studies have identified postural stability deficits in concussed athletes lasting approximately 72 hours following concussion injury, using sophisticated force plate technology and less sophisticated clinical balance tests such as the Balance Error Scoring System (BESS)^{1,2,44}. Postural stability tests are reliable and valid objective tests to assess the motor domain of neurological function, particularly where signs and symptoms indicate a balance component^{2,44}.

The BESS is a brief non-instrumented assessment of balance that may be completed on the sideline or later in the clinician's room. Literature supports the use of the BESS testing in the evaluation of the concussed athlete when the same scorer is used⁴⁴.

2.4.3.2. Neuropsychological assessment

As discussed in Section 2.3.4, recovery rates of athletes post-concussion vary between individuals. In 2001 the CISG underscored the importance of neurocognitive testing in the assessment of concussion¹⁷. Concerns about the diagnosis and management of concussion led to the notion that neuropsychological testing should be the cornerstone of concussion management^{2,40,92,96}. Although in most cases cognitive recovery largely overlaps with the time course of symptom recovery, it has been demonstrated that cognitive recovery may occasionally precede or, more commonly, follow clinical symptom resolution²⁴. This suggests that cognitive function assessment is an important component in the safe return of an athlete to sport².

Neuropsychological (NP) tests are designed to evaluate the brain's ability to process information/cognitive function. Neuropsychological evaluation of a concussed athlete is a means to determine neurocognitive deficits from injury and an athlete's readiness to return to play⁵⁷. Neuropsychological tests have been shown to be an effective and valid means of determining an athlete's recovery^{24,96}. Barth et al⁹ were among the first to conduct a large prospective study in the athletic population demonstrating the effects of concussion could be evaluated by neuropsychological (NP) testing. Collins et al⁹ found deficits in memory and concentration in concussed higher education soccer athletes that persisted up to five days postconcussion when compared to the control group. Matser et al¹⁰² conducted a retrospective study in which he compared the NP test data of amateur soccer players with those of swimming and track athletes. Results showed impairments in both memory and planning in the soccer population. These studies may collectively suggest NP testing be used to detect even the subtle deficits which result from a concussive insult.

The NP assessments should not be the sole basis of concussion management decisions, but rather form a component of a multifaceted approach with a range of clinical domains and concussion investigations^{2,5}. The majority of NP tests should be performed when the athlete is completely asymptomatic in order to assist in the return to play decision. However, there may be a few cases where NP testing may be performed while the athlete is still symptomatic to assist in determining concussion management²⁴. Newer protocols suggest not administering NP tests while symptomatic as this may induce unnecessary cognitive stress²⁴.

Concussion assessment in sport is unique as there is access to the athlete before injury. Pre-season baseline NP evaluation of an athlete's cognitive functioning is becoming standard practice^{54,77,78,83}. This allows for more reliable comparison to post-concussion assessments and promotes accurate decision-making^{24,48,92}. Establishing baseline data ensures that factors such as disease, drugs, practice effects or malingering does not adversely affect test performance²⁴. The NP tests are repeated in serial evaluations of the concussed athlete to determine the point at which neurocognitive deficits and clinical symptoms are no longer present^{29,54}. It is recognised that the traditional method of NP testing, namely 'paper and pencil' tests, may be susceptible to learning, which may produce false negatives offering limited sensitivity⁹⁶.

Improvements in computer technology have led to computerised concussion programmes being more common in the sports medicine setting⁹. The CISG committee was supportive of these computerised tests as these could be administered to large groups; are quick and easier to administer; and able to detect subtle changes in cognitive function by measuring response variability, which is not found with the 'paper and pencil' tests^{24,96,98}. The Zurich concussion statement recommended neuropsychologists are in the best position to interpret neuropsychological (NP) tests². However, this may not always be possible due to resource constraints, in which case other medical professionals may both conduct and interpret such tests.

Lovell et al^{96,103} created the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT) battery. This test battery evaluates attention span, sustained and selective attention, reaction time and several dimensions of memory^{21,70,103}. Lovell et al⁷⁰ found ImPACT detected subtle changes in a sample of concussed high school athletes which were not evident on brief sideline evaluation. In a separate study, Schatz et al correctly identified 82% of concussed athletes utilising ImPACT tests. These findings suggest ImPACT is sensitive to acute changes to neurocognitive functioning immediately after concussion. Examples of other computerised tests include the CogState Sport, Automated Neuropsychological Assessment Metrics (ANAM) and Headminders^{24,104}. Conflicting evidence from Iverson et al⁸¹ found no difference in the baseline performance utilising ImPACT tests between those suffering multiple concussions and those with no history of concussion with Broglio et al¹⁰⁴ reaching the same conclusion in an effort to replicate the study by Iverson et al⁸¹. Therefore these studies show that long term deficits may be undetectable by the computerized NP tests and the individual tests need to be assessed independently.

The South African Rugby Union, as well as other major rugby playing countries utilise CogState Sport, which has been extensively peer reviewed in literature, as an objective measure of cognitive function following head injury⁴⁵. Despite computerised tests being a more practical method of administering NP testing, issues of cost and accessibility may limit the use of computerised test batteries. Realistically, factors such as scarcity of financial resources; lack of internet, as well as geographical remoteness are limiting factors in the utilisation of computerised test batteries^{2,19,55}. To remedy these shortcomings, administering a systematic and thorough clinical evaluation with the SCAT2 card ensures the athlete has fully recovered before returning to sport^{24,44}.

2.4.4. Summary of literature: Evaluating a concussed athlete

As previously discussed, concussion injuries are difficult to diagnose and if undetected, may lead to serious sequelae²⁸. The effects of concussion are well documented in the literature.

Well-formatted standard assessment protocols, such as the SCAT2, have been developed to assist in the diagnosis and subsequent management of concussion injuries^{2,44}. An initial clinical evaluation with neuropsychological tests of a concussed athlete provides an objective and scientifically valid baseline measure providing reference points to monitor an athlete's recovery^{15,24,92}. In the most recent concussion statement, the CISG highlighted that neurocognitive testing should be the cornerstone of all aspects of concussion evaluation and management². The consensus regarding the assessment of concussion promotes an individualised, patient-centred approach to diagnosis and management of any concussive insult using clinical assessments and validated field-side or computerised instruments^{2,68,89}. Management strategies to facilitate an athlete's safe return to play will be discussed in the following sections.

2.5. Concussion management

The First International Conference on Concussion in Sport recognized that athletes must meet a particular standard in care, starting with complete rest following a concussion. The Zurich conference on concussion in sport also emphasised the need for a multi-faceted approach to the management of concussion^{2,17}. The cornerstone of concussion management is complete cognitive and physical rest until athletes are asymptomatic, followed by a graded exercise programme prior to medical clearance and return to play¹⁷. The CISG continues to endorse complete rest of an athlete until asymptomatic. This phase is recognised as the most difficult yet most critical phase of postconcussion rehabilitation²⁸. When athletes return to play they must be symptom free and not using any pharmacological agents or medication as medication may mask or modify symptoms of concussion². As mentioned previously, the majority of concussions resolve spontaneously over a few days². Concussion management in athletes can be divided into two phases. Firstly management of acute symptoms using rest and minimal pharmacological therapy followed by a second component of evaluation of fitness to play with graduated return to play.

2.5.1. Pharmacological therapy

Pharmacological therapy may be administered in two distinct situations of sports related concussion management². Firstly in the management of specific prolonged symptoms of concussion such as sleep disturbances and anxiety. The other use of drug therapy in sports related concussion is to shorten the duration of concussion symptoms by modifying the underlying pathophysiology of the condition². Despite the Zurich concussion guidelines on the use of pharmacological therapy for concussion, Patricios et al²⁴ highlighted the lack of evidence-based pharmacological treatment that may be administered to influence the course of the condition. Pharmacological intervention includes the treatment of headaches with mild analgesics that do not influence the potential for bleeding; anti-emetics for nausea; and anti-vertigo agents for prolonged dizziness. Hypnotics may be used to manage more persistent symptoms such as insomnia. There is no evidence that medication may influence the pathophysiology of concussion²⁴.

2.5.2. Return to play

Significant confusion has been created regarding the return to play of an athlete following a concussion due to the publication of different concussion guidelines⁵³. This confusion surrounding when to safely return an athlete to sporting activities may be contributing to athletes prematurely returning to play and sustaining a repeated concussion. In 1997, the AAN published a “one-size-fits-all” concussion management guideline, which was based on concussion symptoms and the duration of LOC^{1,70}. According to the AAN guidelines, each grade of concussion specified an exclusion period of the athlete that was developed on clinical expertise⁷⁰. These AAN guidelines were similar to the Cantu and Colorado guidelines.

The United States Military academy uses a combination of the AAN and Colorado guidelines, which allowed cadets who are symptom free 24 hours after sustaining a concussion to return to full contact sport five days post injury¹⁰⁵. Some guidelines would permit a player to return to play immediately if asymptomatic; others recommend a 15 to 20 minute wait after symptoms have subsided^{19,87}.

The Prague concussion statement did not endorse any return to play guidelines but instead recommend a safe and structured protocol for return-to-play^{40,45}. The CISG recommends that an athlete's return to play should be in accordance with a supervised step wise protocol^{2,3}. This practical guideline demonstrates a marked move away from the traditional concussion scales.

The average time taken for resolution of symptoms in college football players that sustained concussion was seven days¹⁶. Their cognitive function returned to their baseline recording by three to five days²⁷. Whereas a number of studies in high school and higher education American football found the recovery of majority of concussed athletes had occurred within five to ten days³¹. The time course of cognitive recovery reported in literature is inconsistent with a common error of estimating athletes' pre-concussion and post-concussion performance to match those of the control groups. The same-day, as well as delayed return to play decisions may be difficult due to the subjective interpretation of the signs and symptoms associated with concussion^{27,48}. Most guidelines agree that if the athlete's symptoms lasted for more than 15 minutes after sustaining a concussive injury or an athlete suffers a LOC, the athlete should immediately be removed from play and should not return to sport for a minimum of one week^{19,87}. The International Rugby Board (IRB) has adopted a ruling that any player sustaining a concussion must abstain from playing and training for a minimum of three weeks^{100,106}. The mandatory exclusion period may only be shortened following an assessment by a neurological expert¹⁰⁵. Similarly, the New Zealand rugby union has implemented a three week stand down period¹⁰⁷.

The danger associated with a mandatory exclusion period is that an athlete may be deemed as completely recovered after this period yet the brain function assessed by NP may still be abnormal²⁴. In a sample of Australian football athletes, Makdissi et al³¹ found that the majority of concussed athletes recovered within seven days. However, 17% of their sample continued to experience PCS. The authors highlighted that the mandatory exclusion period may either be excessively conservative or inadequate in cases of delayed recovery.

It is clear that return to play should be based on the resolution of symptoms and the normalisation of neurocognitive function rather than a predetermined period of time^{6,53}. The athlete must also achieve a return to baseline NP test scores without aggravating concussion symptoms with exercise or cognitive stress²⁴. Serial NP assessments play a significant role in identifying patterns of recovery by the concussed athlete and assist in determining if the athlete is able to commence with a return to play protocol^{24,44,96}. The safe return of an athlete to sport participation through the use of a clearly defined return to play protocol will now be discussed.

2.5.2.1. Return to Play Protocol

The final phase of a safe concussion rehabilitation protocol involves a structured and supervised six step return to play (RTP) protocol (Table 2.6)^{1,2,12,14,24}. The progression through the stepwise protocol is dependent on the athlete being completely asymptomatic at each level. Each step should take a minimum of 24 hours. This means the athlete should take approximately one week to complete the protocol once they are asymptomatic at rest and with provocative exercise^{2,28}.

It has been recognised that post-concussive symptoms are aggravated by both physical and cognitive exertion²⁸. Based on this, the protocol begins with complete rest or no activity until the concussed athlete is asymptomatic^{2,12}. This is one of the most difficult levels, especially for the athlete that is used to a high level of participation²⁸. Activities that require concentration and attention, for example scholastic work, video games and text messaging, may exacerbate symptoms and may delay recovery². Each level should take a minimum of one day, as symptoms may not worsen at the time of exertion but rather appear later in the day or even the next day²⁸. Once asymptomatic, the athlete performs increasing degrees of exercise intensity while the symptoms are monitored. Exercise stress testing follows a stepwise process with stage-associated objectives^{2,28}. Firstly, the athlete has to perform light aerobic exercise with no resistance training, such as walking and stationary cycling keeping the intensity at less than 70% of maximum heart rate.

If asymptomatic, the athlete then proceeds onto the third level of sport specific training including running drills and ball handling skills. No head impact activities are permitted during this phase².

The objective in the fourth step of non-contact training drills is exercise co-ordination and cognitive load. The athlete may progress to more complex training drills and may commence load progressive resistance training at this step. Once the athlete is able to complete the non-contact drills and remain asymptomatic, they will then progress to participate in full contact practice^{2,24,28,40}. This step requires confidence and functional skills²⁴. Neuropsychological and postural stability assessment is recommended upon completion of the sport specific skills⁴⁰.

Once the full protocol is successfully completed with no symptom re-emergence, the athlete will receive medical clearance to participate in normal training activities. The final step is the return to normal game play^{2,24,28}.

Table 2. 6: Graduated return to play^{2,24,28}

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
No activity	Complete cognitive and physical rest	Recovery
Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70% MPHR No resistance training	Increase heart rate
Sport-specific exercise	Skating drills in ice hockey, running drills in soccer No head impact activities	Add movement
Non-contact drills	Progression to more complex training drills example passing drills in soccer.	Exercise, coordination and cognitive.
Full contact practice	Following medical clearance participate in normal training activities.	Restore confidence and assess functional skills by coaching staff.
Return to play	Normal game play	

2.5.3. Summary of literature: Management of concussion

There is a lack on consensus and some confusion in the literature and amongst sporting groups surrounding the return of an athlete to sport following a concussion injury²⁵. Several authors propose a multifaceted approach be implemented when managing a concussed athlete². The literature discussed above, places emphasis on cognitive and physical rest. The untimely return of an athlete may be due to the inherent pressures of competition and participation²¹. Current evidence illustrates a clear management plan that includes complete rest, followed by a progressive stepwise return to exercise and contact activities while completely symptom free results in a minimal risk of complications^{2,78}. Considering the risk of complications from concussions, prevention strategies are worth exploring. Methods by which concussion may be minimised in sport will be discussed in the following section.

2.6. Prevention of concussion and its sequelae

Presently there is no curative medical treatment for concussion⁹. The brain cannot be conditioned to withstand injury, therefore attention needs to be paid to the extrinsic factors that may contribute to injury. Unlike musculoskeletal injuries no strength or conditioning methods exist to prevent a concussion²⁹. The following section will discuss possible preventative measures aimed at minimizing the associated sequelae of concussion.

