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**PHYSIOTHERAPY STUDENTS' KNOWLEDGE OF THE
DIAGNOSIS, ASSESSMENT AND MANAGEMENT OF
CONCUSSION**

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**THIS THESIS IS PRESENTED FOR THE DEGREE OF MASTER OF PHILOSOPHY IN
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Declaration

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University of Cape Town

Table of contents

	Page
Declaration	i
Acknowledgements	ii
Table of contents	iii
List of tables	vii
List of figures	viii
Glossary of terms	ix
List of Abbreviations	xi
Abstract	xii
Chapter 1: Introduction and scope of the thesis	1
1.1 Introduction	1
1.2 Aim and Objectives	2
1.3 Significance of the study	2
1.4 Conclusion	3
Chapter 2: Literature review	4
2.1 Introduction	4
2.2 Epidemiology of concussion	5
2.3 Pathophysiology of concussion	8
2.4 Signs and Symptoms of concussion	10
2.5 Assessment of concussion	12

2.6 Complications of concussion	15
2.7 Management of concussion	18
2.7.1 Hospitalisation	21
2.7.2 Return to play	21
2.8 Prevention of Concussion	24
2.9 Physiotherapy in Sport	27
2.9.1 On-field physiotherapy services and scope of practice	27
2.9.2 On-field physiotherapy as part of the undergraduate curriculum	28
2.9.3 Medico-legal considerations	29
2.10 Measurement instruments with which to assess knowledge of concussion	30
2.11 Summary of literature	31
Chapter 3: Methods	33
3.1 Participants and study design	33
3.2 Sample size calculator	34
3.2.1 Inclusion criteria	34
3.2.2 Exclusion criteria	34
3.2.3 Recruitment	34
3.2.4 Concussion questionnaire	35
3.2.5 Procedure	39
3.2.6 Statistical analyses	39
3.3 Limitations of study	40

Chapter 4: Results	41
4.1 Descriptive characteristics	41
4.2 On-field physiotherapy experience	42
4.3 Education and training on concussion	42
4.4 Diagnosis of concussion	43
4.5 Management of concussion	47
4.6 Consequences of repeated concussion injuries	49
4.7 Return to play (RTP) protocols	49
4.8 Comparisons between different years of study	49
4.8.1 Descriptive data	49
4.8.2 Concussion knowledge score	50
4.8.3 Diagnosis, management and knowledge of the consequences of concussion and RTP protocols	51
4.9 On-field experience	52
4.10 Practical supervision	53
4.11 First aid training	54
4.12 Total concussion knowledge scores for questionnaire	55
Chapter 5: Discussion	56
5.1 Questionnaire scores	56
5.2 On- field physiotherapy experience	57
5.3 Education and training on concussion	58

5.4 Diagnosis of concussion	59
5.5 Management of concussion	61
5.6 Consequences of repeated concussion	63
5.7 Return-to-play protocols	64
5.8 Year of study	65
5.9 First aid training	66
Chapter 6: Summary and conclusions	68
Chapter 7: References	70
Appendices	
Appendix 1: Letter to head of departments at universities requesting to approach students	87
Appendix 2: Informed consent	90
Appendix 3: Questionnaire and mark allocation	93
Appendix 4: SCAT test	101
Appendix 5: Balance error scoring system	102
Appendix 6: Concussion monitoring chart	105
Appendix 7: Maddock's scale	107
Appendix 8: Ethics approval	108

List of Tables

Table 2.1 Signs and symptoms of concussion.	10
Table 3.1 Questions added and removed after consultation with experts in concussion field.	37
Table 3.2 Mark allocation for each section of questionnaire.	38
Table 4.1 Frequency of least appropriate principle to determine management at time of concussion.	48
Table 4.2 Concussion knowledge – scores (%) obtained by students with on-field experience and with no on-field experience.	53
Table 4.3 Scores of students who had and had not received supervision from qualified personnel.	54
Table 4.4 Scores of students who had and had not received first aid training.	55

List of Figures

Figure 4.1 Flow diagram of recruitment process.	41
Figure 4.2 Percentage of on-field student supervision.	42
Figure 4.3 Percentage of correct, incorrect and do not know answers for concussion diagnosis.	44
Figure 4.4 Concussion symptoms as identified by students.	46
Figure 4.5 Frequencies of answers that are correct, incorrect or do not know for concussion management.	48
Figure 4.6 Comparison of year of study vs Descriptive total on questionnaire.	50
Figure 4.7 Concussion knowledge scores for second, third and fourth year students.	51
Figure 4.8 Total questionnaire score achieved by students in each year of study.	52

Glossary of Terms

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 (Wilberger, J., Ortega, J. & Slobounov, S. 2006).
Concussion	Defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces (McCrary P, Meeuwisse W, Johnston K, et al 2009).
Loss of Consciousness	A dramatic alteration of mental state that involves complete or near complete lack of responsiveness to people and other environmental stimuli (Oxford English Dictionary 2010).
Maul	A loss scrum that forms around a player that is holding the ball and is still on his feet (International Rugby Board (IRB) Laws of the game of rugby football. 2007, 2009).
Neuropsychological	Referring to the interaction between the nervous system and cognitive function, the influence of one function on the other (McCrea M, Kelly J, Randolph C, Cisler R, Berger L. 2002).
Post-concussion Syndrome	The prolonged presence of a cluster of symptoms, following a concussive blow to the head, lasting for days or weeks (Aubry M, Cantu R, Dvorak J, et al. 2001).
Second Impact Syndrome	A rare condition in which the brain swells rapidly and catastrophically after a person suffers a second concussion before the symptoms from the earlier one have subsided (McCrary P, Meeuwisse W, Johnston K, et al 2009).

Scrum

The act or method of restarting play after an infringement when the two opposing packs of forwards group together with heads down and arms interlocked and push to gain ground while the scrum half throws the ball in and the hookers attempt to scoop it out to their own team. A scrum is usually called by the referee (set scrum) but may be formed spontaneously (loose scrum) (International Rugby Board (IRB) Laws of the game of rugby football. 2007, 2009).

Tackle

To dispose an opponent of the ball, to stop the player from gaining ground towards the goal or to stop them from carrying out what they intend. Any instance in which one person forces another to the ground (International Rugby Board (IRB) Laws of the game of rugby football. 2007, 2009).

List of Abbreviations

ANOVA – Analysis of variance

ATP – Adenosine Triphosphate

BESS – Balance Error Scoring System

CNS – Central nervous system

CT – Computerised topography

GCS – Glasgow Coma Scale

IFSP – International Federation of Sports Physiotherapy

IRB – International Rugby Board

LOC – Loss of consciousness

MRI – Magnetic Resonance Imaging

MTBI – Mild traumatic brain injury

PCS – Post-concussion syndrome

RTP – Return to play

SCAT 2 – Sports Concussion Assessment Tool 2

SCAT – Sports Concussion Assessment Tool

TBI – Traumatic brain injury

Abstract

Background: During their undergraduate studies physiotherapy students often spend time on the side of the sports field. It is, thus, fairly likely that they will be exposed to concussion injuries. However, the inappropriate management of concussion may have fatal consequences and it is, therefore, imperative that physiotherapy students be equipped with sufficient knowledge to enable them to recognise and manage concussion.

Objective of the study: The objective of this research study was to determine whether second, third and fourth year physiotherapy students had sufficient knowledge to be able to diagnose, assess and manage concussion injuries.

Methods: This study had a descriptive, correlational research design. The study was submitted and approved by the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town. Various universities in South Africa were then approached to obtain permission for their students to fill in a concussion knowledge questionnaire consisting of 40 questions. Seven universities were approached. Six universities gave their permission to use their students and 1 university never responded. There were four used as they were able to provide samples of a sufficient size to meet the inclusion criteria of the study.

The inclusion criteria were second, third and fourth year physiotherapy students who were studying at universities in South Africa while the exclusion criteria were universities at which less than 30 students were available or where all the years were not available

Prior to the questionnaire being administered it was reviewed by a panel of experts in the field of sports concussion in order to ensure both content and construct validity. The pass mark was set at 75% as this was the minimum mark at which concussion management was perceived to be "safe". There were two parts to the questionnaire. A section consisting of 12 marks for the descriptive data and a section consisting of 88 marks testing the student's concussion knowledge. The 2 marks were then added to give a mark out of 100.

Results: The average age of all the students participating in the study were 21.4 ± 1.6 years (Range: 18 to 29 years). Of the total number of participants, 145 (43.0%) had performed on-field physiotherapy. Of the 344 participants 268 (77.9%) had completed first aid training with the majority of the participants having a Level 1 first aid qualification (74.7%), 13.8% with a Level 2 qualification and 11.5% with a Level 3 or higher qualification.

There was one student out of 344 who scored above 75%. The total concussion knowledge scores which were obtained on the questionnaire ranged from 7 to 76% with a mean score of $37\% \pm 12.3\%$. If the descriptive information like year of study, side of field duty, supervision on the side of the field and first aid were excluded, the scores ranged from 4.6% to 73.5% with a mean of $33.1\% \pm 12.1\%$. There were 52.1% of the students who were not aware or did not know that it is inappropriate to administer analgesic medicine post-concussion while 9.4% only of the students were aware that death may result from Second Impact Syndrome. In addition, 45.4% recognised that Second Impact Syndrome is the result of a player sustaining further concussion during a match or before the initial concussion has been completely resolved.

There were significant differences between the abilities of the second-, third- and fourth-year students to diagnose concussion ($F(2,341) = 16.50, p < 0.05$), manage concussion ($F(2,341) = 9.88, p < 0.05$) and follow correct RTP protocols ($F(2,341) = 13.19, p < 0.05$). There were, however, no significant differences between the knowledge of the consequences of concussion of the various year groups ($p > 0.05$).

Conclusion: Physiotherapy students are not equipped with sufficient knowledge to manage a concussion safely once it has occurred. It is, thus, imperative that there is qualified supervision at all times when they are gathering on-field experience. In addition, it is also important that the universities assess their curricula to ensure they are enabling their students to manage concussion safely.

Chapter 1

Introduction and Scope of the Thesis

1.1 INTRODUCTION

Concussion is a major problem throughout the world in contact sport with an estimated 1 000 000 incidences being reported annually in the United States (McCrory, Collie, Anderson & Davis 2004). Of these injuries, approximately 250 000 will require hospitalisation. The incidence of concussion in adults has remained relatively constant worldwide, accounting for between 180 and 300 cases per 100 000 patients reporting to hospital emergency departments (McCrory et al. 2004). In South Africa, the incidence of concussion in contact sport accounts for 10 to 15% of all injuries reported in a season (Patricios 2009).

In South Africa, physiotherapy students regularly provide event first aid and physiotherapy services at rugby and soccer matches, endurance running and cycling races. The knowledge these students have can be of vital importance in whether they can diagnose a concussion injury. However, despite the fact that these physiotherapy students should be supervised by a qualified clinician, anecdotal evidence suggests that they often practise with minimal or no supervision. Given that the incidence of concussion is, reportedly, as high as 0.41 concussions per game (Pellman, Powell, Viano, Casson, Tucker, Feuer, et al. 2004), it is extremely likely that physiotherapy students will be called upon to identify and manage concussion injuries. Nevertheless, it is unclear whether physiotherapy students are adequately prepared to engage in on-field or event physiotherapy services and, in particular, whether they have sufficient knowledge of concussion to ensure safe and effective management when this injury presents.

No previous research has examined the ability of students to assess and manage concussion thus the need for this study. Results will add to those from a study conducted to assess the

knowledge of coaches in regards to their understanding of concussion (Ransone & Dunn-Bennett 1999).

This study sets out to determine whether students at four of South Africa's universities do have the knowledge to diagnose, manage and ensure a safe return to play of participants who have sustained a concussion. This was done by administering a questionnaire to them and then analysing the findings.

1.2 AIM AND OBJECTIVES

The aim of the study was to assess the knowledge of second, third and fourth year physiotherapy students in regards to concussion diagnosis, management and safe return to play.

The specific objectives were:

1. to assess whether the students had sufficient knowledge to safely manage a concussion.
2. to assess if there were other specific factors like year of study, first aid, side of field experience and supervision by qualified physiotherapist that may predict better scores on the test.

1.3 SIGNIFICANCE OF THE STUDY

The study was conducted to establish how safe it was for physiotherapy students to work on the side of the field and to manage concussions injuries if and when they occur. It also examines the relevance of what students get taught at an undergraduate level in relation to concussion and where they get their information from regarding concussion. This can be very useful to know in order to set up guidelines to determine what, is relevant information to be taught regarding concussions. The amount of qualified supervision students get is also of importance in order to allow the students to handle the situation knowing they got trained support with them.

1.4 CONCLUSION

A comprehensive literature review (Chapter 2) was undertaken in preparation for the administration of a questionnaire-based study (Chapter 3). The results of this study are presented in Chapter 4. These results are discussed (Chapter 5) and a final conclusion reached (Chapter 6). This paper aims to describe this process.

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Chapter 2

Literature Review

2.1 INTRODUCTION

The term “concussion” is translated from the original Latin word *concutere*, which means “violent agitation or shaking of the brain” (Theye & Mueller 2004; Adam & Craton 2002). The Third International Conference of Concussion in Sport defined concussion as “a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces” (McCrory et al. 2009). This definition will be used in this paper. The incorrect management of concussion injuries may have serious consequences, including memory loss, headaches and death (Bailes & Cantu 2001; Soloman et al. 2006; McCrory 2001). In South Africa, physiotherapy students regularly provide event first aid and physiotherapy services at rugby and soccer matches, endurance running and cycling races. However, despite the fact that physiotherapy students should be supervised by a qualified clinician, anecdotal evidence would suggest that students often practise with minimal or no supervision. Given that the incidence of concussion is, reportedly, as high as 0.41 concussions per game (Pellman et al. 2004), it is highly likely that physiotherapy students will have to identify and manage concussion injuries. However, it is unclear whether physiotherapy students are adequately prepared to engage in on-field or event physiotherapy services, and in particular, whether they are equipped with sufficient knowledge of concussion to ensure safe and effective management when this injury presents.

This literature review will outline the epidemiology, pathophysiology and clinical presentation of concussion injuries and also examine the role of the physiotherapist in the assessment and management of concussion injuries. Measurement instruments used to assess the knowledge of concussion will be evaluated. The data were sourced from sports medicine and science literature using searches on Pubmed, Web of Science, and Medline. Keywords included “concussion”, “concussion prevention”, “concussion pathology”,

“concussion investigation”, “head injuries”, “headgear”, “sports physiotherapy*”, “first aid”, “rugby”, “contact sports”, “gender”, “children”, “questionnaires”, and “surveys”.

2.2 EPIDEMIOLOGY OF CONCUSSION

In the United States, an estimated 1.7 million people sustain a traumatic brain injury (TBI) annually. This may, in turn, be associated with 1.365 million emergency department visits and 275 000 hospitalisations with related costs exceeding \$60 billion (Faul, Xu, Wald & Coronado 2010; Finkelstein, Corso & Miller 2006). The incidence of TBIs in adults has remained relatively constant worldwide, accounting for between 180 and 300 cases per 100 000 patients reporting to hospital emergency departments (McCrory et al. 2004). Concussion, a type of mild TBI, represents an alteration in mental status caused by biomechanical forces that may, or may not result in unconsciousness (Kelly 2000; Powell 2001). Direct sport participation accounts for 15 to 20% of mild TBIs (Jennett 1996; Kraus 1995), while concussion is reported to be the most common acute brain injury in sports (Kelly 2000; Powell 2001).

Concussion is more prevalent in contact sports than in non-contact sports because of the impact forces involved (Koh et al. 2003). In particular, high incidences of concussion have been reported in the rugby football sports, including rugby union, rugby league, American football and Australian rules football (Shuttleworth-Edwards et al. 2008). These are all high risk sports because of the physical nature of competition, with a higher level of play generally being associated with a higher incidence of injuries (Bird et al. 1998; Targett 1998; Jakoet & Noakes 1998). Epidemiological studies have reported injury rates of 32 (Jakoet & Noakes 1998), 53.8 (Fuller, Brooks, Cancea, Hall & Kemp 2007), 55.4 (Holtzhausen et al. 2008), 67.8 (Garraway et al. 2000), 74 (Bathgate, Best, Craig & Jamieson 2002), 91 to 92 (Brooks, Fuller, Kemp & Reddin 2005) and 120 (Targett 1998) per 1000 game hours in professional rugby union players since the game turned professional in 1996.

Reported injury rates in recreational or club level players vary greatly from reported incidences of 114.3 (Gissane, Jennings, Cumine, Stephenson & White 1997) to 490.2 (Phillips, Standen & Batt 1998) per 1000 game hours. These figures are substantially higher than those documented for professional athletes. This difference is potentially a result of lower fitness levels, fatigue associated altered cognitive function, inadequate preparation, lower quality equipment, rule interpretation and different skill levels (Collie, Darby & Maruff 2001). The variation in published estimates is probably an artefact of the actual rate of concussion, the definition of injury used in the study and the method used to collect the injury data (Marshall & Spencer 2001). Head injuries alone account for between 5 and 29% of all rugby injuries (Bird et al. 1998; Bathgate et al. 2002; Marshall & Spencer 2001; Gerrard, Waller & Bird 1994; Finch, McIntosh & McCrory 2001; Durie & Munroe 2000). Variations in the definition of head injury is in part responsible for the variation in reported figures with the majority of such head injuries being superficial soft tissue injuries and lacerations (Bird et al. 1998; Marshall, Waller, Dick, Pugh, Loomis & Chalmers 2002). Match-related concussion in professional rugby union has been reported to account for between 2% (Best, McIntosh & Savage 2005), 5% (Bird et al. 1998; Brooks et al. 2005) and 19.4% (Bathgate et al. 2002) of all injuries.

In children aged 15 years and younger, the estimated incidence rate of TBI is 180 per 100 000 children per year, of which 85% are categorised as mild injuries (Petipas & Danish 1995). Yang, Phillips, Xiang, Allareddy, Heiden and Peek-Asa (2008) reported 755 non-fatal paediatric concussion injuries out of 135 000 hospitalisation cases between 2000 and 2004.

In high school football, head and facial injuries accounted for 5 to 15% and concussions for 1 to 9% of total injuries (Culpepper & Niemann 1984; Turbeville, Cowan, Owen, Asal & Anderson 2003b; DeLee & Farney 1992; Prager, Fitton, Cahill & Olson 1989; Powell & Barber-Foss 1999; Guskiewicz, Bruce, Cantu, Ferrara, Kelly, McCrea et al. 2004). At a youth level, head and facial injuries accounted for 2 to 10% and concussions for 4 to 5% of total injuries (Stuart, Morrey, Smith, Meis & Ortiguera 2002; Turbeville, Cowan, Asal, Owen & Anderson 2003a; Roser & Clawson 1970; Goldberg et al. 1988).