2.6.1. Protective gear

There is no clinical evidence to prove that protective equipment prevents concussion^{3,46,63}. Despite evidence that suggests sport specific helmets reduce the impact forces transmitted to the brain in high speed collision sports, the effect on the incidence of concussion has not yet been established^{2,3}. Despite ice hockey athletes wearing full protective equipment, ice hockey has the highest incidence of concussion. Koh⁶³ suggest that athletes may become over-reliant on protective equipment. Although mouthguards have shown a definite role in preventing dental and oro-facial injuries, there is no evidence to demonstrate any beneficial effects on concussion injuries⁷.

Despite the questionable efficacy of this equipment, there is not sufficient evidence to suggest it should not be used. For safety, athletes, coaches and other role players in sport should pay attention to the suitable size and quality of helmets, and ensure helmets are properly placed and secure⁶³.

2.6.2. Pre-participation evaluation

The pre-participation or screening evaluation (PPE) of an athlete is important as it assists the clinician to identify those individuals that are high risk for concussion^{2,24,58}. The screening should include a detailed structure that includes questions regarding all the signs and symptoms of concussion. A detailed concussion history of an athlete should be noted. In some sports such as football and hockey, baseline testing is often mandated⁸⁹. The history should include injuries to the head, neck or cervical spine^{2,24}.

As discussed in Section 2.4.4.2, pre-participation neuropsychological evaluation establishes the athlete's normal level of function and provides a reliable benchmark to track an athlete's recovery after a concussion injury^{2,19}. This enables the clinician to identify any subtle deficits which may present post-concussion and minimizing premature return to play^{50,54}. The most recent statement from the CISG supports baseline testing for athletes that are high risk for concussion^{55,71}. Pre-participation screening of an athlete also allows for an opportunity to educate the athlete regarding the significance of concussion injuries². Concussion education and the role of the physiotherapist in sport will now be discussed.

2.6.3. Concussion education and the role of the physiotherapist

In healthcare, knowledge transfer (KT) and exchange is an integral part to optimise learning and empowering decision-making. Sharing knowledge enables the individual to diagnose and respond efficiently to the situation¹⁰⁸. This is especially challenging in the sports arena where there is interaction among a diverse group of role players such as medical staff, coaches and athletes^{7,108}. The need for concussion education is evident due to concussion being a topic where many misconceptions exist⁵¹ and studies have highlighted the substantial underreporting of concussion^{47,71}.

LaBotz et al⁷¹ found that although 71% of athletes did not report a history of concussion in their pre-participation evaluation, these athletes described having experienced concussion-like symptoms in a concussion symptom survey. A similar study showed that 86% of athletes that suffered a concussion did not report a concussion history in the PPE. In a post football season survey, 56% of athletes reported that they had returned to play with concussion symptoms; 28% continued to play while dizzy; and 30% played with a headache after a blow to the head respectively⁷¹. Cross et al⁶⁹ found that the appropriate management of sport injuries did not always match the coaches' responses of being "prepared" or "somewhat prepared" to assume responsibility of managing an injured athlete. A previous study found that 42% of youth sport coaches believed that LOC is a hallmark sign of concussion; and 26% would permit an athlete showing symptoms of concussion to return to play⁵⁵. These studies highlight the need to educate athletes and those involved in their training and care about concussion and the importance of reporting symptoms to medical personnel to minimise the risk factors of subsequent injuries.

Medical coverage at sporting events such as rugby could facilitate accurate diagnosis of sports injuries, and proper injury management thereby immediately minimising the risk of complications and promoting a safe environment for athletes⁶⁹. However, Marshall et al⁴⁸ described that much of the world's rugby is played in situations where medical personnel are frequently not present; and those medical personnel that may be available at games are often not adequately equipped with knowledge about the diagnosis and management of concussion. This is of particular relevance in a South African context where the high impact sport of rugby is one of the most popular sports played across all levels of participation²⁴. Cross et al⁶⁹ discussed that various studies have found a lack of suitably qualified medical professionals present at high school level sports. An area of major concern is the increased incidence of unidentified concussions due to the poor qualification of medical staff^{49,69}. All medical personnel responsible for the care of athletes face the challenging problem of concussion diagnosis and management³⁶. Therefore it is believed that the involvement of healthcare professionals who are properly trained in current trends regarding concussion will facilitate improved recognition and management of concussion.

In light of the poor qualification of medical staff, athletes and coaches in terms of concussion knowledge, there has been a marked increase in education on the topic of concussion in these groups⁵⁵. Covassin et al⁴⁰ showed that the inclusion of the Vienna guidelines into an education curriculum increased awareness and knowledge of concussion, which lead to improved diagnosis and management of concussion in the clinical setting. At the 2008 concussion conference the CISG showed growing interest in the transfer of knowledge and highlighted the importance of improving understanding and optimising concussion knowledge^{2,108}. An American study by Sarmiento et al¹⁰⁹ found the concussion education programme, "*Heads up: Concussion in High School Sport*", positively changed coaches' attitudes, knowledge and behaviour relating to concussion prevention and management; contributing to providing a safe environment for athletes^{22,109}. However, recent findings have highlighted the limited understanding and knowledge of sport concussion; and a lack of standardised concussion knowledge amongst coaches, athletes, medical personnel and physiotherapists continues¹⁰⁸.

The contemporary approach to management of sport-related concussion includes the use of a multi-disciplinary medical team⁸⁹. The majority of concussions reported in Italian football were most commonly reported to coaches (39%), followed by the physiotherapists (22%)⁵⁵. The role of the physiotherapist in the assessment and management of concussion in athletes has been highlighted. Physiotherapists frequently work with concussed athletes and play an integral part in concussion management⁵¹. In many cases physiotherapists are the first to come into contact with the injured athlete^{57,89}. The role of the health professional in the sports arena is to provide an objective initial assessment and ensure the safe return to sport of the injured athlete³². Stewart et al⁸⁹ discussed the responsibility of the physiotherapist to use objective criteria when deciding the safe return of an athlete to sport and always to act in the best interest of the athlete. Sullivan et al³⁴ reported that in New Zealand physiotherapists are the primary sports medicine providers for many teams in the rugby union. Sullivan et al³⁴ conducted a Delphi methodology study among physiotherapists that worked with sports teams in New Zealand, and highlighted the need for education regarding the key signs and symptoms in the diagnosis of concussion. This study was used to identify the key categories of information sports physiotherapists used to diagnose concussion.

The cohort of 21 physiotherapists initially placed major emphasis on the loss of consciousness in the diagnosis of concussion. After exposing participants to an educational strategy using a major paper on sports-related concussion, participants indicated the importance of other symptoms of concussion such as amnesia/memory problems; and dizziness, gait instability and balance difficulties in their decision-making. These findings suggest the need for further education regarding concussion knowledge in physiotherapists in New Zealand³⁴.

In South Africa, physiotherapists are allowed to fulfill the role of a primary care provider which allows physiotherapists to diagnose and treat injuries without a referral from another healthcare provider⁶⁹. The physiotherapist should have sufficient knowledge and skills to compile a fully comprehensive post-concussion assessment of the athlete which evaluates neuromusculoskeletal, balance, vestibular and visual aspects as well as psychosocial and cognitive functions⁸⁹. In the clinical setting, physiotherapists working in a sport medicine practice have enough time to fully evaluate and manage the injured athlete⁶⁹. The prevention aspect of physiotherapy practice includes the pre-participation evaluation of an athlete⁶⁹. Gilbourne et al¹¹⁰ interviewed sport physiotherapists and highlighted the pivotal role identified by the physiotherapists in an athlete's recovery, particularly through educating the athlete through goal setting and task orientated skills development. The education of an athlete in the early stages of rehabilitation promoted the potential benefits of various stages of rehabilitation; and encouraged athletes to make informed decisions¹¹⁰. The need for a physiotherapist to properly diagnose and manage cognitive and motor impairments associated with concussion is recognised in the case when a neuropsychologist is not available⁸⁹. If the scope of practice required to manage a concussed athlete exceeds the physiotherapist's ability, the clinician should refer the athlete accordingly.

Given the central role of physiotherapists in the general safety of athletes and more specifically in the diagnosis and management of concussed athletes; as well as the education and decision making responsibilities of a multidisciplinary team in sport, it is surprising to find very few studies assessing physiotherapists' concussion knowledge⁶⁹. In South Dakota it was found that physiotherapists felt "more prepared" and demonstrated better decision-making regarding acute sports injuries than coaches⁶⁹⁷⁰.

The World Confederation of Physical Therapists believes that physiotherapists should use the best available evidence from systematic research and integrate this with clinical expertise to make clinical decisions for individual patients⁶⁹. Despite this push toward evidence-based care, in the United States of America, Shuster et al¹⁰⁷ found 20% to 25% of patients receive physiotherapy treatment that is not required or potentially harmful; and 30% to 40% of patients receive treatment that is evidence based.

The implementation of specialised educational concussion tools have been shown to facilitate change in concussion knowledge and attitudes among athletes and coaches¹⁰⁸. In a survey of physiotherapists in America, Cross et al⁶⁹ found those that completed a certificate to make them eligible for the sports specialist exam make better decisions related to various acute medical conditions. Therefore it was suggested that those physiotherapists assisting at sport events should attend additional training or continuing education programmes in order to facilitate the integration of best evidence with clinical experience⁶⁹.

2.6.4. Summary of literature: Prevention of concussion

The current trend in the literature on concussion identifies the need to promote preventative measures to reduce the incidence of concussion in sport^{15,22}. The use of protective equipment, such as helmets and mouthguards, has not been found to have a significant effect on the prevention of concussion injuries⁶³. Advances in the education and training of sport medical professionals, including physiotherapists, are therefore regarded as essential to improve the standard of care in concussion management³⁴.

Educational programmes may improve the ability of key role players in sport such as the coach or physiotherapist, to identify and manage a concussed player, thereby ensuring player safety^{34,72}. Studies emphasise the central role of physiotherapists in reducing the incidence of concussion injuries⁵⁵. The physiotherapist may also be instrumental in disseminating information regarding all aspects of concussion to athletes and other role players in sport, ensuring the early diagnosis, and the safe return of athletes to sport⁶⁹.

2.7. Summary of literature: Diagnosis, management and prevention of concussion

This review of literature has emphasised the high incidence of concussion in sport, as well as the substantial underreporting of concussion injuries in all levels of athletic participation^{55,71}. Based on estimates, almost 2.1 million adolescents that participate in soccer worldwide will sustain a concussion, of which over half will go unreported and untreated⁸³. Concussion often remains a silent injury as there are no biological markers for its detection^{16,41}.

Diagnosis of concussion is one of the greatest challenges faced by clinicians and relies largely on athletes' self-report of symptoms^{12,41,55,92}. The potential consequences of premature return to sport by a concussed athlete amplify the concerns regarding unreported concussion⁴¹. Physiotherapists are often first line practitioners required to make an informed decision under difficult conditions. A physiotherapist's knowledge of concussion should allow the physiotherapist to make an efficient and timely diagnosis⁸⁵. However, Genuardi and King⁸³ concluded that there is a lack of knowledge regarding the effects and management of concussion in the general medical community. Similarly, studies by Sullivan et al³⁴, Guskiewicz et al⁴⁶ and Guiltmette et al⁷² have identified the need to strengthen current concussion concepts and link these to clinical practice.

The general lack of consensus regarding the diagnostic criteria for concussion has been associated with increased interest and research in this field^{24,100}. Bridging the gap between research and clinical practice is vital to reduce the incidence and severity of sports related concussion⁵⁰. Although it is recognised that physiotherapists have an important role in the diagnosis and management of concussion⁶⁹, there is a lack of evidence regarding physiotherapists' knowledge of concussion injuries. Accordingly, the aim of this study was to determine South African physiotherapists' knowledge of diagnosis, management and prevention of concussion.

CHAPTER THREE: SOUTH AFRICAN PHYSIOTHERAPISTS' KNOWLEDGE OF THE PREVENTION, DIAGNOSIS AND MANAGEMENT OF SPORTS-RELATED CONCUSSION

3.1. Introduction

The high incidence and complexity of concussion injuries has led to growing attention being given to sports-related concussion^{15,17,41}. Progress towards understanding this health concern has resulted in the development and continual revision of the concussion consensus statement to reach a global understanding of concussion injuries^{2,15,46}. The consensus statement surrounding sports-related concussion focuses on the understanding, diagnosis and management of a concussed athlete. The key issues of concussion evolve as the body of literature grows. The current trend focuses on the early identification of concussion, promoting an individualised approach to managing a concussed athlete³¹. The prevention of the sequelae of concussion remains of utmost importance^{8,15,17,41}.

Much of the world's rugby is played in situations in which medical personnel are not present⁴⁷. Marshall and Spencer⁴⁷ discussed that the medical personnel available at rugby are often not well trained in identifying and managing concussion. As discussed in the literature review, the physiotherapist plays an important role in ensuring the safety of athletes' particularly in the prevention, diagnosis and management of concussion injuries⁶⁴. In many cases the physiotherapist is the first person in contact with the injured athlete^{39,41,55,64}. The American Physical Therapy Association (APTA) called for physiotherapists to form a part of the multi-disciplinary team that diagnose concussion. To this end, the National Football League (NFL) has enforced that each of the 32 teams in the league have a physical therapist on their staff. In addition to concussion diagnosis, physical therapists play an integral role in the management and prevention of concussion injuries¹¹¹.

In South Africa, doctors and emergency personnel are not always present at practices and matches. The physiotherapist is often responsible for field-side care as the sole “medical officer”²⁴. In this role, the physiotherapist may be required to deliver emergency care, including managing head injuries, such as concussion. Physiotherapists’ knowledge and prioritisation of clinical information is essential to the efficient diagnosis and management of concussion³². However, there is a lack of evidence regarding physiotherapists’ current levels of knowledge of concussion. Accordingly the purpose of this study was to determine South African physiotherapist’s knowledge of the prevention, diagnosis and management of concussion as stated in Section 1.2 (page 2).

3.2. Methodology

3.2.1. Study design

This study had a descriptive, cross-sectional, quantitative, correlational design.

3.2.2. Participants

The study was approved by the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town (HREC REF:325/11) (Appendix I). Physiotherapists registered with the Orthopaedic Manipulative Physiotherapists Group (OMPTG) and/or the Sports Physiotherapy Group (SPG) of the South African Society of Physiotherapy (SASP) at the time the study was conducted were included in the sample. Physiotherapists of these groups were included because of their special interest in assessing and treating sports injuries. All physiotherapists were required to be registered with the Health Professions Council of South Africa (HPCSA).

Participants were excluded from the study if they did not provide consent on the SurveyMonkey® online questionnaire. These participants were not able to access the questionnaire, and automatically exited the online site. Those participants that completed only the demographic information of the concussion questionnaire were also regarded as incomplete and excluded from the study.