Covassin, Swanik and Sachs (2003a) conducted the National Collegiate Athletic Association injury surveillance programme and found that, between 1997 and 2000, 14 591 injuries were reported, of which 5.9% were concussion injuries. American football, soccer and lacrosse were associated with an increased risk of concussion; while gymnastics, baseball and soft ball had a decreased risk of concussion. However, despite the fact that this study had a large sample size, it was limited to six sporting codes, and did not include rugby. Interestingly, there was a significantly higher incidence of concussion injuries in female athletes (471; 3.2%), compared to male athletes (402; 2.7%). This latter finding is supported by other studies (Dick 2009; Broshek, Kaushik, Freeman, Erlanger, Webbe & Barth 2005; Covassin, Schatz & Swanik 2007). Conversely, Yang et al. (2008) ascertained that gender was not associated with an increased risk of sports-related concussion. The most common impact site resulting in concussion in high school players is the parietal-temporal region (86%) followed by the occipital region (10%) (McIntosh, McCrory & Comerford 2000; McIntosh & McCrory 2000). In American football, concussion injuries resulted predominantly from impact forces to the side of the helmet, or the player falling on the back of the head (McCrory et al. 2004).

While it is accepted that concussion is of particular concern in contact sports, many events take place without the presence of medical personnel, while the medical personnel who may be available are not well trained in the recognition and management of concussion (Miller et al. 2011). In addition, any player who self-reports or is diagnosed as having a concussion is subject to an automatic three week suspension from all competitions and team practices (Marshall & Spencer 2001). This applies even should a player have sustained an extremely mild injury and have returned to a normal level of functioning within minutes. This may, indeed, be the cause of the under reporting of concussion injuries (Marshall & Spencer 2001). The majority of concussions occur without a loss of consciousness and, thus, the players themselves may be unaware that they have suffered a concussion (Marshall & Spencer 2001; Wilberger, Ortega & Slobounov 2006). In addition, many studies report cases of concussion diagnosed at hospitals only, whereas persons with mild concussions may not require hospitalisation and may be managed by general medical practitioners.

In view of the fact that the reported incidence of concussion injuries is high in both professional and amateur contact sports, and that the true incidence of concussion may, in fact, be higher than the reported incidence, it is essential that physiotherapy students providing medical cover at games have the knowledge to accurately diagnose and correctly manage concussion injuries. Most of the literature is based on studies conducted in America and Australia. There is limited literature from South Africa currently but this is changing at a rapid rate as more research regarding the safe management of concussion injuries is being conducted. A thorough understanding of the pathophysiology of concussion, as a background to the clinical features of the condition, is also necessary.

2.3 PATHOPHYSIOLOGY OF CONCUSSION

The exact pathophysiology of concussion is unknown (Alexander 1995). Moderate and severe brain injuries cause a complex cascade of neurochemical changes in the brain and it is assumed that the same applies to concussion. Concussion may either be caused by a direct or indirect blow to the head, face or neck or elsewhere on the body that causes a force to be transmitted to the head (McCrory et al. 2009). In the case of a linear impact, a sufficient force in the form of an opposite velocity vector may cause the brain to strike against the inner skull in the direction in which it was initially travelling (Wilberger et al. 2006).

Under normal conditions, cerebral blood flow is tightly coupled with neuronal activity. However, after a concussion injury, cerebral blood flow may be decreased by up to 50% as a result of neurotransmitters causing vasoconstriction of the cerebral vessels (Lee 2004). There is also an ionic shift that leads to acute and sub-acute changes in the cellular physiology. In an effort to restore neuronal membrane potential, the sodium–potassium pump requires increased amounts of adenosine triphosphate (ATP) and this, in turn, requires a major increase in glucose metabolism. The disparity between the glucose required and the glucose supplied is most probably the mechanism responsible for post-concussive vulnerability which causes secondary injury and longer-lasting cognitive deficit (Lee 2004; Giza & Hovda 2001). There is also an associated accumulation of calcium ions, which may persist for two to four days after the concussion injury. Increased intra-cellular

calcium concentrations may lead to impaired oxidative metabolism, and ultimately energy failure and cell death (Giza & Hovda 2001). It is, therefore, important to avoid increasing cerebral blood flow during recovery, as increased blood flow immediately post-concussion may lead to the increased destruction of brain cells (Lee 2004).

Concussion may also be associated with diffuse axonal injury. The mechanical stretching of axons may result in membrane disruption and depolarisation (Julian & Goldman 1962). This increased axonal permeability may last for up to six hours post-injury (Povlishock & Pettus 1996) leading to an influx of calcium ions as well as mitochondrial swelling (Maxwell, McCreath, Graham & Gennarelli 1995). Increased axonal calcium ion levels have been shown to lead to microtubule breakdown from six to 24 hours after the initial injury (Pettus & Povlishock 1996). Signs of secondary axonal disconnection may be seen as soon as four hours post-injury but have been reported to persist for some days, and even weeks, in braindead human beings (Blumbergs, Scott, Manavis, Wainwright, Simpson & McLean 1994). During the post-injury period, when cellular metabolism is already stretched to its limits, cells are more vulnerable to further insults (Prince, Lux & Neher 1973). Injured cells may, thus, be able to recover after an initial injury, but a second concussion during this energy crisis may lead to cell death (Giza & Hovda 2001).

In addition, brain tolerance to biomechanical forces differs between adults and children. Concussion in children results in higher mortality rates than in adolescents as a result of an increased incidence of cerebral oedema (Aldrich, Eisenberg, Saydjari, Luerssen, Foulkes, Jane, et al. 1992). Furthermore, a greater magnitude of impact force is required to produce clinical symptoms in children with concussion symptoms, as compared to adults (McCrorry et al. 2004). It is, thus, extremely important that physiotherapy students understand that concussion occurs as a metabolic process and not merely as a purely physical macroscopic process and that they then manage such injuries appropriately.

2.4 SIGNS AND SYMPTOMS OF CONCUSSION

Concussion injuries may be associated with cognitive, somatic and affective signs and symptoms. The common signs and symptoms of concussion are summarised in Table 2.1.

Table 2.1: Signs and symptoms of concussion.

Cognitive	Somatic	Affective
Confusion	Headache	Emotional liability
Post traumatic amnesia	Fatigue	Irritability
Retrograde amnesia	Dizziness	
Loss of consciousness	Nausea/vomiting	
Disorientation	Visual disturbance	
Feeling “foggy”	Phonophobia	
Vacant stare	Saccadic latency	
Inability to focus	Postural stability	
Delayed verbal response	ringing in ears	
Slurred speech	Loss of libido	
Excessive drowsiness		

Source: Guskiewicz et al. (2006); Lee (2004); Aubry, Cantu, Dvorak, Graf-Baumann, Johnston, Kelly, et al. (2002); Herring, Bergfeld & Boyd (2010).

Confusion and amnesia are among the most commonly reported symptoms of concussion (Makdissi, Darby, Maruff, Ugoni, Brukner & McCrory 2010). Although disorientation may be present during a confusional state, more subtle abnormalities are typical. The cardinal features of confusion include disturbance of vigilance with heightened distractibility, inability to maintain a coherent stream of thought and inability to carry out a sequence of goal-directed movements (Mesulam 2000).

Despite the wealth of literature that is available to show that this is, in fact, not the truth, the misunderstanding persists that loss of consciousness is required for a concussion injury to have occurred. This misunderstanding may, in turn, lead to the misdiagnosis and under reporting of this injury (Eckner & Kutcher 2010). However, loss of consciousness presents in 10% of concussion injuries only (Covassin et al. 2003a; Fischer & Vaca 2004) while any head injury leading to mental status alterations without loss of consciousness are, in fact, also concussions (Erlanger, Kaushik, Cantu, Barth, Broshek, Freeman, et al. 2003). Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, in a small number of cases, post-concussive symptoms may be prolonged (McCrory et al. 2009). There are no associated abnormalities on standard neuro-imaging studies after a concussion injury and this differentiates concussion from more traumatic head injuries (Alexander 1995).

Signs and symptoms of concussion may either present immediately following impact to the head or may be a delayed process taking several days to evolve fully (Guskiewicz et al. 2006; Makdissi et al. 2010; Randolph, Millis, Barr, McCrea, Guskiewicz, Hammeke, et al. 2009). Consequently, close observation and assessment of any individuals suspected to have sustained a concussion injury over some period of time is warranted. This is done to determine if there are evolving neuro-pathologic changes associated with the concussion which may lead, at a later date, to physical signs and symptoms or to the development of memory dysfunction (Kelly & Rosenberg 1997; Eckner & Kutcher 2010; Schneiders, Sullivan, Gray, Hammond-Tooke & McCrory 2010).

The grading of severity of a concussion injury is controversial. Although loss of consciousness (LOC) is a poor prognostic indicator for concussion it was previously regarded an important factor in the grading of concussion injuries (Lovell, Iverson, Collins, McKeag & Maroon 1999; Leininger, Gramling, Farrell, Kreutzer & Peck 1990). Decisions regarding the basing of grading concussion injuries and the subsequent return to play on LOC are now considered to be inaccurate (Bailes & Hudson 2001). The Cantu, Colorado and American Academy of Neurology (AAN) grading systems also do not take into account the presence or duration of impaired neuropsychological test performance (Hinton-Bayre & Geffen 2002).

This lack of clarity associated with different grading systems may have led to the incorrect use of the guidelines, and the subsequent inappropriate management of the concussed player (Lovell et al. 1999). In addition, mandatory exclusion periods based on the concussion grading are not supported by recent consensus statements. The recent Zurich Consensus Statement proposed abandoning both grading terminology and the guidelines for the grading of concussion injuries (McCrory et al. 2009).