3.2.3. Recruitment

A contact list of all the members of the OMPTG (n=1339) and the SPG (n=639) was verified by the head office of the SASP. Four hundred and sixteen physiotherapists were members of both the SPG and OMPTG groups. Therefore 1562 physiotherapists were requested to volunteer for the study. The head office of the South African Society of Physiotherapy (SASP) was requested to inform all members of the OMPTG and the SPG of the study. The contact details of members were regarded as private and therefore no direct access to potential participants was possible. All information regarding the purpose of the study, including a link to the online questionnaire was distributed by the SASP head office via bulk electronic mail to all potential participants. In addition, the study was also advertised in Durban, where the principal investigator works as a physiotherapist, in an attempt to improve the response rate to the survey. Hard copies of the informed consent form and the questionnaire were hand-delivered to physiotherapists in Durban area.

3.2.4. Sample size calculation

In the absence of more definitive data regarding physiotherapists' knowledge of the diagnosis and management of concussion, the prevalence of concussion injuries were used to calculate the required sample size for this study. This was used as a proxy to ensure that the sample included participants that have been exposed to diagnosing or managing concussion. An expected frequency of concussion of 40% was selected based on previous studies, which report the incidence of concussion injuries between 20% and 55%^{65,68,71,112}. If the worst expected frequency was 35%, with 95% confidence intervals, the required sample size was 230. Previous questionnaire-based studies have reported response rates of 35% to 55%^{39,72,113,114}. Therefore 920 participants were recruited for this study, to ensure sufficient statistical power based on an estimated response rate of 25%.

3.3. Procedure

Once ethical approval was granted from the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee (Appendix I), the questionnaire was validated, and a feasibility study was completed.

Bulk electronic mail was sent to physiotherapists with a covering letter informing them of the nature of the study (Appendix II) and a direct link to the SurveyMonkey® online concussion questionnaire. The participants were required to give informed consent before accessing the SurveyMonkey® questionnaire by indicating that they had understood the information sheet and were willing to complete the questionnaire (Appendix III). If participants did not indicate consent, they were not able to proceed, and automatically exited the online questionnaire. Participants were also required to provide their email address on completion of the questionnaire to ensure that the information booklet could be forwarded to them (Appendix VI). However, this was separate from the rest of the questionnaire to ensure that participants' questionnaire responses remained anonymous. All completed questionnaires were allocated a code ensuring anonymity. Follow up emails were sent to all participants every fortnight over a period of five months reminding them of the study and encouraging them to complete and return their questionnaire to achieve the highest response rate possible. On completion of the questionnaire, participants were sent the questionnaire with the correct answers (Appendix V), an information booklet about concussion as well as the SCAT2 pocket tool to assist them with on-field identification of concussion (Appendix VI).

3.3.1. Concussion questionnaire

A questionnaire was designed to assess the participants' knowledge of the prevention, diagnosis and management of concussion (Appendix III). The questionnaire was comprised of seven sections, and determined: demographic information; clinical experience; educational background; physiotherapists' knowledge of the diagnosis, management and consequences of concussion; and physiotherapists' knowledge of return to play decisions.

The questionnaire was only available in English as majority of universities in South Africa teach in the English medium and due to the professional nature of the sample. The questionnaire was made available online using SurveyMonkey® (www.surveymonkey.com).

3.3.1.1. Validity of the concussion questionnaire

The questionnaire was reviewed by a panel of experts on sports-related concussion to ensure content and construct validity. The panel, consisting of a neurosurgeon, two sports doctors and a sports physiotherapist, were contacted requesting their voluntary assistance in validating the questionnaire. The validators were not considered to be study participants. Validators were requested to comment on the relevance and importance of questions; the clarity and ease of understanding of questions; and the correct answers for the concussion knowledge sections of the questionnaire (Appendix V). In addition the validators were able to suggest additional questions that could be included in the questionnaire (Appendix III).

All experts from the validation panel returned the questionnaires. The majority of feedback was related to language simplification of some questions, and appropriate adjustments were made to the questionnaire. There was agreement that two questions regarding the sequelae of concussion were ambiguous and potentially confusing. Consequently questions 38 and 39 were combined and re-worded in the questionnaire (Appendix III). One further question regarding the International Rugby Board (IRB) rules regarding the final decision regarding an athlete's participation after sustaining a concussion was deemed as vague and the validators felt it had no real value in assessing knowledge of concussion. It was subsequently deleted from the questionnaire. The panel of experts all indicated that the questionnaire was thorough and covered all components of concussion knowledge appropriate to physiotherapists.

3.3.1.2. Feasibility of the concussion questionnaire

A feasibility study was conducted after validation had been completed, and before data collection for the main study. The feasibility of the questionnaire was determined by using a sample group that consisted of five physiotherapists. The participants were able to provide comments and feedback on each question as well as on the overall questionnaire. Participants were also requested to provide feedback on the ease of completion of the questionnaire. The questionnaires and completed informed consent forms were returned electronically indicating that the participants understood the study procedure.

No changes were made to the questionnaire following the feasibility study. The feasibility study questionnaires were not included in the final data analysis.

3.3.2. Data analysis

3.3.2.1. Adequate concussion knowledge

Responses to the questionnaire were scored as either correct or incorrect with one mark allocated for each correct answer. Percentages were calculated for each subsection and for the total questionnaire. Scores for incomplete questionnaires were calculated as a total score of the questions answered. As one of the objectives of the study was to determine whether physiotherapists had adequate knowledge of concussion, an adequate concussion knowledge score was calculated. The panel of experts was requested to identify specific questions from the questionnaire that comprised “adequate concussion knowledge” (Table 3.1). Responses to these specific questions were then used to calculate percentage scores to establish adequate or inadequate concussion knowledge. A concussion knowledge score of greater than or equal to 75% for these specific questions was selected to represent an adequate level of concussion knowledge. This score is regarded as a first class pass at the University of Cape Town. In addition, the Resuscitation Council (UK) uses 75% as a standard pass mark for examination in the Advanced Life Support (ALS) Course (ALS Provider Course Regulations, 2011)¹¹⁵. Therefore 75% was regarded as a minimum required score for adequate concussion knowledge (a minimum score of 27) (Table 3.1).

Table 3.1: Selected questions and scoring for the calculation of adequate concussion knowledge scores

Questions	Answer options and scores					Score
Section B : 9. Wearing protective gear such as soft-shelled headgear can reduce the risk of concussion.	Strongly agree	Agree	Do not know	Disagree[1]	Strongly disagree[1]	1
Section C 1. Concussion only occurs following a direct blow to the head	Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree[1]	1
2. Acceleration – deceleration forces may cause concussion.	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
3. Loss of consciousness of any duration is the main diagnostic criteria for concussion.	Strongly agree	Agree	Do not know	Disagree[1]	Strongly disagree[1]	1
4. Concussion may also be termed “mild traumatic brain injury”.	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
5. From the list below select any 6 symptoms which may be indicative of concussion.	Any 6 of those below: <input type="radio"/> Nausea <input type="radio"/> Headache <input type="radio"/> Feeling ‘foggy’ <input type="radio"/> Paraesthesia (tingling) <input type="radio"/> Drowsiness <input type="radio"/> Sensitivity to light <input type="radio"/> Aggressiveness <input type="radio"/> Loss of consciousness <input type="radio"/> Dizziness <input type="radio"/> Poor balance <input type="radio"/> Confusion <input type="radio"/> ‘Just not feeling right’ <input type="radio"/> Blurred vision <input type="radio"/> Ringing in the ears <input type="radio"/> Vomiting <input type="radio"/> Vacant, glassy eyes					6
6. Neuro-imaging studies (MRI, CT scan, X-ray) may be normal after a first concussion	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
7. Routine questioning of person, time and place is a reliable test for side of the field assessment of concussion.	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
8. A Sports Concussion Assessment Tool card (SCAT/SCAT2 card) should be used to assist rapid side of the field assessment of concussion.	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
9. Balance Tests may be used to assist rapid side of the field assessment of concussion.	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
10. Neuro-psychological testing alone may be used for sideline diagnosis of concussion.	Strongly agree	Agree	Do not know	Disagree[1]	Strongly disagree[1]	1
Section D: 1. Choose the most likely consequence for an adult player who suffers from more than one concussion in a season	<input type="radio"/> No serious consequence <input type="radio"/> Post concussion syndrome <input type="radio"/> Loss of consciousness <input type="radio"/> Second impact syndrome <input type="radio"/> Death					1
2. 2 nd Impact Syndrome is most likely to occur when:	<input type="radio"/> A 2 nd concussion is sustained in the same match <input type="radio"/> A 2 nd concussion is sustained in the same season <input type="radio"/> A 2 nd concussion is sustained in a career <input type="radio"/> A 2 nd concussion is sustained whilst the 1st concussion has not yet resolved [1] <input type="radio"/> All of the above					1
3. Choose the most likely consequence of Second Impact Syndrome	<input type="radio"/> No serious consequence <input type="radio"/> Post concussion syndrome <input type="radio"/> Loss of consciousness <input type="radio"/> Death <input type="radio"/> Severe neurological dysfunction [1]					1
4. The most common sequelae to repeated concussions that may present later in life is:	<input type="radio"/> Neurological deficit <input type="radio"/> Post Concussion Syndrome [1] <input type="radio"/> Second impact syndrome <input type="radio"/> All of the above <input type="radio"/> None of the above					1

Section E:						
1. If a player is suspected of having sustained a concussion he must leave the field of play immediately.	Strongly agree[1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
2. Only a player with a severe concussion needs to leave the field immediately.	Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree[1]	1
3. If a player left the field for concussion but 'he/she is fine' within some minutes he/she may safely return to the field of play.	Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree[1]	1
4. Any player with a suspected concussion should consult a medical doctor as soon as possible.	Strongly agree [1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
5. A child or adolescent (under the age of 18) is more susceptible to concussion than an adult.	Strongly agree [1]	Agree [1]	Do not know	Disagree	Strongly disagree	1
6. The recovery time for a concussed child or adolescent is often longer than that for an adult.	Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree[1]	1
7. The recommended treatment for concussion is:	Physical and Cognitive rest [1]					1
Section F:						
1. Are you familiar with the Stepwise Return to Play Protocol following a concussion?	Yes [1]No[0]					1
3. 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 [1]	Strongly disagree[1]	1
5. A player has to be examined by a medical doctor and be symptom free, at rest and with exercise, before returning to play.	Strongly agree [1]	Agree[1]	Do not know	Disagree	Strongly disagree	1
6. When a player returns to play following a concussion he/she can immediately resume full contact practice with his/her team.	Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree[1]	1
7. When a player returns to play after a concussion and develops a headache, the only management of choice would be analgesics.	Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree[1]	1
9. If you were to use a Stepwise Return to Play – 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)	1. No activity, complete physical and cognitive rest 2. Walking, stationary bicycle, swimming 3. Jogging, light running 4. Running and agility drills, no impact activities 5. Drills incorporating running and passing, co-ordination activities 6. Resistance training (eg: lifting weights at the gym) 7. Tackle bags and contact allowed at full practice (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)					4
	Total					36

3.3.3.2. Continued education score

A continued education score (CES) was calculated from a question within the physiotherapist education section of the questionnaire to determine the level of continuing education among physiotherapists. 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 10 points (Table 3.2).

Table 3. 2: Calculation of continued education scores (CES)

Question	Answer options and scores	Max score
The majority of my knowledge about concussion was learned through:	Internet [1] Library [1] Undergraduate studies [1] Postgraduate studies [1] Media: TV [1] Courses/Workshops [1] Media: Print [1] Fellow physiotherapists [1] Media: DVD [1] Other medical professionals[1]	10

3.3.3. Statistical analyses

Statistical analyses were performed using Statistical software [StatSoft, Inc. (2011) STATISTICA (Data analysis software system), (version 10. www.statsoft.com)]. Chi-square measures of association and percentages were used for descriptive information. 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 study¹¹⁶. Independent t tests were performed to compare differences within groups. Kruskal-Wallis tests were used to determine differences between groups for questionnaire data, for example the duration of qualification, participants' involvement at different levels of competition in sport, the type of sport involved in and highest level postgraduate education on concussion knowledge. Statistical significance was accepted as $p < 0.05$.

3.3.4. Ethical considerations

The study was performed in accordance with the principles of the Declaration of Helsinki (Seoul version, 2008). The research proposal was submitted to the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town. The participants received an information letter (Appendix II) that explained the purpose and significance of the research study. Participants were informed about the nature of the questionnaire and all the risks and benefits of the study. The information sheet provided the participant with an option to choose if they were willing to participate in the study. This was taken as informed consent. If participants did not indicate consent, they were not able to proceed (Appendix III), and automatically exited the online questionnaire. In addition, confidentiality and anonymity were maintained throughout the study, through the secure, password-protected storage of data; the coding of completed questionnaires; and the separation of participants' email addresses from the responses to the questionnaire.

3.3.4.1. Risk to participants

There were no risks to any participant, as no physical tests were performed. There were also no psychosocial risks associated with completing the questionnaire.

3.3.4.2. Benefits to participants

All participants that provided an email address on completion of the survey were provided with information pamphlets on concussion, including a SCAT2 pocket tool to assist with on-field identification and assessment of concussion.

3.4. Results

Responses were received from 258 physiotherapists, yielding a response rate of 16.5%. However, two respondents did not provide informed consent; seven respondents gave informed consent but did not complete any part of the questionnaire; and 36 respondents only completed the demographic section of the questionnaire resulting in 45 respondents being excluded from the study. Therefore 213 questionnaires were used for data analysis. Thirty nine percent of respondents in this study were members of the OMTPG; with the remaining 28.1% and 32.9% being members of SPG and both, OMTPG and SPG, respectively. The response rate is summarised in Figure 3.1.

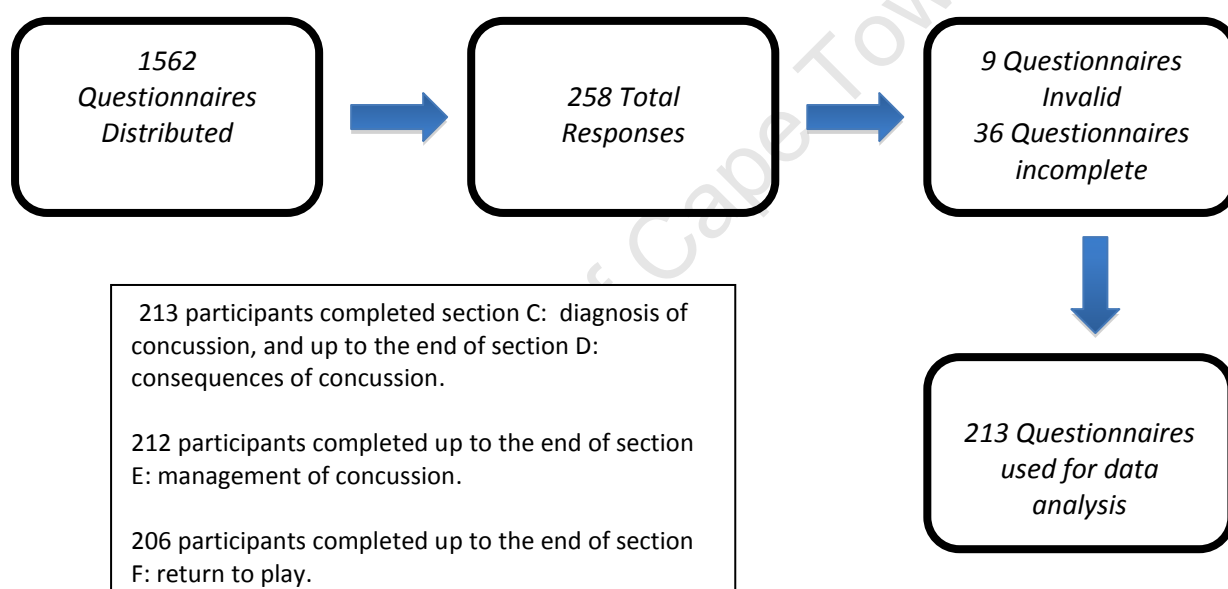


Figure 3.1: Summary of response rate

3.4.1. Socio-demographic characteristics

The majority of participants were female (81%). All nine South African provinces were represented in this study, with the greatest number of physiotherapists participating from the KwaZulu-Natal (38%) and Gauteng (27.2%) provinces. The socio-demographic characteristics are presented in Table 3.3.

Table 3.3: Socio-demographic characteristics of the sample (n=213)

	Frequency n (%)	Mean ± SD (Range)
Age (years)		
Female		34.0 ± 8.9 (24-60)
Male		30.6 ± 5.4 (23-51)
Gender		
Female	173 (81.2)	
Male	40 (18.8)	
Province		
Kwa Zulu Natal	81 (38)	
Gauteng	58 (27.2)	
Western Cape	51 (23.9)	
Free State	7 (3.3)	
Limpopo	7 (3.3)	
Northern Cape	3 (1.4)	
North West	2 (0.9)	
Eastern Cape	2 (0.9)	
Mpumalanga	2 (0.9)	

3.4.2. Academic experience

Fifty percent of the sample had completed postgraduate studies. A wide variety of postgraduate qualifications were represented in the sample, with participants having completed continuing education courses (38%); postgraduate diplomas (3.3%); Masters (12.7%) and PhD (1.4%) degrees (Table 3.4). All professional postgraduate courses such as the Orthopaedic Manipulative Therapy (OMT1) and Sport Physiotherapy Courses (SPT1) were classified as continuing education courses. Seventy four percent of the sample had completed a first aid qualification; however only 47.4% of the sample had a valid qualification, having completed the first aid course within the last two years (Table 3.4). Thirty six percent of the first aid qualifications completed were for Level 1 or Basic Life Support; and 32.8% had a valid level two qualification or higher (Table 3.4). The highest continued education score attained was seven points out of a maximum of 10. This score was achieved by 1.9% of the sample (Table 3.4)

Table 3.4: Academic experience of the sample (n=213)

	Frequency (n)	Percentage (%)
Completed postgraduate studies		
Yes	107	50.2
No	106	49.8
Highest level of postgraduate qualifications[✦]		
Continuing education course	81	38
Masters	27	12.7
Postgraduate diplomas	7	3.3
PhD	3	1.4
Missing responses	95	44.6
Competed a first aid qualification		
Yes	159	74.6
No	54	25.4
Completion of first aid course		
Within 2 years	101	47.4
More than 2 years ago	53	24.9
Missing responses	59	27.7
Level of first aid qualification		
Basic Life Support/Level 1	77	36.2
Level 2 and above	70	32.8
Missing responses	66	31
Continued Education score		
1	63	29.6
2	52	24.4
3	39	18.3
4	35	16.4
5	10	4.7
6	5	2.4
7	4	1.9
Missing responses	5	2.3

[✦]Note: Participants were able to select more than one postgraduate qualification

3.4.3. Clinical experience

Thirty three percent of the sample had been in practice for one to five years (Table 3.5). The majority of the sample had been involved in private practice³ only (92.5%). Only 70% of the total sample responded to the section asking for information on their current clinical experience. In the sample, 51.2% of participants worked in a sports physiotherapy practice setting and were classified as having off-field physiotherapy management experience. The on-field physiotherapy management group comprised of those participants that worked with a sports team and at a sports physiotherapy practice (13.7%); or were involved with a sports teams only (5.2%). Participants were asked to respond to their confidence in dealing with a concussed athlete. Fifty nine percent of participants responded that they did not feel confident when dealing with a concussed athlete (Table 3.5).

³ Physiotherapists concerned specifically with the profession of physiotherapy in the private sector

Table 3.5: Clinical experience of the sample (n=213)

	Frequency (n)	Percentage (%)
Clinical experience		
1 to 5 years	70	32.9
6 to 10 years	67	31.5
11 to 15 years	29	13.6
> 15 years	47	22.1
Community service⁴		
No	210	98.6
Yes	3	1.4
Setting of practice		
Private practice	197	92.5
Public health sector	6	2.8
Private practice/public health sector	4	1.9
University lecturer	3	1.4
Private practice/school	1	0.5
Private practice/university lecturer	1	0.5
School	1	0.5
Confidence handling concussion		
Yes	88	41.3
No	125	58.7
On/off-field management experience		
Off-field management	109	51.2
On-field management	40	18.8
Missing Responses	64	30

Ninety six percent of physiotherapists in this study sample had experience in treating athletes. The majority of the sample (25.4%) were involved at club level of sport, with other levels of involvement being at school (13.6%), provincial (11.3%) and national (5.6%) levels. Sporting codes were widely represented, with most physiotherapists in the sample being involved in a variety of contact and non-contact sports (Table 3.6).

⁴ Physiotherapy service in the public health infrastructure of South Africa

Table 3.6: Sports physiotherapy experience of the sample (n=213)

	Frequency (n)	Percentage (%)
Experience in sports physiotherapy		
First year	1	0.5
2 years and less	41	19.2
3 to 5 years	54	25.4
6 to 9 years	31	14.6
10 years and more	45	21.1
Missing responses	41	19.2
Current level of involvement in sports physiotherapy		
Schools	29	13.6
Club	54	25.4
Provincial	24	11.3
National	12	5.6
Missing responses	94	44.1
Clinical experience treating athletes/sports injuries		
All patients are athletes	4	1.9
More than 75%	15	7.0
Between 50% and 75%	31	14.6
Between 25% and 50%	92	43.2
Less than 25%	69	32.4
None	2	0.9
Involvement in contact or non-contact sports		
None	69	32.5
Contact sports	62	29.1
Non-contact sports	13	6.1
Contact and non-contact sports	67	31.5
Missing responses	2	0.8
Conducting pre-participation screening of athletes		
No	106	49.8
Yes	45	21.1
Not applicable	62	29.1

Physiotherapists are often a part of a multi-disciplinary team that may include a medical doctor, neurologist, biokineticist⁵, fitness trainer; and other professionals in clinical practice and/or at training and competition. The results showed that 15.9% of physiotherapists had the clinical experience of treating athletes as part of a multi-disciplinary team. Thirty four percent of the sample reported that there were other healthcare practitioners at competitions and/or practice, while 33.8% of respondents reported that they were the only medical personnel at sporting competitions and training sessions (Table 3.7).

Table 3.7: On-field physiotherapists' experiences and responsibilities (n=213)

	Frequency (n)	Percentage (%)
Specified medical team working with the physiotherapist		
No	77	36.2
Yes	34	15.9
Missing responses	102	47.9
Physiotherapist as the only medical personnel at sporting competition and/or training		
No, Never	74	34.7
Yes, less than 50% of the time	40	18.8
Yes, 50% to 80% of the time	16	7.5
Yes, more than 80% of the time	16	7.5
Not applicable	1	0.5
Missing responses	66	31
Attendance of other medical personnel		
At matches only	17	8.0
Both, matches and practice sessions	12	5.6
Contacted only when required	11	5.2
Missing responses	173	81.2

⁵ A Biokineticist treats people with a variety of sport and orthopaedic injuries through the modality of exercise therapy which is based on scientific based on evidence and personalised exercise prescription

3.4.4. Concussion knowledge scores

The maximum possible score of the concussion knowledge questionnaire was 41. The overall concussion knowledge mean score was 26.8 ± 4.8 ($65.4\% \pm 11.7\%$). The concussion knowledge score comprised four sections: “Diagnosis”, “Consequences”, “Management”, and “Return to play”. Participants obtained the highest mean score for the ‘diagnosis’ section of the survey ($76.2\% \pm 11.8\%$); and the lowest mean score for the ‘consequences’ section ($39.3\% \pm 22.3\%$) (Table 3.8).

Table 3.8: Total concussion knowledge sub-section scores (n=213)

Concussion questionnaire sub-section	Mean scores of concussion knowledge sub-sections
	Mean \pm SD
Diagnosis score	$76.2\% \pm 13.8\%$
Consequences score	$39.3\% \pm 22.3\%$
Management score	$71.7\% \pm 14.5\%$
Return to play score	$57.2\% \pm 19.9\%$

There were no significant differences in the total concussion knowledge scores when analysed by gender ($65.6\% \pm 12.8\%$ vs. $66.2\% \pm 11\%$; $t=-0.3$, $p=0.8$). There were no significant differences in the total concussion knowledge scores when analysed by duration of physiotherapy qualification ($H=6.2$, $p=0.1$). In those participants that had completed postgraduate studies, there were no significant differences on the concussion knowledge scores when analysed by the completion of postgraduate studies ($67.4\% \pm 11.7\%$ vs. $64.8\% \pm 10.8\%$; $t=1.7$, $p=0.09$). There were also no differences in concussion knowledge scores when analysed by the highest level of postgraduate education completed ($H=2.2$, $p=0.5$). There were no significant differences between concussion knowledge scores when analysed by continued education scores (CES) (2.7 ± 1.8 vs. 2.5 ± 1.4 ; $t=0.8$, $p=0.4$).

There were no significant differences in concussion knowledge scores in the sample between those physiotherapists that had completed a first aid course and physiotherapists that had not completed a first aid course ($65.2\% \pm 11.2\%$ vs. $64\% \pm 12.7\%$; $t=0.6$, $p=0.5$).

There were also no significant differences in concussion knowledge scores in participants with current (completed within the last two years) first aid qualifications, compared to participants with outdated (completed more than two years ago) first aid qualifications ($66\% \pm 10.3\%$ vs. $68.3\% \pm 10.8\%$; $t = -1.3$; $p = 0.2$). No significant differences in concussion knowledge were found when analysed according to participants' involvement at different levels of competition in sport ($H = 0.4$; $p = 0.9$); and the type of sport involved in ($H = 1.5$, $p = 0.5$).

Significant differences were found between those physiotherapists that felt confident in dealing with concussion compared to those that did not feel confident in dealing with concussion in the sections on the consequences of concussion ($43.5\% \pm 23.8\%$ vs. $36.4\% \pm 20.7\%$; $t = 2.3$, $p = 0.02$); and management of concussion ($74.2\% \pm 13.8\%$ vs. $69.9\% \pm 14.8\%$; $t = 2.1$, $p = 0.03$) (Figure 3.3). However, there were no significant differences in the scores for the total scores, diagnosis of concussion and return to play sections between those physiotherapists that felt confident in dealing with concussion and those that did not feel confident in dealing with concussion.

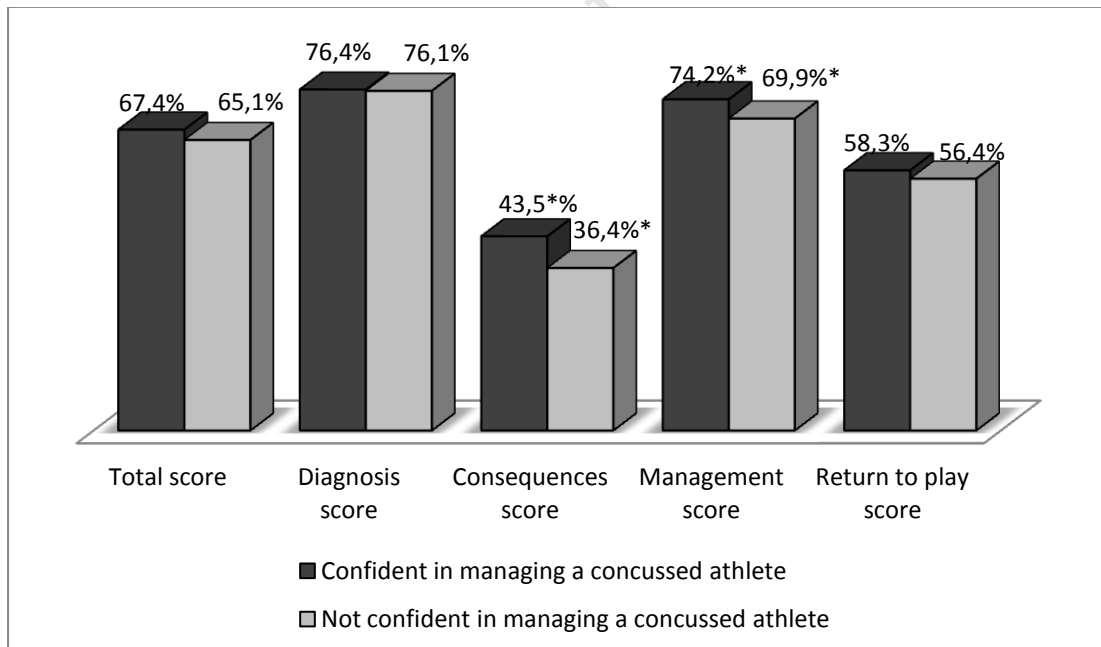


Figure 3.2: Concussion knowledge sub-section scores in physiotherapists that were confident in managing a concussed athlete and physiotherapists that were not confident in managing a concussed athlete (n=213)

*significant difference between groups ($p < 0.05$)

3.4.5. Adequate and inadequate concussion knowledge

As discussed in Section 3.3.2, the concussion experts used for this study selected concussion knowledge questions to establish whether participants had adequate levels of concussion knowledge. Similar to findings in the total concussion knowledge scores, participants obtained the highest mean score for the “diagnosis” section of the survey (76.2% ± 11.8); and the lowest mean score for the “consequences” section (39.3% ± 22.3) (Table 3.9).