2.5 ASSESSMENT OF CONCUSSION

The primary aim of the on-field assessment and management of suspected head injuries is to stabilise the individual. Basic aspects of first aid, including the assessment and maintenance of airways, breathing and circulation, as well as the protection of the cervical spine, are immediate priorities. This may be followed by a specific neurological assessment focusing on neurological deficit, mental status and cervical spine status (Herring et al. 2010; Adam & Craton 2002). The fieldside assessment should confirm a diagnosis of concussion, analyse initial symptoms and determine any urgent indications for referral to hospital, including skull fracture, penetrating skull trauma, deterioration in levels of consciousness and loss of consciousness for more than five minutes after injury (Patricios, Kohler & Collins 2010). Maddock's questions may be used either on-field or at the field-side in order to differentiate between concussed and non-concussed players (Maddocks, Dicker & Saling 1995). These questions, which include standard orientation item questions of time, place and person are, however, unreliable when used in isolation, as this component of cognitive function may be preserved.

The Sports Concussion Assessment Tool 2 (SCAT2) represents a standardised method of evaluating injured athletes for concussion (Appendix I). The SCAT2 supersedes the original Sport Concussion Assessment Tool SCAT, published in 2005 (McCrory et al. 2009; McCrory et al. 2005). The SCAT2, like the SCAT, is a brief neuropsychological test, and was formulated by taking eight existing tools and combining them into a standardised test (McCrory et al. 2005). The test was designed to assess acute neurocognitive impairment on the sideline and includes measures of orientation, immediate memory, concentration and delayed recall. It takes approximately five minutes to perform the test.

SCAT2 was designed for individuals with no existing expertise in neurocognitive testing. Orientation is assessed by asking the injured player to identify the time and date, including the day of the week, month and year. Immediate memory is assessed by asking the injured player to recall five unrelated words, while concentration is tested by asking the player to repeat a string of numbers in reverse order. A composite score out of 30 is derived from these different components of the test (Guskiewicz et al. 2006; McLeod et al. 2006). The SCAT2 is a reliable, repeatable and inexpensive measurement instrument for the assessment of concussion symptoms on the side of the sport field. The longer SCAT2 takes additional time to complete compared with the original SCAT and includes a more formal balance assessment component, the Glasgow Coma Scale (GCS), and a more in-depth, cognitive assessment (McCrory et al. 2005).

Nevertheless, these brief testing procedures should not replace formal neuropsychological testing, as the onset of concussion symptoms may be delayed for several hours after the initial injury. Accordingly, once the player is off the field, a more detailed history and physical examination are required (McCrory et al. 2009; Theye & Mueller 2004). In addition, concussion symptoms should be assessed using a graded symptom checklist immediately post-injury, two to three hours post-injury, and daily for 72 hours post-injury (Guskiewicz et al. 2006). It is also important to note that conventional Magnetic Resonance Imaging (MRI) and Computerised Tomography (CT) scans are normal following concussion injuries. However, either CT or MRI scans are recommended if structural intracranial lesions or diffuse cerebral oedema are suspected (Lee 2004).

The measurement of postural stability should be included in the post-concussion assessment. Concussion may be associated with acute balance deficits as a result of the potential involvement of the brain stem, which leads to either delayed or poor processing of vestibular and visual information (Guskiewicz, Ross & Marshall 2001). Postural stability may be assessed using the Balance Error Scoring System (Appendix 6). In this test, athletes are required to stand on an unstable base and maintain three different positions. A balance score is obtained by recording the amount of deviation from each set position. A baseline measurement of postural stability is required to determine the influence of other factors, for example, previous injuries to the ankle or knee. Changes in postural stability will usually resolve within three to five days after a concussion injury. However, it is recognised that

neurocognitive deficits may persist beyond the recovery of postural stability (Theye & Mueller 2004).

Traditional “pencil and paper” neuropsychological tests have been replaced by computerised neuropsychological tests. Computerised tests detect subtle changes in cognitive function and are more sensitive to cognitive deficits than traditional pencil and paper tests (Makdissi et al. 2010). There are a number of computerised neuropsychological assessment tools that are sensitive to transient disturbances in brain function, including memory learning, reaction time and information processing speed, and which may be used to assess concussion. Baseline data is important for the computerised testing of an athlete in order to establish pre-injury functional levels for all assessment tools (Theye & Mueller 2004). However, computerised neuropsychological tests should be used in conjunction with clinical tests. In a recent cohort study, 1015 Australian rules players underwent baseline computerised and clinical tests at the start of the season. Eighty-eight concussion injuries occurred during the season and, in 35% of cases, the computerised neuropsychological assessments were impaired for two to three days after the resolution of the clinical symptoms (Makdissi et al. 2010).

The Cog State Sport System computerised neuropsychological test was developed in Australia and is used by the South African Rugby Union (Patricios et al. 2010). The test is sensitive to mild cognitive changes, and measures psychomotor function, speed of processing, visual attention or vigilance, visual learning and memory, and verbal learning and memory. The test is simple, reliable, and relatively inexpensive to administer (Collie, Maruff, Makdissi, McCrory, McStephen & Darby 2003).

Saccadometry may be used to assess saccadic reaction time or latency following a concussion injury. Saccadic reaction time is the time it takes to identify an object, to process the information and then to react to the information. The time or latency reflects the operation of cerebral decision-making mechanisms. A concussion injury will adversely affect the saccadic reaction time. For example, there was a significant positive relationship between the saccadic latency time and the magnitude of head trauma sustained during a boxing match (Pearson, Armitage, Horner & Carpenter 2007). Although this test is more sensitive to changes in cognitive function compared to standard, computerised

neuropsychological tests, it is expensive and is, therefore, not widely available in clinical practice (Pearson et al. 2007).

The different methods for the assessment of concussion highlight the importance of using a multi-faceted approach when evaluating and managing a concussed player (Guskiewicz et al. 2006). It is important to assess baseline neuropsychological function, and to assess concussion symptoms and cognitive function regularly in order to monitor an athlete's progress during the recovery phase (Patricios et al. 2010). It is evident that there may be discrepancies between symptom resolution and the full recovery of neuropsychological function after a concussion injury (McCrory et al. 2009). The next section will discuss the management of an athlete with concussion, including return to play guidelines.

2.6 COMPLICATIONS OF CONCUSSION

Concussed athletes are at risk of developing complications following initial injury, particularly if the correct guidelines for management of the injury are not followed. In addition, a previous concussion injury may lead to an increased risk of further concussion injuries (Giza & Hovda 2001). Complications associated with concussion include convulsive motor phenomena, post-traumatic seizures, subdural hematoma, post-concussion syndrome, second impact syndrome, and death (Herring et al. 2010; Kushner 2001; Kelly, Nichols, Filley, Lillehei, Rubinstein & Kleinschmidt-DeMasters 1991).

Post-concussion syndrome (PCS) is the term used to refer to the constellation of symptoms reported in a subset of individuals who have sustained a concussion injury (Smith-Seemiller, Fow, Kant & Franzen 2003). These individuals may complain of a number of physical symptoms, for example, headaches, dizziness, nausea, visual disturbances, sensitivity to light and noise and fatigue, cognitive symptoms, for example, memory loss, poor concentration and reduced processing speed, and emotional/behavioural symptoms, for example, irritability, depression and anxiety (Gerber & Schraa 1995; Ryan & Warden 2003). These symptoms may persist for months, and even years, following injury. In addition, they may even become permanent and cause disability (Brown, Fann & Grant 1994; Gouvier, Cubic, Jones, Brantley & Cutlip 1992).

Although this cluster of symptoms has been termed 'late symptoms' because they are often reported either a few days, or even weeks, following the injury, symptoms such as headaches, dizziness, nausea, vomiting and drowsiness may be reported immediately following injury and are generally short lived (Bohnen & Jolles 1992). It is unclear whether the symptoms of PCS are as a result of alterations in both neurophysiology and neuropathology, secondary to the injury, or as a result of pre- or post-injury psychological factors (Szymanski & Linn 1992). It has been postulated that persistent PCS may be the result of multiple, premorbid, injury-related factors, and also postmorbid neuropathological and psychological factors (Alexander 1995; Bohnen & Jolles 1992).

Second Impact Syndrome occurs as a result of a second concussion injury occurring while the individual is still symptomatic from an earlier concussion (Kelly et al. 1991). The increased potassium concentrations, together with the hyper-metabolism that occurs following a concussion injury, render the brain more susceptible to cell death after a second sublethal insult of lesser intensity than the original trauma (Maroon et al. 2000). This is as a result of the loss of the autoregulation of intracranial and cerebral perfusion pressures (Fischer & Vaca 2004). In severe cases, this may lead to cerebral oedema, followed by brain herniation (Bey & Ostick 2009). Death has been reported as occurring within two to five minutes after the injury, and this usually does not allow sufficient time either to stabilise an athlete or to transport the athlete to an emergency department. The death of an individual in these circumstances may be far more rapid than when death is caused by an epidural hematoma (Cantu 2003).

Second Impact Syndrome normally occurs in athletes under the age of 20 years. Although there is some evidence to suggest that repeated brain trauma is a risk factor for Second Impact Syndrome (Randolph et al. 2009), the evidence is predominantly anecdotal. It is possible for Second Impact Syndrome to occur after a single concussion, particularly in children where diffuse cerebral oedema is a rare, but recognised, complication (McCrory et al. 2004). Second Impact Syndrome presents as a severe headache with nausea and vomiting. The symptoms become progressively worse, depending on the area of the brain affected by the increase in pressure, with death normally being caused by herniation of the brain stem (Randolph et al. 2009). Early identification of Second Impact Syndrome is required, and the condition may then be managed with intubated hyperventilation and

intravenous osmotic diuretics in order to lower the intracranial pressure. This will prevent a pressure build up on the brain stem as a result of the increased cerebral oedema. Surgery is usually ineffective and the general prognosis is poor (Cantu & Voy 1995).

Subdural hematoma is a common complication associated with repeated concussion injuries and is thought to be a major cause of brain swelling following a concussion injury (Kelly & Rosenberg 1997). The majority of such cases usually involve young males aged 16 to 23 years, who sustained a second head injury before the symptoms arising from the first head injury had been resolved. Kelly and Rosenberg (1997) determined that 10 out of 15 cases did not suffer loss of consciousness at insult but still suffered from a subdural haematoma. Eight cases were confirmed by means of brain CT scans after the second injury, and all eight cases revealed the brain swelling associated with a thin, subdural hematoma (Kelly & Rosenberg 1997).

It has been hypothesised that diffuse mechanical injury may have long-term effects, such as headaches, emotional lability, memory deficit and impaired executive functioning (Yang et al. 2008). Persistent neurocognitive deficits have also been identified after paediatric mild TBI's, and may negatively influence social and educational performance (McCrory et al. 2004). These deficits may be related to the cognitive maturation of the brain between nine and 18 years of age. The largest improvements in cognitive function, including mean response time, decision-making, working memory and learning ability test performances, occurred between nine and 15 years (McCrory et al. 2009).

2.7 MANAGEMENT OF CONCUSSION

The goals in managing an athlete with a concussion include the prevention of catastrophic outcomes, for example, second impact syndrome and severe head injury or death; in order to minimise the time away from competition; and to ensure a safe return to play (McCrory et al. 2009). Concussion management should begin in the preseason with baseline testing prior to participation in sport (Guskiewicz et al 2006; Theye & Mueller 2004). Wide inter-individual variability has been reported in studies investigating the reliability of baseline values on both the SCAT test (Shehata, Wiley, Richea, Benson, Duits & Meeuwisse 2009) and components of the SCAT2 test (Schneiders et al. 2010; Schneiders, Sullivan, McCrory, Gray, Maruthayanar, Singh, et al. 2008; Finnoff, Peterson, Hollman & Smith 2009; Riemann & Guskiewicz 2000).

Establishing 'normal' baseline values for each individual would assist in the speedy identification of concussion injury occurrence as well as providing the most reliable benchmark against which to measure recovery (Guskiewicz et al. 2006). Baseline testing also provides controls for extraneous variables, for example, attention deficit disorder, and for the effects of earlier concussions (Guskiewicz et al. 2004). The main components of concussion management include physical and cognitive rest until the symptoms resolve. Rest should then be followed by a graded exercise programme prior to medical clearance and a return to play (McCrory et al. 2009).

Previously the principles of concussion management depended on the classification of the severity of concussion injuries. As mentioned above, the grading of concussion injuries is controversial, and at least 16 different classification systems for head injury severity have been described (Collins, Lovell, Iverson, Cantu, Maroon & Field 2002). These systems were based predominantly on anecdotal evidence and, in most cases, have not been scientifically validated. The GCS, designed for the assessment of severe head trauma, is not sufficiently sensitive to provide for the easy and reliable grading of concussion injuries (McCrory et al. 2009).

Additional problems with concussion scales include difficulties in determining whether a momentary loss of consciousness has occurred, as well as the variations in

recommendations regarding the management of the injury and the criteria for return to play (McClincy, Lovell, Pardini, Collins & Spore 2006, Cantu 1986).

In addition, post-traumatic amnesia may only be diagnosed retrospectively and is, therefore, of little use in first aid evaluations. Accordingly, coaches and physicians utilise the scale that best suit their requirements and these may not correspond with the best medical management for the player (Patricios et al. 2010). The lack of validity of such scales, together with the consensus that the term of simple vs. complex concussions do not fully describe the entities, have led to the abandonment of the classification of the severity of concussion injuries (McCrory et al. 2009). Simple concussion is characterised by an uneventful progressive recovery within seven to 10 days with rest as the most important aspect of the management of simple concussion. On the other hand, complex concussion is characterised by symptoms lasting longer than seven to 10 days and is complicated by problems such as convulsions and the recurrence of symptoms associated with exercise or prolonged unconsciousness (McCrory et al. 2009).

The immediate management of concussion involves the basic aspects of first aid. The player should be removed from the field during this period, particularly if there has been any loss of consciousness, if the player is confused or if the mechanism of injury or symptoms suggests any possibility of associated spinal injury (Herring et al. 2010). In subtle presentations of concussion injuries, the administration of Maddocks's questions may be used to assess recent memory (Maddocks et al. 1995). Maddocks's questions include the following: Which ground are we at? Which team are we playing today? Who is your opponent at present? Which quarter is it? How far into the quarter is it? Which side scored the last goal? Which team did we play last week? and Did we win last week? (Maddocks et al. 1995).

Maddocks's questions have been shown to be more useful in discriminating between concussed and non-concussed players than the standard approach of asking orientation item questions, for example, time, place and date, as this component of cognitive function may be preserved in concussion (Maddocks et al. 1995; McCrea, Kelly, Randolph, Kluge, Bartolic, Finn et al. 1998). If concussion is suspected by answering the questions wrong, the player must be removed from the field of play or training session immediately. A return to

either play or training before further assessment has been carried out, or in the presence of concussion injury, are contraindicated (Guskiewicz et al. 2004; Herring et al. 2010).

Following removal from either the game or practice situation, a further assessment using the SCAT2 card should be performed in a quiet place. Based on the results of this assessment, the individual should be referred either to hospital for further investigation, or be allowed to return home. This is the reason baseline testing is extremely useful as it can determine whether the athlete is showing impaired signs. Definitive normative baseline “cut off” scores are not available at this time (McCrary et al 2005). In either situation, individuals must not be left alone and must be monitored continuously (McCrary et al 2005; Guskiewicz et al 2006). Home supervision requires the presence of a responsible adult as well as the provision of a set of information guidelines (Patricios et al. 2010).

During the period of recovery during which symptoms of concussion are still present, it must be emphasised that individuals must rest cognitively as well as physically. Activities that require concentration and attention, for example, school work or video or computer games, etc., may exacerbate symptoms and possibly delay recovery (McCrary et al. 2009). If these guidelines are adhered to, the majority of concussions resolve spontaneously within a relatively short period of time, usually within seven to 10 days after injury. However, the recovery time for children and adolescents may be longer (McCrary et al. 2005). Theye and Mueller (2004) reported that high school athletes showed deteriorated neurocognitive signs and also exhibited significant memory loss seven days post-concussion as compared to collegiate athletes who regained memory within a day and whose balance deficits returned to baseline between three and five days post-concussion. In addition, in the collegiate athletes, cognitive function returned to normal within five to seven days and other somatic symptoms resolved within seven days after the concussion had occurred. These findings indicate that guidelines should, potentially, be more conservative for children and adolescents as the developing brain in both children and adolescents may respond differently to concussion injuries, compared to the developed brain in adults. There are currently no evidence-based guidelines for the management of paediatric concussion injuries. It is, therefore, important that children, parents and emergency cover are educated regarding the risk of repeated concussion and secondary impact syndrome (Guskiewicz et al. 2006; Giza & Hovda 2001).

2.7.1 Hospitalisation

In the presence of persistent confusion, lethargy, focal neurological signs, abnormal findings on brain CT-scans or seizures, individuals should be hospitalised for further investigation (Kushner 2001). Imaging is not a conclusive tool with which to assess concussion. Studies have shown that plain film, CT or MRI investigations may not show any structural abnormalities as a result of the predominantly metabolic nature of concussion injuries (Adam & Craton 2002). Metabolic signs may include an inability to awaken the patient; severe or worsening headaches; confusion, restlessness, vomiting, fever, a stiff neck; urinary or bowel incontinence; and weakness and/or numbness involving any part of the body, especially the tongue and face (Guskiewicz et al. 2006; Aubry et al. 2002; Kushner 2001).

In addition, all children with head injuries, high-risk individuals, for example, haemophiliacs, and those individuals who have suffered a high-risk injury mechanism such as a high velocity impact and, therefore, have suspected skull fractures or spinal trauma, should be hospitalised (Patricios 2009). Admission should also be considered if there is no responsible person available to monitor the patient for any progression of symptoms (Kushner 2001).

2.7.2 Return to play

Expert consensus guidelines recommend that players should not return to play until they have recovered totally from their concussive injury (Makdissi et al. 2010). However, the problem with this recommendation is the fact that there are no direct objective measures of brain function that may guide return to play decisions by definitively indicating a return to pre-injury levels of brain function.

The final phase of a safe, structured and supervised concussion rehabilitation protocol involves the progressive exposure of the recovering individual to increasing degrees of exercise intensity while symptoms are carefully monitored (Guskiewicz et al. 2004; Aubry et al. 2002; Herring et al. 2010; Patricios et al. 2010). However, before this is embarked upon, the individual must be asymptomatic, have undergone a normal neurological examination and the neuropsychological data must have either returned to baseline or be comparable

with age-appropriate norms (Guskiewicz et al. 2006). This is usually the case when an individual has had sufficient physical and cognitive rest.

Progressive exercise loading should follow a stepwise process with stage-associated objectives in order to test whether the individual is ready to progress to the next level. This procedure will facilitate return to play protocols. These stages commence with light aerobic exercises, such as walking and stationary cycling, which allow for a gradual increase in the heart rate. Sport-specific training, which includes running drills and ball handling skills, follow the initial stage. Non-contact drills, which allow for coordination and cognitive loading exercises, should precede full-contact practice. This latter stage allows the athlete to build confidence and functional skills before returning to game play (Guskiewicz et al. 2004; Aubry et al. 2002; Herring et al. 2010; Patricios et al. 2010).