Table 3.9: Concussion knowledge sub-sections scores (n=213)

Concussion questionnaire sub-section	Mean scores of concussion knowledge subsections
	Mean ± SD
Diagnosis score	76.2% ± 13.8%
Consequences score	39.3% ± 22.3%
Management score	65.6% ± 16.6%
Return to play score	58.5% ± 21.8%

Participants were categorised as either having “Adequate Concussion Knowledge” if they scored greater than or equal to 75% or “Inadequate Concussion Knowledge” if they scored less than 75% for the questions specified in Table 3.1. Forty-four participants (20,7%) had adequate concussion knowledge. The participants’ knowledge in the four sub-sections of the concussion knowledge were categorised as either adequate or inadequate. Figure 3.4 illustrates the distribution of participants’ with adequate concussion knowledge in the various subsections. Seven participants did not complete the return to play section of the questionnaire.

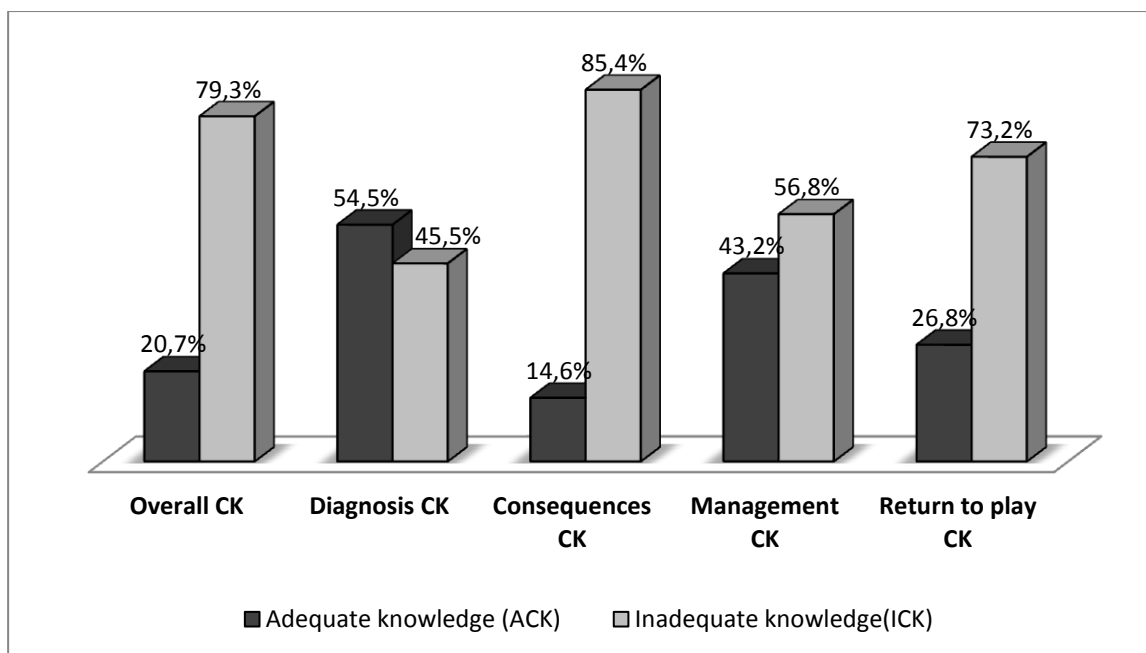


Figure 3.3: Adequate and inadequate concussion knowledge scores for the different sections of the concussion knowledge questionnaire (n=213)

3.4.6. Factors associated with adequate concussion knowledge

3.4.6.1. Socio-demographic characteristics

There were no significant differences in the age of physiotherapists obtaining adequate concussion knowledge scores and those obtaining inadequate concussion knowledge scores (34.1 ± 8.9 vs. 33.2 ± 8.3 ; $t=0.6$, $p=0.5$). There were no significant differences in gender between physiotherapists with adequate and inadequate knowledge ($\chi^2=0.1$; $p=0.7$).

3.4.6.2 Academic experience

Only 12.7% of physiotherapists that had completed postgraduate studies were classified as having adequate concussion knowledge. There were no significant differences in highest level of postgraduate education completed ($\chi^2=6.9$; $p=0.7$) between those with adequate concussion knowledge and those with inadequate concussion knowledge (Table 3.10). There were no significant differences in duration of physiotherapy qualification between those with adequate and inadequate knowledge ($\chi^2=1.64$; $p=0.65$).

Table 3.10: Associations between postgraduate education and adequate/inadequate concussion knowledge (n=118)

Highest level of postgraduate education	Adequate concussion knowledge n (%)	Inadequate concussion knowledge n (%)
Continued education	22 (78.6)	59 (65.6)
Postgraduate diploma	0	7 (7.8)
Masters	4 (14.3)	23 (25.6)
PhD	2 (7.1)	1 (1.1)

In this study, 25.4% of the physiotherapists had never completed a first aid course, 47.4% had an active first aid qualification (completed within the last two years). Table 3.11 shows the associations between first aid qualification and adequate and inadequate concussion knowledge. There were no significant differences in first aid qualifications between those with adequate concussion knowledge and inadequate concussion knowledge ($\chi^2=0.004$; $p=0.95$). There were also no significant differences in the validity of a first aid qualification between those with adequate and inadequate concussion knowledge ($\chi^2=0.004$; $p=0.95$).

Table 3.11: Associations between first aid qualification and adequate/inadequate concussion knowledge (n = 154)

First aid qualification	Adequate concussion knowledge n (%)	Inadequate concussion knowledge n (%)
Active first aid (completed within the last 2 years)	20 (62.5)	81 (66.4)
Inactive first aid (completed more than 2 years ago)	12 (37.5)	41 (33.6)

3.4.6.3. Clinical experience

There were no significant differences in the duration of physiotherapy experience ($\chi^2=1.6$; $p=0.7$); and the clinical setting in which the participants worked ($\chi^2=4.8$; $p=0.6$) between those participants with adequate concussion knowledge and inadequate concussion knowledge.

Forty one percent of the sample reported that they felt confident dealing with a concussed athlete (Table 3.12). There was no significant difference in reported confidence on managing a concussion between those with adequate or inadequate concussion knowledge ($\chi^2=0.4$; $p=0.5$)

Table 3.12: Associations between confidence in managing concussion and adequate/inadequate concussion knowledge (n=213)

Confident managing concussion	Adequate concussion knowledge n (%)	Inadequate concussion knowledge n (%)
Yes	20 (9.4)	68 (31.9)
No	24 (11.3)	101 (47.4)

There were no significant differences in on-field sports physiotherapy experience between those participants with adequate or inadequate concussion knowledge ($\chi^2=2.4$; $p=0.1$).

Table 3.13: Associations between on-field physiotherapy experience and adequate/inadequate concussion knowledge (n=149)

On-field management experience	Adequate concussion knowledge n (%)	Inadequate concussion knowledge n (%)
Yes	12 (37.5)	28 (23.9)
No	20 (62.5)	89 (76.1)

There were also no significant differences in adequate or inadequate concussion knowledge based on physiotherapist's involvement at different levels of competition ($\chi^2=1.3$; $p=0.7$); or the type of sport ($\chi^2=1.8$; $p=0.4$) (Table 3.14).

There were also no significant differences in adequate or inadequate concussion knowledge based on the performance of pre-participation evaluation of athletes ($\chi^2=0.9$; $p=0.4$).

Table 3.14: Associations between sports physiotherapy experience and adequate/inadequate concussion knowledge (n=213)

	Adequate concussion knowledge n (%)	Inadequate concussion knowledge n (%)
Setting of clinical practice		
Works at a sports practice	20 (62.5)	89 (76.1)
Sports team	2 (6.3)	9 (7.7)
Works at a sports practice and a sports team	10 (31.2)	19 (16.2)
Duration of sports physiotherapy experience		
This is my 1 st year	0	1 (0.7)
2 years and less	7 (20.6)	34 (24.6)
3 to 5 years	7 (20.6)	47 (34.1)
6 to 9 years	9 (26.5)	22 (15.9)
10 years and more	11 (32.4)	34 (24.6)
Level of Involvement		
National	4 (14.8)	8 (8.7)
Provincial	4 (14.8)	20 (21.7)
Club	12 (44.4)	42 (45.7)
School	7 (25.9)	22 (23.9)
Pre-participation screening of athletes		
Yes	12 (36.4)	33 (28.0)
No	21 (63.6)	85 (72.0)

3.4.7. Summary of results

In summary, 20.7% of physiotherapists in this study were classified as having adequate concussion knowledge (score $\geq 75\%$). The physiotherapists who responded to the survey obtained an overall mean score of $65.4\% \pm 11.7\%$. Those physiotherapists that felt confident dealing with concussion scored significantly higher in the consequences of concussion knowledge section ($43.5\% \pm 23.8\%$ vs $36.4\% \pm 20.7\%$); and management of concussion knowledge section ($68.5\% \pm 16.2\%$ vs $63.6\% \pm 16.4\%$) as compared to physiotherapists that did not feel not confident in dealing with concussion. No socio-demographic, academic or clinical experience factors were found to be associated with adequate or inadequate concussion knowledge scores.

3.5. Discussion

The watershed on sports-related concussion commenced in Vienna when experts in the field of concussion developed a consensus statement³. Recent developments in evidence-based research has significantly improved current knowledge and understanding of sports-related concussion^{8,9}. Since 2001, this consensus statement has been reviewed and revised to facilitate concussion education in clinicians. The early identification of concussion and appropriate management of a concussed athlete minimises the risk of serious sequelae and provides a safe sporting environment¹⁷. It has been recognised that the physiotherapist is frequently the only medical personnel at sporting events⁶⁹. Extensive research has previously been conducted to establish coaches' understanding and management of concussion injuries and the implementation and effectiveness of education programmes^{55,72}. However, only a single study by Sullivan et al³⁴ examining the identification of concussion by physiotherapists was found. The novel aspect of the present study was the investigation of South African physiotherapists' knowledge of concussion. The findings of this study will be discussed in more detail. The discussion follows the order of presentation of the results in Section 3.4; however the discussion will be focused on the main findings of this study that have been described above.

3.5.1. Study sample

There was a 16.5% response rate in the present study. In comparison to a previous physiotherapy concussion study by Sullivan et al³⁴ (n=21); this was a relatively large sample (n=213). Although this sample was short of the targeted 230 participants required for a 95% confidence level, 213 participants were sufficient for 90% power. This means that the results obtained are correct within a 10% margin of error. In addition, when compared to previous concussion studies amongst coaches by McLeod et al¹¹⁴ (n=156) and Guilmette et al⁷² (n=62), this study yielded a relatively large sample.

However, it should be noted that the sample of the present study was drawn from a population of physiotherapists who are members of special interest groups, which may have resulted in a sampling bias.

This sampling bias may have influenced the response rate of the study. Further, participation in this study may have been influenced by individuals' confidence in their understanding of concussion, possibly positively skewing the results. In addition, it should be noted that the results of this study are limited to the specific population and not generalised to all South African physiotherapists.

The majority of the sample in the present study had completed postgraduate studies, suggesting a well-qualified sample in terms of academic experience. The level of PG qualification within the population is unknown and it may be that only those physiotherapists that have completed PG studies felt confident enough to participate in this study contributing to a sampling bias.

Although the results of the present study cannot be generalized to the physiotherapy population of South Africa as a whole, the sample was more broadly representative of physiotherapists involved in sport than samples reported on in previous studies on concussion knowledge. Participants in the present study were involved in providing physiotherapy services at various levels of competition; including national, provincial, club and school level. Consequently, the sample in the current study is markedly different to the sample reported on by Sullivan et al³⁴ in which only physiotherapists involved mostly in rugby at the community level of competition were surveyed. In addition, participants in this sample were involved in various sporting codes, including non-contact and contact sports, compared to other studies that focused specifically on contact sports such as rugby⁶⁸, soccer⁵⁵ or hockey^{60,117}.

3.5.2. Concussion knowledge scores

This research study was the first known study to attempt to quantify adequate concussion knowledge amongst physiotherapists. Adequate concussion knowledge was classified as a minimum concussion knowledge score of 75%. Results of this study showed only 20.7% of participants had adequate concussion knowledge (Section 3.4.5, Page 60). This is concerning, particularly as physiotherapists are often the only health care professionals providing on-field medical support.

Inadequate concussion knowledge may negatively impact on the safe management of athletes with concussion, and may place athletes at risk of serious complications of concussion injuries. The inadequate concussion knowledge of the participants may be suggestive of a poor understanding of the seriousness of concussion. Previous studies have emphasized that undermining the seriousness of concussion leads to a lack of interest in concussion and poor knowledge⁴¹. Poor concussion knowledge may also be a reflection of the confusion in the literature and the lack of consensus surrounding concussion among health professionals¹⁵. The effect of the lack of consensus and confusion in the literature is supported by Covassin et al⁴⁰ who found that athletic trainers underused the Vienna concussion guidelines due to ineffective dissemination of the continually evolving concussion guidelines.

In the present study there were no significant differences in socio-demographic factors between those with adequate and inadequate concussion knowledge. These results could not be compared to the study of Sullivan et al³⁴ where the population was predominantly male. However, they did not analyse concussion knowledge by socio-demographic profile highlighting a lack of research investigating possible relationships between concussion knowledge and socio-demographic factors such as gender and age. The relationship between concussion knowledge and level of qualification and continuing education, number of years in physiotherapy practice, sports physiotherapy experience and current practice with a sports team, will now be discussed further.

3.5.2.1. Level of qualification and continuing education

In 2008, the Zurich concussion statement recognised that education of all role players in sport, including healthcare providers, is the mainstay for progress in the field of concussion². In this study there were no significant differences in the academic experience of the sample between those with adequate concussion knowledge and inadequate concussion knowledge (Section 3.4.5, Page 62). In addition, there were no relationships between level of postgraduate training and concussion knowledge. This result may be a reflection of either poor training in concussion or of participants not receiving any concussion specific training in the postgraduate courses completed.

Whether either of these possible contributing factors played a role in this sample cannot be determined as the content of postgraduate education was not explored. It is possible that the specific postgraduate education completed by the participants had not included concussion education in the curriculum.

In the present study, there were no significant differences in concussion knowledge when analysed by first aid qualification (Section 3.5.4, Page 59). Similarly, McLeod et al¹¹⁴ found that 45% of youth coaches with a first aid qualification or medical training showed no improved recognition of concussion. Further, it has also been reported that training in acute medical sports-related conditions does not result in a transfer or acquisition of concussion knowledge if concussion is not the focus of the training⁶⁹. A survey by Cross et al⁶⁹ found that those physiotherapists that complete courses pertinent to athletic injuries felt more confident in managing acute medical conditions generally. Sullivan³⁴ observed that although 81% of physiotherapists had completed a first aid qualification within the last three years, their recognition of concussion only improved after a specific concussion educational intervention. Similarly, McLeod et al¹¹⁴ found no significant relationship between coaches with first aid certification (34%) or medical training (11.5%) and their ability to diagnose of concussion. The findings of these previous studies may explain why no significant differences were found in concussion knowledge scores when analysed by first aid qualification in the present study. It would seem that general first aid or acute medical training is not sufficient to ensure adequate concussion knowledge. Rather, specific concussion education and training appears to be required. The role of concussion specific training is further supported by the results of a previous study which found that continuing education and increased attention to sports-related concussion had a significant impact on the assessment and management of concussion injuries by clinicians³⁹.