The individual should proceed in a step-wise manner to the following level 24 hours after have completed the previous level, providing he/she remains asymptomatic. If post-concussion symptoms reoccur during any stage of the process, the individual should rest for 24 hours, then return to the previous asymptomatic level before again trying to progress to the level at which the symptoms reoccurred (Aubry et al. 2002).

Same day return to play is a controversial issue, particularly in athletes whose symptoms have completely resolved (Herring et al. 2010). The recommended course of action is to keep an athlete out of any exercise if any form of concussion has occurred. Guskiewicz et al. (2004) suggest that players should be symptom free for at least one week after a concussion injury before the step-like approach is embarked upon to re-introduce them to sport. A study was conducted on 72 participants who were given a battery of tests to carry out within 21 days of concussion injury. Within seven days the post-concussion test scores had returned to baseline levels, thus indicating the return of normal function. This waiting period is often reduced by clinicians who feel that this process is too conservative, despite the fact that the one week waiting period has been reported to reduce the risk of injury recurrence (Guskiewicz et al. 2004). It was suggested that this period allows for complete healing to occur at a cellular level before the brain is exposed to the increased intra-cranial pressure as a result of exercise. However, the study did not control for inter-participant

variability through the use of pre-injury evaluation and merely compared values to normative data (Guskiewicz et al. 2004).

In addition, the inclusion criteria for the study included the stipulation that concussion must have been sustained during the preceding 21 days. This exceeds the seven to 10 day period in which symptoms have often returned to pre-injury baseline levels. A previous study by Guskiewicz et al. 2004 reported that postural stability problems resolved within three days post-concussion. It was, however, earlier discovered that neurocognitive factors may resolve only at a later stage (Guskiewicz et al. 2001). Other factors that may influence the time between injury and return to play include a previous concussion and also the number, severity and proximity of any concussions sustained between the concussive episodes (Soloman et al. 2006; McClincy et al. 2006).

It is recommended that a more conservative return to play protocol be used in children as the brain in children is still developing (McCrary et al. 2004; Yang et al. 2008). It is, thus, appropriate to extend the length of time of asymptomatic rest and graded exertion in children (McCrary et al. 2009; Kraus 1995). In addition, in sports where children between the ages of eight and 15 years may be at risk of concussion injuries, neurocognitive testing should be conducted at six month intervals. This will provide regular assessments of baseline cognitive function as maturational improvements may occur between the baseline testing and post-concussion testing and confound post-injury test results (McCrary et al. 2004).

There are two instances in which pharmacological treatment is advised in concussion. These two cases include the management of specific symptoms such as sleep disturbances, or the modification of the underlying pathophysiology with the aim of shortening the duration of the symptoms (McCrary et al. 2004). The drug of choice post-concussion is acetaminophen for immediate treatment (McCrary et al. 2004). This drug is used in view of the increased risk of non steroidal anti-inflammatory drugs causing increased cerebral bleeding and, therefore, haemorrhaging within the first 48 to 72 hours after the concussion. However, this increased risk of bleeding is theoretical and there are no clinical trials indicating that it may happen (McCrary et al. 2004).

The underlying pathology, as stated above, may possibly be treated with corticosteroids, calcium channel antagonists and drugs inhibiting arachidonic acid metabolism (McCrory et al. 2004). Corticosteroids have been used for many years in experimental neurotrauma as they stabilise lysosomal activity as well as reducing tissue oedema (McCrory et al. 2004). It has also been proposed that the entry of calcium through voltage dependent channels may contribute to secondary brain injury and, therefore, a calcium channel antagonist may inhibit this secondary damage from occurring (McCrory et al. 2004). The toxic breakdown of arachidonic acid metabolism may exacerbate central nervous system (CNS) injury. Studies with cyclo-oxygenase inhibitors (ibuprofen) have indicated benefits in animal models (McCrory et al. 2004). There is, however, no evidence based pharmacological treatment to offer to the concussed athlete (McCrory et al. 2004).

2.8 PREVENTION OF CONCUSSION

Previous concussion injury is recognised as a major risk factor for further concussion injuries as well for the development of associated complications (Shuttleworth-Edwards et al. 2008; Covassin, Schatz & Swanik 2007). The prevention of concussion injuries is, thus, of paramount importance. The use of protective equipment and the enhancement of skill levels, of players, may reduce the incidence of concussion injuries (Schulz, Marshall, Mueller, Yang, Weaver, Kalsbeek, et al. 2004).

Properly fitted and maintained helmets or headgear, mouth guards and face shields are believed to help in the prevention of concussion. Although protective headgear is obligatory and there is also supporting empirical evidence supporting its effectiveness in certain sports, for example, cycling (Thompson, Rivara & Thompson 2000), there is little consensus among researchers as to the effectiveness of protective headgear in many of the contact sports, including rugby, soccer and Australian rules football. In rugby, two studies found no significant differences in the concussion rates between players wearing protective headgear and those not wearing protective headgear (McIntosh et al. 2009; McIntosh & McCrory 2001) while two other studies reported a significant reduction in the concussion rate of players wearing headgear (Kemp, Hudson, Brooks & Fuller 2008; Kahanov, Dusa, Wilkinson & Roberts 2005).

In American football, two studies reported no measureable benefit as regards protective headgear (Torg, Harris, Rogers & Stilwell 1999; Alles, Powell, Buckley & Hunt 1979), while a further study reported a 31% reduction in concussion risk for players wearing updated helmets as compared to an older design (Collins et al. 2006). However, the differences in these findings may be as a result of different study populations, the use of different definitions of concussion, prospective compared to retrospective studies and the use of self-reporting rather than assessment by trained personnel. In addition, it has been suggested that players may believe that they are able to tackle harder and more confidently while wearing headgear and this may negate any potential benefits of wearing headgear (Finch et al. 2001). Athletes should, therefore, be educated regarding the appropriate use and purpose of protective equipment, but cautioned that it does not either prevent or protect against concussion (Marshall & Spencer 2001; Guskiewicz et al 2004; 2006; McCrory et al 2005; Herring et al 2006). Nevertheless, protective headgear may be beneficial in reducing the incidence of superficial scalp and facial injuries (Jones, Lyons, Evans, Newcombe, Nash, McCabe, et al. 2004).

Studies investigating the use of mouth guards have also produced conflicting results. Some studies have concluded that mouth guards may reduce the incidence of concussion (De Wet, Badenhorst & Rossouw 1981; McNutt et al. 1989; Stenger, Lawson, Wright & Ricketts 1964; Benson, Rose & Meeuwisse 2002) while others have reported no significant protective effects associated with the use of mouth guards (Blignaut, Carstens & Lombard 1987; Garon, Merkle & Wright 1986; Marshall et al. 2005; Benson & Meeuwisse 2005; Labella, Smith & Sigurdsson 2002). However, anecdotal evidence has suggested that mouth guards may be useful in reducing concussion following impact forces to the mandible (Stenger et al. 1964; Hickey, Morris, Carlson & Seward 1967), with more recent biomechanical evidence supporting this theory (Chalmers 1998; Barth, Freeman, Broshek & Varney 2001). These variations in the findings regarding the effectiveness of mouth guards in reducing concussion may be as a result of methodological limitations, including self-selection bias, retrospective self-diagnosis of concussions, temporal association and the use of different types of mouth guards. Some studies utilised mouth-formed guards while others focused on mouth guards that were either custom made or bimaxillary (one piece covering upper and

lower teeth). It may, thus, be beneficial if future studies were to specify exactly which type of mouth guard was being investigated (Chalmers 1998).

The majority of concussion injuries result from contact phases of match play with the main causes being the tackle (24–58%), ruck (6–17%), maul (12–16%), collision (8–9%) and scrum (2–8%) in senior and elite rugby players (Bird et al. 1998; Targett 1998; Bathgate et al. 2002; Brooks et al. 2005; Best et al. 2005; Kemp et al. 2008, Lee & Garraway 1996, Bottini et al. 2000).

A recent study demonstrated that, while tackles caused five times more injuries than any other type of contact event (33.9 injuries/1000 playing hours), collisions had a greater propensity to cause injury (10.5 injuries/1000 events) (Fuller et al. 2007). However, the tackle is the most common contact event and this may explain the consistent finding that tackles are responsible for the highest number of injuries and the most lengthy “time off” play in rugby union. Collisions are far less common than tackles, but are 70% more likely to result in an injury than a tackle. Despite Law 10.4(g) of the International Rugby Boards laws and regulations which identifies charging or knocking down an opponent without trying to grasp the player as dangerous play (International Rugby Board 2006), referees do not always penalise these events (Fuller et al. 2007). Soccer has also been shown to have a high incidence of concussions as a result of unintentional collisions (Boden, Kirkendall & Garrett 1998).

The major preventative action in decreasing concussion would be rule changes (Fuller, Ashton, Brooks, Cancea, Hall & Kemp 2010) and, in fact, since stricter rules have been applied to high tackles in rugby and when the number of players allowed in an area was altered in lacrosse, the incidence of concussion injuries in these sports was reduced (Fuller et al. 2010; Covassin, Swanik & Sachs 2003b). In addition, a lack of tackling skill is thought to be a risk factor in catastrophic cervical injuries and concussion; while a lack of skill in contact situations may be associated with the increased incidence of concussion in school athletes (Garraway et al. 1999). It is, thus, essential that players be trained in effective and safe tackling techniques in order to reduce the risk of concussion injuries being sustained. This includes factors such as placing the head in the safest place, fully committing to a tackle,

dominating the tackle situation and practising evasive techniques to reduce the magnitude of collision forces when being tackled (McIntosh & McCrory 2005).