Marshall and Spencer⁴⁷ believed that an increase in the number of properly trained healthcare professionals would be a step towards improving the recognition and management of concussion injuries. To address the lack of suitable assessment and management of concussion the Accident Compensation Corporation (ACC) in New Zealand developed a concussion management education programme (CMEP).

This programme resulted in an increase in concussion awareness in coaches and managers involved in community rugby in New Zealand. Similarly, McLeod et al¹¹⁴ found that coaches' education in concussion predicted their ability to diagnose sports-related concussion. Programmes such as "Heads up: Concussion in high school" have shown a positive change in coaches attitudes, behaviors and skills related to concussion identification and management in the United States of America. Echlin¹¹⁷ found a positive trend following a concussion education intervention, Thinkfirst's "Smart hockey" programme, in junior hockey players in Canada. These studies further highlight the necessity for concussion-specific continuing education programmes. The widespread benefits of concussion-specific education programmes are also proposed to contribute to an increase in the reported incidence of concussion¹⁵. Guilmette et al⁷² found that the majority of high school football coaches' in New England reported a concussion educational tool such as "Heads up" moderately helpful in recognising concussion. Sullivan et al³⁴ found the identification of concussion improved with a concussion educational strategy.

In South Africa, the Boksmart programme²³, a concussion education programme, has only been implemented for the sport of rugby. While this would appear to be a good initiative, attendance is only compulsory for coaches and referees. The implementation of similar programmes in various other codes of sport and the participation of physiotherapists involved in these sports would appear to be indicated. Concussion specific education in the appropriate use of evidence-based approaches should result in clinicians ultimately improving patient outcomes¹¹⁸.

3.5.2.2. Sports physiotherapy experience and current practice

In the present study there were no significant differences in concussion knowledge scores when analysed by clinical experience. This could suggest that exposure to sport environment did not result in an acquisition of concussion knowledge. However, exposure to concussion injuries was not investigated in the participants.

The concussion knowledge of physiotherapists may differ depending on exposure at different levels of competition; and through exposure to different codes of sport. Sullivan et al³⁴ evaluated the number of concussions participants had been involved in assessing or treating. Exposure to a condition is recognized to stimulate self-directed learning in healthcare professionals¹¹⁹. Investigating the participants' experience with concussed athletes may have allowed for further understanding regarding knowledge acquisition and the role of exposure to sports-related concussion knowledge. It is possible that participants, although involved in sports physiotherapy, may not have been exposed to concussion injuries. Though many of the participants in the present study were involved in sport physiotherapy, there may have been participants that had never been responsible for assessing or managing a concussed athlete.

Cross et al⁶⁹ found that the duration of sports physiotherapy experience in providing acute sports physiotherapy; and the continuing education that allowed physiotherapists to be eligible to qualify as a sports physiotherapist were found to have a positive effect on the physiotherapists' ability to make appropriate decisions regards various acute medical conditions, including concussion⁶⁹. The role of South African physiotherapists as first line practitioners responsible for the diagnosis and management of concussion was not investigated in the present study. It may be that the recognition, assessment and management of concussion are regarded as being outside the scope of physiotherapy practice specific to this population.

The argument to support the importance of exposure to concussion as a stimulus for learning is further highlighted by the work of Broglio et al⁵⁵. They found a significant relationship between sports physiotherapy experience and the number of concussions diagnosed. Similarly, youth coaches, with less experience, were found to have more misconceptions regarding the symptoms and management of concussion when compared to high school coaches⁷².

Gianotti and Hume⁴ found that in New Zealand, sport medical experts involved at the professional level of sport had a good understanding of concussion; whereas at the community level of involvement there was little evidence of concussion management systems. Therefore, while the present study, found no significant differences in adequate concussion knowledge and inadequate concussion knowledge when analysed by clinical experience, exploration of participants' exposure to athletes with concussion injuries may have provided greater insight into factors that contribute to adequate concussion knowledge.

3.5.2.3. Confidence in dealing with concussion

A significant finding in the study was that those physiotherapists who felt confident in dealing with concussion scored significantly higher in two subsections of the concussion questionnaire (consequences of concussion; and management of diagnosis) (Section 3.4.4, Page 60). This may be a reflection of a sampling bias. Ilies and Davidson¹¹⁸ found that Australian physiotherapists with more positive attitudes, or more confidence in their knowledge were more likely to return surveys possibly skewing the results. Though many of the participants in the present study were involved in sport physiotherapy, there may have been participants that had never been responsible for assessing or managing a concussed athlete. Cross et al⁶⁹ also found physiotherapist who felt confident managing acute sport injuries had higher athletic injury knowledge scores when compared to physiotherapists that lacked confidence. In this study there is a cause for concern, as knowledge scores were still inadequate despite perceived levels of confidence. This highlights the need for regular assessment of proficiency in managing concussed athletes, and the importance of feedback regarding competency levels.

3.5.3. Concussion sub-section knowledge

The diagnosis of concussion section was the only one in which the majority of the participants had adequate knowledge. The CISG have developed a consensus paper in an effort to develop a standard definition of concussion to reduce the confusion surrounding concussion and improve the identification of concussion.

The guidelines have endorsed the use of uniform terminology in describing the signs and symptoms of concussion. In South Africa there has been extensive concussion research by the South African Rugby Union. The results of this research were included in the most recent Zurich consensus statement²⁴, and have been implemented in the Boksmart concussion education programme²³. Published literature regarding concussion incidence and education programmes may serve as a platform to disseminate information regarding the identification of concussion^{55,109}. It is possible that this work has contributed to improved knowledge in the diagnosis of concussion.

The participants performed particularly poorly in the sections on the management of concussion and return to play. The difference in performance on the diagnosis section and these two sections may be a reflection of the scope of practice of physiotherapists. As first line practitioners in South Africa it would be expected that these health professionals have the ability to recognize concussion and make a diagnosis. However, it is not in the scope of physiotherapy practice to manage the condition or to make decisions about readiness to return to play. Therefore poor performance in these sections may be a reflection of the need for specific knowledge relevant to the practice of the profession⁶⁹. Poor performance in the consequences and management of concussion sections may also be a reflection of disjointed literature on these topics. The concussion statements are based mostly on expert opinion rather than empirical evidence⁹. The Zurich concussion conference led to the abandonment of the previous Prague statement further confusing the literature. Genuardi and King⁸³ also found a lack of knowledge regarding the effects and management of concussion in a medical community managing young athletes with concussion.

After the diagnosis and management of concussion, return to play decisions are the next most important decisions to be made¹⁵. The significant controversy regarding the return to play of a concussed athlete to sport is evident in the literature. In the present study, several participants did not answer the return to play knowledge section, which may suggest a lack of confidence in their knowledge or a complete lack of knowledge in this section.

In addition, the majority of the participants were classified as having inadequate concussion knowledge in the return to play section. Presently there are no prognostic measures of concussion which contribute to the confusion surrounding the return of an athlete to sport participation²⁸. A survey of youth coaches revealed that 25% would allow athletes to return to play despite exhibiting symptoms of concussion⁵³. In addition, Schneider et al⁹⁴ found different levels of awareness of return to play guidelines in youth ice hockey athletes. Johnston et al²⁸ published soccer and hockey programmes incorporating a stepwise return to play that were sports-specific demonstrating that return to play guidelines may benefit from being sport specific.

3.5.4. Limitations

It is recognised that although the sample was large in comparison to other studies^{72,114}, a larger sample drawn from a broader population of physiotherapists would have allowed for better representation of physiotherapists' level of involvement, clinical and academic characteristics. A further limitation of the study was that the questionnaire was self-administered. A self-administered questionnaire must 'stand alone' without assistance in the interpretation and understanding of the content. Participants may execute the task from their perspective and may differ from what they were asked to do. Literature suggests that if a topic is not important to a respondent they will probably not participate in the study¹²⁰. In personal communication with participants who had not responded to the initial distribution of the questionnaire, participants had expressed their reluctance to complete the questionnaire due to their perception of not sufficiently understanding concussion or being directly involved in sport. The motivation of the individual who chooses to respond to the survey may differ from those who do not respond, thus biasing the estimates¹²⁰. In addition, respondents may be motivated to give answers that present themselves in a favorable light.

It is also not possible to control whether participants have gained assistance by referring to literature or colleagues when completing the questionnaire. The use of both electronic and paper versions of the questionnaire might have biased the study results. This may be related to the differences in completion times, with a longer completion time for participants in the experimental group. Other limiting factors such as computer literacy and internet accessibility to complete the online questionnaire also need to be taken into consideration. A problem highlighted by a participant was the abrupt exit of the online survey due to the disruption of his/her internet connection thereby rendering the response incomplete. This could possibly be a reason for some of the incomplete questionnaires with these incomplete responses being excluded from the sample.

A further limitation was that the questionnaire was only available in one of South Africa's 11 official languages, English. English is the most common medium of education for physiotherapy taught at South African universities (used by five of the eight universities). The common use of English within the profession and the simplification of the questionnaire based on the expert panel's feedback will have minimised the impact of this on the results. A further limitation was the lack of information obtained on whether the physiotherapist had attended concussion related workshops or had been exposed to assessing or managing an athlete with a concussion. This information would have been useful to determine whether concussion education programmes had an impact on physiotherapists' concussion knowledge.

3.5.5. Clinical implications

This study highlights the necessity for physiotherapists, as first line practitioners, to have sufficient concussion knowledge to recognize and report concussion. A more rigorous system of concussion injury reporting needs to be implemented to understand the role of the physiotherapist in concussion as well as more information regarding concussion.

As discussed in the literature, the underreporting of concussion is likely to be associated with mismanagement with the possibility of significant health implications. Accordingly, those physiotherapist involved in sport physiotherapy should attend courses specific to sport medicine with concussion specific training, to provide an environment to minimize the risk of injury and ensure the safe management of athletes. This study highlights the need to strengthen the link between current concussion research knowledge and clinical practice by physiotherapists.

University of Cape Town

CHAPTER FOUR: SUMMARY AND CONCLUSION

The high incidence of sport-related concussion is well documented in the literature⁴¹. The early recognition of concussion and appropriate management of a concussed athlete is vital to ensure the safety of an athlete. This prevents potential long-term sequelae of concussion, possible life-threatening consequences and provides a safer playing environment for all athletes at all levels of competition^{15,38,41,48,62}. In South Africa, physiotherapists are first line practitioners and as such may be required to manage a concussed athlete in the absence of other medical professionals or coaching staff that are adequately trained in emergency care¹²¹. Physiotherapists may be responsible for imparting concussion knowledge to athletes, as well as the multi-disciplinary team involved in sports, such as coaching staff and parents³⁸. This study was conducted in the context of a lack of literature regarding physiotherapists' knowledge regarding concussion, particularly in the South African milieu.

The overall aim of this study was to determine South African physiotherapists' knowledge of the prevention, diagnosis and management of sports-related concussion. Based on the evidence provided in this thesis, the study objectives, as described in Section 1.2, page one, may be answered as follows:

1. To determine the level of knowledge of the prevention, diagnosis and management of sports-related concussion.

The physiotherapists who responded to the survey obtained an overall mean concussion knowledge score of 65.4% \pm 11.7%. Participants obtained the highest mean score for the "diagnosis" section of the survey (76.2% \pm 11.8%); and the lowest mean score for the "consequences" section (39.3% \pm 22.3%). The wide range in scores for different domains in concussion knowledge suggests that physiotherapists do not have a comprehensive understanding of concussion, and this may impede both the immediate on-field and long-term management of athletes with concussion.

2. To determine whether physiotherapists have adequate knowledge of the prevention, diagnosis and management of sports-related concussion.

The majority of physiotherapists participating in this study had inadequate concussion knowledge. Only 20.7% of participating physiotherapists were classified as having adequate concussion knowledge (score \geq 75%). This is concerning, particularly as physiotherapists are often the only health care professionals providing on-field medical support. Inadequate concussion knowledge may negatively impact on the safe management of athletes with concussion, and may place athletes at risk of serious complications of concussion injuries.

3. To determine factors associated with knowledge of prevention, diagnosis and management of sports-related concussion including level of qualification, number of years in physiotherapy practice, sports physiotherapy experience, current practice with a sports team, and continuing education.

No socio-demographic, academic or clinical experience factors were associated with adequate concussion knowledge scores. However, physiotherapists that felt confident in managing concussion had significantly higher concussion knowledge scores for consequences of concussion and management of concussion domains, compared to physiotherapists that did not feel confident in managing concussion. This is a cause for concern, as knowledge scores were still inadequate despite perceived levels of confidence. This highlights the need for regular assessment of proficiency in managing concussed athletes, and the importance of feedback regarding competency levels.

An important finding from the literature was that the physiotherapist may be responsible for concussion knowledge transfer to athletes and other role players in sport. This highlights the essential need for physiotherapists to have adequate knowledge of all aspects of sports-related concussion.

Based on the findings of this study it is recommended that sport-related concussion education programmes be developed and delivered in a method to ensure maximum efficacy to a diverse target audience of South African physiotherapists, thereby ensuring physiotherapists have adequate knowledge to diagnose and manage sports-related concussion efficiently and safely.

University of Cape Town

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APPENDIX I



UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Human Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • Facsimile [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

11 July 2011

HREC REF: 325/2011

Ms U Govender
c/o Dr T Burgess
Division of Physiotherapy
Health & Rehab
F-Floor, OMB

Dear Ms Govender

PROJECT TITLE: SOUTH AFRICAN PHYSIOTHERAPISTS' KNOWLEDGE OF THE PREVENTION, DIAGNOSIS AND MANAGEMENT OF CONCUSSION.

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

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

Approval is granted for one year till the 30 July 2012.

Please correct the spelling of "principle" investigator in the Information Letter (principal).

Please submit a progress form, using the standardised Annual Report Form (FHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (FHS010) if the study is completed within the approval period.

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

Please quote the HREC. REF in all your correspondence.

s.thomas

Yours sincerely



PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.

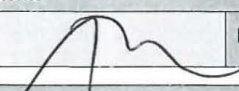
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human 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 Human 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.