2.9 PHYSIOTHERAPY IN SPORT

2.9.1 On-field physiotherapy services and scope of practice

The physiotherapy profession has developed rapidly over the years, incorporating a progressively greater depth and breadth of knowledge and skills (Bennett & Grant 2004). There is wide recognition of sports physiotherapy as a specialisation, with many national organisations having collaborated to form the International Federation of Sports Physiotherapy (IFSP) in 2000 (Bulley & Donaghy 2005a). A sports physiotherapist works with athletes and teams on the field of play, as well as with athletes who have sustained injuries in physical and sporting environments. Bulley and Donaghy (2004) define a sports physiotherapist as follows:

A recognised professional who demonstrates advanced competencies in the promotion of safe physical activity participation, provision of advice, and adaptation of rehabilitation and training interventions, for the purpose of preventing injury, restoring optimal function, and contributing to the enhancement of sports performance in athletes of all ages and abilities, while ensuring a high standard of professional and ethical practice.

This definition encompasses eleven competencies describing different roles within the professional framework of sports physiotherapists (Bulley & Donaghy 2005a). Broadly speaking, these roles include those of manager, advisor, professional leader and innovator. This, in turn, illustrates the multifaceted role of the physiotherapist on the sports field (Bulley & Donaghy 2005b). In practice, this multifaceted role includes preventative management; for example, warming up players, strapping, massage, and checking that venue conditions, such as playing surfaces, are adequate; provision of sideline first aid, examination; assessment of injury extent and decisions as to whether players may continue as well as administering the necessary treatment (Zuluaga 1995).

Students regularly provide first aid and physiotherapy services at sporting events as part of the clinical placement component of their course (Bennett & Grant 2004). Although it is debatable whether such students are qualified to diagnose concussions, given that many will have undergone basic first aid training only, it is, nevertheless, essential that they be aware of the need to refer concussion, when necessary, to physicians. It is, thus, important that these students are aware of their role and that they are able to make appropriate decisions in order to prevent catastrophic outcomes (Patricios et al. 2010; Osborne 2001).

2.9.2 On-field physiotherapy as part of the undergraduate curriculum

Universities in South Africa have varied curricula demands with regards to the time spent on concussion. The data required in order to assess the time to be spent by the undergraduate students at various universities were obtained from the course coordinators as there was either no, or very limited, information available on the university websites. Students are required to have 1500 hours of practical experience across all fields of physiotherapy cumulatively in order to graduate. It emerged from the course coordinators for the various universities that there is a huge variance in the amount of work required on field management and concussion. Certain universities offered as many as five lectures, each consisting of two hours, for their fourth year students on sports injuries, of which one lecture only was on field-side physiotherapy, including concussion. The curriculum for the third-year students recommended that they spend time working with interfaculty rugby teams where they are likely to experience concussive cases. However, this work is purely voluntary and the universities do not have any data on the total number of hours spent carrying out the work. Another university did not dedicate any lecture time to concussion during its undergraduate curriculum. However, the university's third-year students are required to spend 20 hours working with a sports team while the fourth-year students' work with sports teams on a voluntary basis. The fourth-year students do spend time on concussion in one of their tutorials during their sports teaching module. As regards the postgraduate students, part of a two-hour lecture dedicated to sporting emergencies is on concussion.

The other universities allocated minimal time to concussion. It fell under head injuries in sports during their fourth year of study although there was no specific lecture time allocated to concussion and the topic comprised a small part only of the injuries in sports lecture given. The students were also encouraged to spend time observing qualified physiotherapists with the third and fourth year students receiving their practical experience mainly at endurance sport. Some second year students, usually those who were more motivated and at their own volition, apparently spent time performing first aid duties or working with physiotherapists at sporting events. Because these students would not have been exposed to any formal lectures on field-side physiotherapy or concussion, they were included in the study to ascertain whether their knowledge levels were sufficient for them to undertake these roles safely. This information was obtained by consulting with the course co-ordinators at the universities that were used in the study. The course co-ordinators were asked if any time was spent on concussion, how much time was spent on it and during which teaching module the time was spent on concussion. However no formal review of the curricula was conducted to get this information.

2.9.3 Medico-legal considerations

The recognition and treatment of concussion on the sports field remains one of the most problematic issues for both coaches and team physicians. There are legal as well as medical issues involved in allowing an injured player to continue participating and there is always the threat of a lawsuit if inappropriate decisions are made (Osborne 2001).

Negligence law allows for the compensation of those who are harmed by either failure or carelessness. The person who was harmed must prove that all four of the following four elements of negligence were present. The first element to be proved is that a “duty of care” existed between the parties concerned. Accordingly, the coach and team physician have a duty to the players to protect their health and safety. In concussion, it is important to assess the patient’s condition properly, to ensure that the proper medical treatment is obtained, to provide clearance before participation in the game/sport involved and to inform the patient, before participation, of the possible risk factors (Osborne 2001).

The second element of negligence involves proving that the duty owed to the injured party has been breached. In order to assess whether such a breach has occurred, the coach or physician are measured against “reasonable person standards”. This standard of care is established by expert testimony based on Athletics Training Certification Boards and standardised training programmes. The standardised return to play programme is currently not accepted as the “gold standard” for concussion management and it is, therefore, difficult to establish the legal standard of care as regards concussion (Osborne 2001).

The third element involves proving that the breach caused harm to the injured party, for example, a concussed athlete was allowed to participate in either training or a competition, or else a concussed athlete was inadequately assessed. The fourth element involves proof that that actual harm has taken place and that the athlete was injured as a direct result of the coach or medical physician’s actions or lack thereof (Osborne 2001).

It is, therefore, important that all the members of a multi-disciplinary team, including physiotherapy students, understand the ethical and medico-legal implications of the correct management of concussion injuries. This is necessary in view of the fact that physiotherapy students work on the side of the sports field. Nevertheless, they are supposed to be under the direct supervision of qualified personnel but, as stated earlier in this study, this is, unfortunately, not always the case.

2.10 MEASUREMENT INSTRUMENTS WITH WHICH TO ASSESS KNOWLEDGE OF CONCUSSION

Questionnaires provide an objective measurement of knowledge, beliefs, attitudes, and behaviour (Oppenheim 1998). There have been no previous studies conducted to assess the knowledge of physiotherapy students regarding the diagnosis, assessment and management of concussion. Accordingly, a questionnaire was devised to address the aims and objectives of this study. The content validity of the questionnaire was assessed using a panel of experts on concussion. Content validity is the degree to which an instrument explores all the areas identified by relevant literature (Jensen 2008). In addition, the feasibility of the

questionnaire was assessed by conducting a pilot study on a small, representative sample of physiotherapy students ((Boynton & Greenhalgh 2004).

The criterion for adequate knowledge was set at 75%. This figure is used because it is accepted that this level of knowledge is sufficient to deal with life-threatening situations (Parker et al. 2009). This criterion has been used in previous studies which investigated the revised pain knowledge and attitudes questionnaire administered to final year health sciences students (Parker et al. 2009). The same criterion has been used in previous studies conducted in health sciences departments (Chiu, Trinca, Lim & Tuazon 2003; Mackintosh & Bowles 2000; McMillan et al. 2005; Rochman 1998; Strong, Tooth & Unruh 1999), while another study considering the assessment of newly qualified medical graduates set the competence level at 85% (Burch, Nash, Zabow, Gibbs, Aubin, Jacobs, et al. 2005).

2.11 SUMMARY OF THE LITERATURE

Concussion is prevalent in contact sports with incidences reported across all levels of play and involving all age groups (Bird et al. 1998; Bathgate et al. 2002; Gissane et al. 1997; Phillips et al 1998; Marshall & Spencer 2001; Gerrard et al. 1994; Finch et al. 2001; Durie & Munroe 2000). Concussion injuries occur as a result of either a direct or an indirect blow to the head, face, or neck or elsewhere on the body that causes a force to be transmitted to the head, thus resulting in a cascade of neurochemical changes in the brain (McCrory et al. 2009). These changes, in turn, result in a combination of somatic, cognitive and emotional signs and symptoms, some of which present immediately and some after a number of hours (Guskiewicz et al. 2006; Lee 2004; Aubry et al. 2002; Herring et al. 2010). Concussed athletes are at risk of developing complications following the initial injury, particularly if the correct guidelines for management are not followed (Giza & Hovda 2001). It is, thus, important that concussions are recognised and managed correctly so that those individuals who have sustained a concussion are not exposed to further risk during the recovery stage.

Much of the research has focused on the identification and management of concussion injuries and there have been a series of international consensus statements published since 2001 (McCrory 2006). The consensus statements highlight the importance of player safety

and propose that a multifaceted approach be used in the assessment and diagnosis of concussions and, thereafter, in the management of the concussed individual (McCrory 2004). The goals of managing an athlete with a concussion include the prevention of catastrophic outcomes, for example, Second Impact Syndrome, severe head injury or death, in order to minimise the time away from competition; and to ensure a safe return to play (McCrory et al. 2009). Premature return to play (RTP) may have a number of potentially deleterious effects in terms of physical wellbeing, cognitive function and the increased likelihood of suffering a subsequent catastrophic concussion (Guskiewicz et al. 2004; Aubry et al. 2002; Herring et al. 2010; Patricios et al. 2010; McCrory et al. 2005).

Physiotherapy students regularly provide event first aid and physiotherapy services as part of the clinical placement component of their course. However, it is questionable whether South African universities allocate sufficient time within their curricula to concussion. There is also insufficient literature available to be able to determine whether physiotherapy students possess adequate knowledge to enable them to diagnose and provide immediate management and the appropriate referral of concussion injuries. Accordingly, the main aim of the study was to determine those factors that would enable second, third and fourth year physiotherapy students to diagnose, assess and manage concussion correctly.