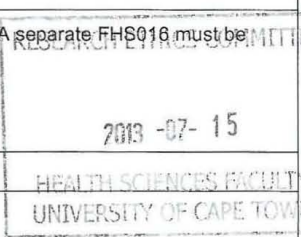
s.thomas

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938)		
This serves as notification of annual approval, including any documentation described below.		
<input checked="" type="checkbox"/> Approved	Annual progress report	Approved until/next renewal date 30/07/2014
<input type="checkbox"/> Not approved	See attached comments	
Signature Chairperson of the HREC		Date Signed 15/7/2013
Comments to PI from the HREC		

Principal Investigator to complete the following:

1. Protocol information

Date form submitted	13/07/13	
HREC REF Number	325/2011	Current Ethics Approval was granted until
Protocol title	South African physiotherapists' knowledge of the prevention, diagnosis and management of concussion	
Protocol number (if applicable)		
Are there any sub-studies linked to this study?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
If yes, could you please provide the HREC Ref's for all sub-studies? Note: A separate FHS016 must be submitted for each sub-study.		
Principal Investigator	Miss Ugendrie Govender	
Department / Office Internal Mail Address	ugendrie@telakomsa.net	

1.1 Does this protocol receive US Federal funding?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No
1.2 Does this study require full committee approval?	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No

APPENDIX II



Department 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 Schuur Hospital,
Observatory 7925
Tel: +27 (0) 21 406 6401 Fax: +27 (0) 21 406 6323

Internet: www.uct.ac.za

Information letter and informed consent

South African physiotherapists' knowledge of the prevention, diagnosis and management of concussion

Dear Colleague

I am a MPhil Sports Physiotherapy student at the University of Cape Town, Division of Physiotherapy and I am conducting a study to investigate the South African physiotherapists' knowledge of the prevention, diagnosis and management of concussion. This study has been given ethics approval by the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee (HREC REF 325/2011).

Concussion is a common injury, with a reported incidence of between 20% and 55%. The identification and correct management of concussion is essential in ensuring athlete safety. In South Africa, doctors and emergency personnel are not always present at practices and matches. The physiotherapist is often responsible for field-side care, and is often required to deliver emergency care, including the management of head injuries, such as concussion, often leaving the physiotherapist as the sole 'medical officer'. There is a lack of consensus regarding the optimal management of concussion. It is therefore important that physiotherapists have a good understanding of the diagnosis, management and complications of concussion injuries.

The knowledge gained from this study will provide information on the current levels of knowledge of South African physiotherapists regarding the prevention, diagnosis and management of concussion. The information generated will highlight the current gaps in the knowledge of physiotherapists in

this particular area. This information may assist in curriculum development for undergraduate physiotherapy training, and may improve the content of sports physiotherapy or sport related concussion workshops. Prevention of concussion through education may become a key factor for progress in this field.

Physiotherapists that are members of the orthopaedic manipulative therapists group and the sports group have been selected to participate in this study. If you decide to take part in this study, you will be asked to complete a concussion questionnaire. The questionnaire is designed to firstly determine your physiotherapy experience and level of involvement in sport physiotherapy, followed by physiotherapy education.

The questionnaire will also determine your knowledge on the diagnosis of concussion, concussion consequences, management of a concussed player and return to play protocols. It should take you a maximum of 45 minutes to complete the questionnaire. You will be required to give informed consent on the Survey Monkey questionnaire by indicating that you have understood the information sheet and that you are willing to complete the questionnaire. If you do not indicate consent, you will not be able to access the questionnaire, and you will exit the online questionnaire. You will be required to provide their email address to ensure that an information booklet may be sent to you on completion of the questionnaire. This will be separate from the rest of the questionnaire by an independent research assistant, to ensure you're your questionnaire responses remain anonymous. All questionnaires will be coded to ensure anonymity, and confidentiality will be strictly upheld. The questionnaires will be stored in a locked filing cabinet, and will only be accessed by the principal investigator and the research assistant. There are no risks associated with taking part in this study. There is no remuneration for taking part in the study; however you will be sent a 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 athlete.

This study is being supervised by Dr Theresa Burgess and Ms Romy Parker of the Division of Physiotherapy, University of Cape Town. 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.

Participation in the study is voluntary. The informed consent form and questionnaire will be available online via a survey monkey. You will be required to accept the willingness to participate in

the study. Please note that by accepting the option to participate in the study will be taken as you providing your informed consent. This will then lead you to the concussion questionnaire.

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

Kind regards

Ugendrie Govender

B. Physiotherapy

Researcher:	Ms Ugendrie Govender	084 6077 293	ugendrie@telkomsa.net
Supervisor:	Dr Theresa Burgess	012 4066 571	theresa.burgess@uct.ac.za
Co-Supervisor:	Dr Romy Parker	021 4066 571	romy.parker@uct.ac.za
Human Research Ethics Committee:			
	Professor Marc Blockman	021 406 6492	marc.blockman@uct.ac.za

APPENDIX III

South African physiotherapists' knowledge of the prevention, diagnosis

1. Informed Consent

Title: South African physiotherapists' knowledge of the prevention, diagnosis and management of concussion.

I, Ugendrie Govender, am a MPhil Sports Physiotherapy student at the University of Cape Town, Division of Physiotherapy. The information obtained in this study will be used for the completion of a mini-dissertation as required for the partial fulfilment of the MPhil (Sports Physiotherapy). This study has been granted ethical approval by the University Of Cape Town Faculty Of Health Sciences Human Research Ethics Committee, HREC REF:325/2011.

Concussion is a common injury, with a reported incidence of between 20% and 55%. The identification and correct management of concussion is essential in ensuring athlete safety. In South Africa, doctors and emergency personnel are not always present at practices and matches. The physiotherapist is often responsible for field-side care, and is often required to deliver emergency care, leaving the physiotherapist as the sole 'medical officer'. There is a lack of consensus regarding the optimal management of concussion. It is therefore important that physiotherapists have a good understanding of the diagnosis, management and complications of concussion injuries.

The knowledge gained from this study will provide information on the current levels of knowledge of South African physiotherapists regarding the prevention, diagnosis and management of concussion.

You have been selected for this study as a participant who is a physiotherapist, identified by membership of the Sports Physiotherapy Group and/ or the Orthopaedic Manipulative Physiotherapy Group of the South African Society of Physiotherapy.

Participation in this study is voluntary and involves completing this consent form and filling out the online questionnaire which will take approximately 15 to 20 minutes. You will be asked to provide your email address to enable us to send you an information booklet on the management of concussion when you have completed the questionnaire. Your e-mail contact information is not linked to the online questionnaire data collection, thereby ensuring confidentiality and anonymity. There are no risks associated with taking part in this study. There is no remuneration for taking part in the study; however you will be sent a 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 athlete.

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.

Thank you for your time and assistance.

Kind regards

Ugendrie Govender

Researcher: Ms Ugendrie Govender 084 6077 293 ugendrie@telkomsa.net

Supervisor: Dr Theresa Burgess 012 4066 171 theresa.burgess@uct.ac.za

Co-Supervisor: Ms Romy Parker 021 4066 401 romy.parker@uct.ac.za

***I,**

- hereby give informed consent to participate in the above-mentioned study.
- hereby do not wish to participate in the above-mentioned study.

South African physiotherapists' knowledge of the prevention, diagnosis

Date:

South African physiotherapists' knowledge of the prevention, diagnosis

2. Demographic Information

Please complete the demographic information below.

1. What is your age?

2. Gender:

Male

Female

*3. In which province do you practice?

Eastern Cape

Kwa Zulu Natal

North West

Freestate

Limpopo

Western Cape

Gauteng

Mpumalanga

Northern Cape

4. Please select your current setting(s) of practice.

Government hospital

Private hospital

Private Practice

Community centre

School

If other, please specify.

5. Are you currently a community service physiotherapist?

Yes

No

6. Have you ever or do you currently treated any sportsmen/women?

Yes

No

7. What percentage of your clinical time do you treat athletes/sports people?

None, I do not treat any athletes

Between 25% to 50%

More than 75%

Less than 25%

Between 50% to 75%

All of my patients are athletes

South African physiotherapists' knowledge of the prevention, diagnosis

3. SECTION A: PHYSIOTHERAPY EXPERIENCE

*1. How many years have you been a qualified physiotherapist?

- 1 to 5 years 6 to 10 years 11 to 14 years > than 15 years

*2. Are you registered as a physiotherapist with the Health Professional Council of South Africa?

- Yes No

*3. Which professional group are you a member of?

- Orthopaedic Manipulative Physiotherapy Group Both
 Sports Physiotherapy Group

If other, please specify.

*4. Are you currently involve with?

- A sports team Work at a sports practice
 Individual athletes Not applicable

If other, please specify.

5. What is your current level of involvement in sport?

- Junior school Schools provincial team Not applicable
 High school Provincial team
 Club level National level

6. Which sports are you currently involved in?

- Rugby Hockey Not applicable
 Soccer Athletics
 Cricket Gymnastics
 If other, please specify.

7. What age group of athletes do your work with?

- <12 years 19 to 25 years Not applicable
 12 to 18 years >25 years

South African physiotherapists' knowledge of the prevention, diagnosis

8. How many years have you been involved in sport physiotherapy?

- This is my first year 3 - 5 years 10 years and more
 1 - 2 years 6 - 9 years Not applicable

9. Do you perform pre-participation screening on the athlete?

- Yes No Not applicable

10. If you answered YES to question 9, do you do include neuropsychological assessment?

- Yes No Not applicable

11. Are you in a position where you are the only medical person present at a competition and/or practice, whereby you would be responsible to handle a medical emergency?

- No, never Yes, more than 80% of the time
 Yes, less than 50% of the time Not applicable
 Yes, 50 - 80% of the time

*12. In your current position, do you have a set medical team working with your team/athlete?

- Yes No Not applicable

13a. If you answered YES to question 12, the medical team...

- are contacted only when required attend matches only attend both matches and practice sessions

If other, please specify.

13b. The medical team consists of....

- Medical Doctor Fitness Instructor Orthopaedic surgeon
 Physiotherapist Masseur Dietician
 Biokineticist Psychologist
 Chiropractor Neurologist

If other, please specify.

South African physiotherapists' knowledge of the prevention, diagnosis

4. SECTION B: PHYSIOTHERAPIST EDUCATION

*1a. Do you have a first aid qualification?

- Yes No

1b. What date did you attend the most recent first aid course? (mm/yy)

2. What is your current level of first aid qualification?

- 1 2 3 4 5 Not applicable

*3. Have you completed any postgraduate studies?

- Yes No

4. Please indicate if you have completed any of the following.

- OMT Postgraduate diploma PhD
 SPT Masters Not applicable

Please specify Masters/ PhD qualification and/or any other qualifications not mentioned above.

*5. At present I am confident dealing with a concussed player.

- Strongly agree Agree Do not know Disagree Strongly disagree

6. The majority of my knowledge about concussion was learned through

- Internet Library Undergraduate studies
 Media: TV Courses/Workshops Postgraduate studies
 Media: Print Fellow physiotherapists
 Media: DVD Other medical professionals

7. My current concerns about attending courses/workshops are:

- Cost Fear of failure No concerns
 Language barrier Courses are not productive, a waste of my time
 Time constraints I know everything about concussion

South African physiotherapists' knowledge of the prevention, diagnosis

5. SECTION C: DIAGNOSIS OF CONCUSSION

***1. Concussion only occurs following a direct blow to the head.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***2. Acceleration – deceleration forces may cause concussion.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***3. Loss of consciousness of any duration is the main diagnostic criteria for concussion.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***4. Concussion may also be termed “mild traumatic brain injury”.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***5. From the list below, select any 6 symptoms which may be indicate concussion.**

- | | | |
|--|---|---|
| <input type="checkbox"/> Nausea | <input type="checkbox"/> Aggressiveness | <input type="checkbox"/> Vacant, glassy eyes |
| <input type="checkbox"/> Headache | <input type="checkbox"/> Loss of consciousness | <input type="checkbox"/> Dizziness |
| <input type="checkbox"/> 'Feeling foggy' | <input type="checkbox"/> Loss of appetite | <input type="checkbox"/> Poor balance |
| <input type="checkbox"/> Paraesthesia (tingling) | <input type="checkbox"/> Vomiting | <input type="checkbox"/> Blurred vision |
| <input type="checkbox"/> Neck stiffness | <input type="checkbox"/> Sensitivity to noise | <input type="checkbox"/> 'Just not feeling right' |
| <input type="checkbox"/> Drowsiness | <input type="checkbox"/> Improved concentration | <input type="checkbox"/> Confusion |
| <input type="checkbox"/> Sensitivity to light | <input type="checkbox"/> Increased alertness | <input type="checkbox"/> Ringing in the ears |

***6. Neuro-imaging studies (MRI, CT scan, X-ray) may be normal after a first concussion.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***7. Routine questioning of person, time and place is a reliable test for rapid side of the field assessment of concussion.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***8. A Sports Concussion Assessment Tool card (SCAT/SCAT2 card) should be used to assist rapid side of the field assessment of concussion.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***9. Balance Tests may be used to assist in rapid side of the field assessment of concussion.**

- Strongly agree Agree Do not know Disagree Strongly disagree

South African physiotherapists' knowledge of the prevention, diagnosis

***10. Neuro-psychological testing alone may be used for sideline diagnosis of concussion.**

Strongly agree

Agree

Do not know

Disagree

Strongly disagree

6. SECTION D: CONSEQUENCES OF CONCUSSION

***1. Choose the most likely consequence for an adult player who suffers from more than one concussion in a season.**

- No serious consequences
- Loss of consciousness
- Second impact syndrome
- Post concussion syndrome
- Death

***2. Second Impact Syndrome is most likely to occur when:**

- A 2nd concussion is sustained in the same match
- A 2nd concussion is sustained whilst the 1st concussion has not yet resolved
- A 2nd concussion is sustained in the same season
- All of the above
- A 2nd concussion is sustained in a career

***3. Choose the most likely consequence of second impact syndrome.**

- No serious consequences
- Loss of consciousness
- Severe neurological dysfunction
- Post concussion syndrome
- Death

***4. The most common sequelae to repeated concussions that may present later in life is:**

- Second impact syndrome
- Post concussion syndrome
- Neurological deficit
- None of the above

South African physiotherapists' knowledge of the prevention, diagnosis

7. SECTION E: MANAGEMENT OF CONCUSSION

***1. If a player is suspected of having sustained a concussion he/she must leave the field of play immediately.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***2. Only a player with a severe concussion needs to leave the field immediately.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***3. If a player left the field for concussion but 'he/she is fine' within some minutes, he/she may safely return to the field of play.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***4. Any player with a suspected concussion should consult a medical doctor as soon as possible.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***5. A child or adolescent (under the age of 18) is more susceptible to concussion than an adult.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***6. The recovery time for a concussed child or adolescent is often longer than that for an adult.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***7. The recommended treatment for concussion is:**

- Physical and cognitive rest Cognitive rest only Do not know
 Physical rest only Medication for symptom relief

South African physiotherapists' knowledge of the prevention, diagnosis

8. SECTION F: RETURN TO PLAY

***1. Are you familiar with the Stepwise Return to Play Protocol following a concussion?**

- Yes No

***2. Have you ever used a Stepwise Return to Play Protocol with any concussed players?**

- Yes No Not applicable

***3. 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

***4. A player who reports that he/she is symptom free following concussion can return to practice the same day.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***5. A player has to be examined by a medical doctor and be symptom free, at rest and with exercise, before returning to play.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***6. When a player returns to play following a concussion he/she can immediately resume full contact practice with his/her team.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***7. When a player returns to play after a concussion and develops a headache, the only management of choice would be analgesics.**

- Strongly agree Agree Do not know Disagree Strongly disagree

***8. When a player reports experiencing mild to moderate symptoms of concussion, he/she should be allowed to progress to the next step of the Return to Play Protocol.**

- Strongly agree Agree Do not know Disagree Strongly disagree

South African physiotherapists' knowledge of the prevention, diagnosis

***9. If you were to use a Stepwise Return to Play Protocol – 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 contact game)**

	1	2	3	4	5	6	7
Tackle bags and contact allowed at full practice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Running and agility drills, no impact activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Jogging, light running	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Walking, stationary bicycle, swimming	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drills incorporating running and passing, co-ordination activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resistance training (eg: lifting weights at the gym)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
No activity, complete physical and cognitive rest	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

South African physiotherapists' knowledge of the prevention, diagnosis

9.

Thank you for completing the questionnaire!

Your participation is greatly appreciated!

***Please fill in your e-mail address for the information booklet on concussion**

APPENDIX IV



Department 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 Schuur Hospital, Observatory 7925

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

Internet: www.uct.ac.za

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 your voluntary assistance to take on the task of validation of a concussion questionnaire. As a 'validator', you will not be considered as a study participant and all information will be treated with utmost confidentiality.

The correct diagnosis, management and return to play protocol for concussion are essential to ensure the athlete's safety and to prevent the risk of associated complications. Research conducted has highlighted the fact that there is little known about the physiotherapists' knowledge regarding concussion is limited. In South Africa the physiotherapist are frequently the only medical personnel present at practices and during competition indirectly making them responsible for dealing with any medical emergency. At present there is no literature documenting South African physiotherapists' knowledge of concussion diagnosis and management. This is cause for concern, particularly with regards to an athlete's safety and medico-legal ramifications. Accordingly, I propose to investigate South African rugby physiotherapists' knowledge of the prevention, diagnosis and management of concussion. The study has been given ethics approval by the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee (HREC REF 325/2011).

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

As a recognised (*insert individuals specific expertise*) and an expert in the field of sport injuries 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 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*). 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:

084 6077 293

ugendrie@telkomsa.net

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

Kind regards

Ugendrie Govender

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

APPENDIX V

	For Office use Only
	Questionnaire Code:

Validators' Questionnaire

Thank you for taking the time to complete this questionnaire, which will greatly add to the body of knowledge and literature about physiotherapists and concussion.

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

Please read each question carefully

Please tick the appropriate box to indicate your answer:

1. For convenience, and where applicable, the most desirable/correct answer is indicated in **Bold**, the second acceptable response is indicated in *Italics*, should you agree or disagree with this please mark the answer which you feel is correct.
2. Please also indicate in the boxes below each question, where applicable, your consensus as to the importance and clarity of the question.
3. You may add a comment or suggestion below each question should you feel the need.

Please note that the physiotherapists demographic have been removed from the validator's questionnaire. Section A requires the participant to complete information about his/her experience as a physiotherapist as well as their experience in the sport physiotherapy. In section B the first 14 questions that have been removed. These are questions regarding the participant's education and ways in which they have supplemented their knowledge as a physiotherapist. Your questionnaire will start from question number 15 in section B, continuing with determining the physiotherapist's knowledge.

SECTION B: PHYSIOTHERAPIST EDUCATION¹⁻⁴

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

Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	-------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

16. My current concerns about attending 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	know everything about concussion	

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

Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	-------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

18. 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
-----------------------	-------	-------------	----------	-------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

SECTION C: DIAGNOSIS OF CONCUSSION⁴⁻¹⁴

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

Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
-------------------	-------	----------------	----------	------------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

20. Acceleration – deceleration forces may cause concussion

Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
---------------------------	-------	----------------	----------	----------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

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

Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
-------------------	-------	----------------	----------	------------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

22. Concussion may also be termed “mild traumatic brain injury”

Strongly Agree	Agree	Do not Know	Disagree	Strongly Disagree
---------------------------	-------	----------------	----------	----------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

23. From the list below select any 6 symptoms which may be indicative of concussion

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

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

24. Neuro-imaging studies (MRI, CT scan, X-ray) may be normal after a first concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	-------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

25. 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
----------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No

Comments:

26. A Sports Concussion Assessment Tool card (SCAT/SCAT2 card) may be used to assist rapid on-field assessment of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No

Comments:

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

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No

Comments:

28. Neuro-psychological alone may be used for sideline diagnosis of concussion

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No

Comments:

Section D: MANAGEMENT OF CONCUSSION⁴⁻¹⁷

29. 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
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

30. Only a player with a severe concussion needs to leave the field immediately

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

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

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

32. According to the International Rugby Board, Who has 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	The physiotherapist

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

33. Any player with a suspected concussion should consult a medical professional as soon as possible

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

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

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

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

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

36. The mainstay of treatment for concussion is

Physical and Cognitive rest	Physical rest only	Cognitive rest only	Medication for symptom relief	Do not know
------------------------------------	--------------------	---------------------	-------------------------------	-------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

SECTION E: CONSEQUENCES OF CONCUSSION^{4,7-11,18,19}

37. Choose the most likely consequence for an adult player who suffers from more than one concussion in a season

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

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

38. Choose the most likely consequence for a child or adolescent who suffers from more than one concussion in a season

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

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

39. 2nd Impact Syndrome occurs when

A 2 nd concussion is sustained in the same match	A 2 nd concussion is sustained in the same season	A 2 nd concussion is sustained in a career	A 2nd concussion is sustained whilst the 1st concussion has not yet resolved	All of the above
---	--	---	---	------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

40. Choose the most likely consequence of 2nd Impact Syndrome

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

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

41. The most common sequel to repeated concussions that may present later in life is

2 nd Impact Syndrome	All of the above	Post Concussion Syndrome	None of the above	Neurological Deficit
---------------------------------	------------------	---------------------------------	-------------------	----------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

SECTION F: RETURN TO PLAY^{4,7-10,14,15,20,21}

42. 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
----------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

43. A player who reports that he is symptom free following concussion can return to practice that day

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
----------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
Is the question clear?	Yes	No

Comments:

44. A player has to be examined by a medical professional and be symptom free as well as neuro-psychologically cleared before returning to play

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

45. When a player returns following a concussion he can resume full contact practice with his team

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

46. A player returns to play after a concussion and develops a headache. The management of choice would be analgesics

Strongly Agree	Agree	Do not know	Disagree	Strongly Disagree
-----------------------	-------	-------------	----------	--------------------------

Is the question important?	Yes	No
----------------------------	-----	----

Is the question clear?	Yes	No
------------------------	-----	----

Comments:

47. If you were to use a Stepwise Return to Play – 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	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 (eg: lifting weights at the gym)	6
No activity, complete physical and cognitive rest	1

Is the question important?	Yes	No
Is the question clear?	Yes	No
Comments:		

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

University of Cape Town

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University of Cape Town

APPENDIX VI

What is a concussion?

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.

Several common features of concussion include:

1. 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. Results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
3. The acute clinical symptoms of concussion 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).
5. Typically associated with normal neuro-imaging.

Sign and symptoms

Concussion should be suspected in the presence of **any one or more** of the following:

Typical symptoms	Headache, dizziness, nausea, unsteadiness, loss of balance, "feeling in a fog", ringing in the ears, double vision, "seeing stars"
Physical signs	Loss of consciousness, poor co-ordination/balance, convulsive convulsion, vacant expression, vomiting, inappropriate playing behaviour, gait unsteadiness, slowed reactions, amnesia, photophobia, glassy eyes, poor concentration, slurred speech, personality changes.
Behavioural changes	Inappropriate emotions, irritability, feeling nervous or anxious, mood swings, aggressiveness
Cognitive features	Unaware of period, opposition, score of the game, confusion/disorientation, amnesia, loss of consciousness, unaware of time, date and place
Sleep disturbances	Drowsiness, fatigue, insomnia

Management

Acute management

The aim of immediate management is to stabilise the player and follow a basic first aid protocol. Assess the ABC's, Airway, Breathing and Circulation. If a cervical spine injury is suspected, the player should only be removed by emergency healthcare professionals with appropriate spinal care training.

Sideline evaluation includes neurological assessment and mental status testing. If any signs or symptoms of concussion are identified and/or the player fails to answer correctly the five memory questions in Pocket Scat 2 (provided below), the player **MUST** be removed from the field of play for a comprehensive medical evaluation.

The Player **MUST NOT** resume play once removed from the field for suspected concussion.

Memory questions:

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

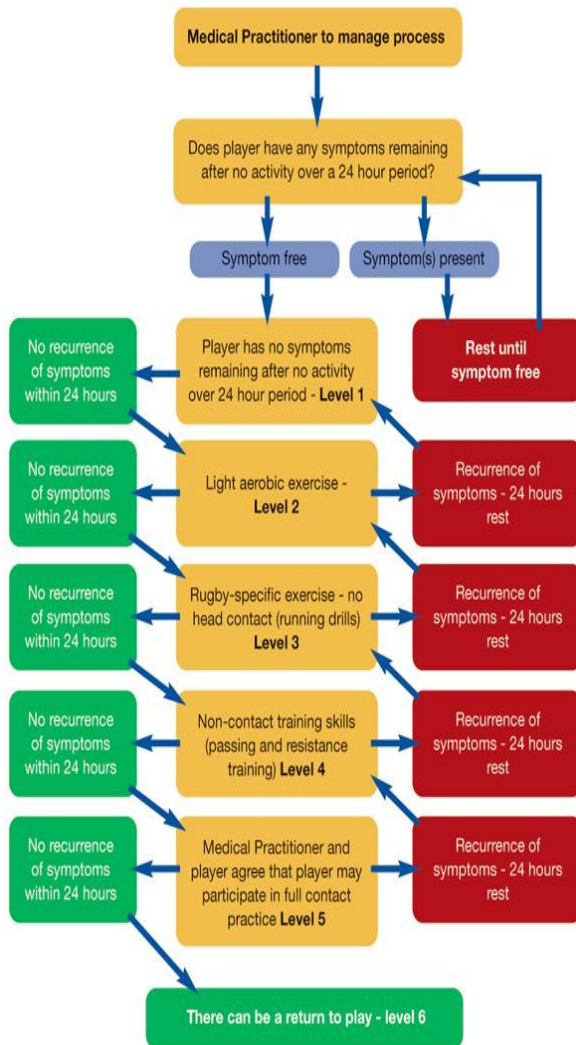
If a concussion is suspected the player should not be left alone, and must be regularly monitored for any deterioration in condition.

Treatment for concussion is complete rest, which includes both physical rest and cognitive rest.

For cognitive rest, the player must reduce all work/school work; reduce the length of their day, move meetings or examinations; and 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 must be assessed by a doctor), the player may then start the Stepwise Return to Play Protocol.

Stepwise Return to Play Protocol



IRB Guidelines, Graduated Return to Play Guidelines.

Complications:

Post concussion symptoms are a range of non specific cognitive, emotional or somatic symptoms that may occur following a concussion. These symptoms include headaches, dizziness, difficulty remembering and irritability. After repeated concussions the likelihood of serious sequelae may increase, the symptoms may be more significant, and symptoms may also resolve at a slower rate. Prolonged recovery after a subsequent concussion may therefore be linked to a previous history of concussion.

Second impact syndrome is a very rare occurrence, with catastrophic brain swelling leading to severe disability or death. Should the player return prematurely, the physiological effects of the initial concussion may not have resolved. This poses an increased vulnerability to injury and a second blow may result in further swelling.

Damage to cerebral veins may be associated with concussion injuries. The bleeding of these vessels may lead to epidural, subdural or intracerebral haematomas causing raised intracranial pressure. The initial presentation of a concussed athlete may overlap with that of an athlete that may have sustained an intracranial bleed. This stresses the need for continual monitoring of a head injured athlete in the first 48 – 72 hours after injury

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 than 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.

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: _____

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 or awaking	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): _____
 (Half of score in table, maximum possible 22 ÷ 2 = 11)
Symptom severity score
 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

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
 No motor response: 2
 Extension to pain: 3
 Abnormal flexion to pain: 4
 Flexion/Withdrawal to pain: 5
 Localize to pain: 6
 Obey commands: 6
Glasgow Coma Scale (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 SCAT2 summary score for final 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."
 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 return the athlete that dropped out will be tested.

Word	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	morning	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	ston	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 7-1-8, you would say 8-1-7."
 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.

	0	1	2	3	4	5	6	7	8	9
4-9-3	0	1	0	1	0	1	0	1	0	1
3-8-1-4	0	1	0	1	0	1	0	1	0	1
6-2-9-2-1	0	1	0	1	0	1	0	1	0	1
7-1-8-4-6-2	0	1	0	1	0	1	0	1	0	1

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

What is the SCAT2?
 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. This tool also enables the calculation of the Standardized Assessment of Concussion (SAC)¹ score and the Maddocks questions² 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 distribution 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.

¹This 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 consensus document and the authors of the tool are published in British Journal of Sports Medicine, 2009, Volume 43, supplement 1.
²The outcome paper will also be simultaneously co-published in the May 2009 edition of the 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.
 McCrea M, et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. British Journal of Sports Medicine, 2005, 39: 196-204.

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³Maddocks DL, Dicker CD, Selinger JMB. 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).¹ An stopwatch or watch with a second hand is required for this test.

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

- Hands lifted off floor/mat
- Opening eyes
- Steps, stumble, or fall
- Moving hip into > 30 degrees abduction
- Lifting forefoot or heel
- 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
(in which is the non-dominant foot)

Condition

Double Leg Stance (feet together)	of 10
Single leg stance (non-dominant foot)	of 10
Tandem stance (non-dominant foot in 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 letters: 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.

Set	Alternative word list		
elbow	candle	baby	finger
apple	paper	monkey	peony
egg	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 15
Concentration score	of 5
Delayed recall score	of 5
SAC subtotal	of 30
SCAT2 total	of 100
Misdiagnosis 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:

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

There should be approximately 24 hours (or longer) for each stage and the athlete should drop back to the previous asymptomatic level if any post-concussive symptoms recur. Resistance training should only be added in the later stages.
Medical clearance should be given before return to play.

Test	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		
	Orientation score		
SAC	Immediate memory score		
	Concentration score		
	Delayed recall score		
	SAC Score		
Total	SCAT2		
Symptom severity score (max possible 132)			
Return to play	<input type="checkbox"/> Y <input type="checkbox"/> N	<input type="checkbox"/> Y <input type="checkbox"/> N	<input type="checkbox"/> Y <input type="checkbox"/> 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

Contact details or stamp

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

The best way to manage concussion is to prevent it!! Educate players, coaches and others involved!! Education is empowerment and the key to concussion prevention and management.

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