Chapter 3

Methods

3.1 PARTICIPANTS AND STUDY DESIGN

This study utilised a descriptive, cross sectional design. The study was submitted and approved by the Faculty of Health Sciences Human Research Ethics Committee, University of Cape Town REC/359/2007 (Appendix 8). There were an estimated 1050 possible students who could, potentially, have participated in the study. This figure was calculated by taking into account the eight universities in South Africa which offer physiotherapy as a course. The study was open to all second, third and fourth year students at these eight universities. It was estimated that there are 50 students per class, thus providing a total of 1050 possible students who may have completed the questionnaire.

The Heads of Department for Physiotherapy were contacted via e-mail and a letter was sent to them explaining the purpose of the study to obtain their permission to approach their students (Appendix 1). They were informed that there would not be a comparison made between the universities with the aim of differentiating between the knowledge of the students at the respective universities. Positive responses were received from six of the universities. The universities that were situated outside of Gauteng were asked to administer both the questionnaires and the informed consent forms to their students. The questionnaires and informed consent forms were then delivered to the universities. All the student participants were required to complete an informed consent form prior to completing the questionnaire (Appendix 2). The informed consent form explained the purpose and procedure of the study, the way in which confidentiality would be ensured, and the right to withdraw from the study without reason or prejudice.

3.2. SAMPLE SIZE CALCULATION

As a result of the nature of the data captured internet-based sample size calculators were used. There were three such sample size calculators used. These were from researchinfo.com (<http://www.researchinfo.com/docs/calculators/samplesize.cfm>), Macorr (http://www.macorr.com/ss_calculator.htm), and Survey systems (<http://www.surveysystem.com/sscalc.htm#one>). The possible population size was estimated to be 1050, as discussed earlier. The confidence interval was 5% and the confidence level 95%. The three sample-size calculators all gave the same reading of 281. This implied that 281 students had to complete the questionnaire to ensure that statistical significance was possible when analysing the data.

3.2.1 Inclusion criteria

The inclusion criteria were second-, third- and fourth-year physiotherapy students who were studying at universities in South Africa.

3.2.2. Exclusion criteria

Universities at which fewer than 30 students were available though out the university or where all the years of study were not represented were excluded.

3.2.3. Recruitment

The students were recruited through seven of the universities that had been approached. In addition, it was necessary that they meet the inclusion criteria. The Heads of Department were contacted and a letter outlining the study was sent to them, together with the study proposal and the initial ethical clearance letter. They were then asked whether it would be possible for the researcher to approach their students and also what the best method would be to administer the questionnaire to the students. University A requested that the researcher administer the questionnaires to the relevant students himself while the

questionnaires at Universities B, C and D were administered by the lecturers associated with each year of study. The questionnaires and the informed consent were, thus, dispatched to these universities which, in turn, administered the questionnaires. The lecturers were all instructed that the questionnaires had to be filled in as if under an examination situation and that the students would not be allowed to take the questionnaires home. The students were instructed that participation was voluntary and they did not have to participate in the survey. They were also requested to fill in the informed consent form.

3.2.4. Concussion questionnaire

A questionnaire was designed to assess second-, third- and fourth-year physiotherapy students' knowledge of the diagnosis, assessment and management of concussion (Appendix 3). The questionnaire was divided into separate sections to assess different aspects of participants' knowledge of concussion as well as associated factors that may predict this knowledge. Section A was descriptive, and included questions regarding the year of study, the institution where the participants were studying, gender, age, exposure to field side assistance and first aid qualifications. Section B assessed the participants knowledge on the diagnosis of concussion and their familiarity with the tools necessary to assess concussion. There was one mark allocated to the questions in this section. Section C addressed the management of concussion and two marks were assigned per question here. Section D assessed the consequences if concussion were not managed properly. Again two marks were allocated per section here. Section E dealt with the return to play guidelines and four marks were allocated per section. The questionnaire was administered only in English.

3.2.4.1. Validity of the concussion questionnaire

A panel of experts in the field of sports concussion reviewed the questionnaire to ensure both content and construct validity. Three medical professionals were recruited to the validation panel. Two of these were medical doctors, and one was a leading sports physiotherapist, who had 15 years of experience in working with a provincial Currie Cup Rugby team. One of the medical doctors had been head of the South African Sports Medicine Association (SASMA) and head of the concussion centres in Rosebank and Morningside in Johannesburg. He had also attended the Second and Third World Congresses on Concussions held in Prague in 2004 and Zurich in 2008. The second medical doctor is at the Western Province High Performance Centre in Cape Town. He has extensive experience working with rugby related injuries and has been the medical doctor for both the Stormers and Western Province professional rugby teams. The validators were requested to comment on the relevance and importance of the questions, and whether the questions were clear and easy to understand. They were also asked to indicate whether they agreed with the answers to the questions. In addition, the validators were requested to provide input regarding those areas or questions that had not been included in the questionnaires and that may have contributed to the assessment of the participants' knowledge of concussion.

The validators recommended that certain questions be either removed from the questionnaire as they were ambiguous or that the wording of these questions be changed. The main ambiguous question identified, was question 9 where the validators had felt that it was confusing to place the correct numbers between two and seven. They had, thus, recommended that the "most important" answer the students felt were correct only be rated. There were also some questions that were removed by their recommendation while others were added in (Table 3.1). They also recommended that certain wording be changed to make the questions clearer and more relevant. Overall they were of the opinion that "it is a very good question paper and could yield some very interesting responses" (Dr Jon Patricios 2010).

Table 3.1: Questions added and removed after consultation with experts in the concussion field.

Questions removed	Questions added
16. Torsion forces may cause concussion	26. The diagnosis of concussion is a clinical one requiring assessment by a doctor
23. Neuro psychological testing alone are used for sideline assessment	22. Computerised Neuro-psychological testing alone are used for sideline assessment of concussion
39. Choose the most common sequel to repeated concussion that may appear later on in life	39.If a concussed player was removed from play, select which of the following will assist you in deciding when the player can return to play

3.2.4.2. Feasibility of the concussion questionnaire

The initial feasibility of the questionnaire was ascertained by asking a panel of experts to assess and to validate the questionnaire. Their input regarding whether the study was viable was also requested. They all reported that they felt that the study would be viable and that they were keenly awaiting the results of the study. The feasibility of the study was further established by approaching 49 third year physiotherapy students at the University of the Witwatersrand. This was the first group of students to be approached. Both the questionnaire and the informed consent were administered. They all completed both and, on completion, were asked if there were any changes they would recommend. They were all satisfied with the informed consent. However, as regards the questionnaire they indicated that they had found some of the questions difficult to answer as they had not understood the terminology. This was the case as regards second impact syndrome and certain of the symptoms of concussion. However, they all reported that they had been able to answer the questionnaire to the best of their knowledge. The terminology of second impact syndrome and symptoms of concussion all play a major part in understanding the knowledge of concussion. The questionnaire was therefore not changed after administering it to the 49

third year physiotherapy students at the University of the Witwatersrand. Therefore their results were included in the study.

3.2.4.3. Safe management of concussion

One of the important objectives of the study was to determine whether second-, third- and fourth-year physiotherapy students possessed sufficient knowledge of concussion to ensure that they were able both to diagnose concussion and to make the correct management decisions to keep players suffering from concussion safe. The mark required for safe adequate knowledge in dealing with concussion was set at 75% as discussed earlier in the literature review (Parker et al 2009). There were marks allocated to each section of the questionnaire according to importance as explained in Section 3.2.4.

Table3.2: Mark allocation for each section of questionnaire.

Section	Marks allocated/ Section
A- Descriptive information	12
B- Diagnosis	32
C- Management	32
D- Consequences	16
E- Return to play	8

The questions were allocated with specific marks and certain questions that were deemed important by the panel of experts had negatives marks assigned to them. This can be seen in Appendix 3 where the mark allocation appears in []. Where no marks were allocated no scores are put in for those questions.

3.2.5. Procedure

Once the questionnaire had been validated, students were contacted through the universities, as discussed earlier. The questionnaires for the second- and fourth-year students at University A were handed out and collected by a physiotherapist who was associated with the researcher conducting the study. The other physiotherapist was a colleague of the researcher. Prior to data collection, administration of the questionnaire was discussed in detail and the other physiotherapist given full and detailed instructions on the specific protocol and procedures required. He was in full contact with the researcher throughout administration of the questionnaires. Similar briefing sessions were conducted with specific lecturers who had agreed to administer the questionnaires at Universities B, C and D when the researcher or associated physiotherapists were not present. These individuals were also in full contact with the researcher throughout data collection.

The third-year students received the questionnaire from the researcher himself. The questionnaires for Universities B, C and D were all printed in Johannesburg and then distributed to the universities through Postnet courier offices. The students were required to provide their written, informed consent (Appendix 2) before completing the concussion questionnaire (Appendix 3). Both the informed consent form and the concussion questionnaire were then returned to the researcher who collected them personally from the relevant departments. The data were then captured by the researcher on an Excel spread sheet. The questionnaires were coded and filed to address any queries that may arise in the future. In addition, to ensure further confidentiality and anonymity no contact details were included in the questionnaire.

3.2.6. Statistical analyses

Statistical analyses were performed using Statistica software (StatSoft, Inc. 2004). STATISTICA (Data analysis software system, version 8. www.statsoft.com). The initial data were analysed by means of frequency tables. Pearson's chi-square measures of association and percentages were used for the descriptive information. The descriptive data were presented in the form of both the mean and the standard deviation ($X \pm SD$). Independent-samples *t* tests were performed to compare differences within groups. A one-way analysis

of variance (ANOVA) was used to determine differences between the groups as regards parametric data, for example, the effect of years of study, first aid qualification and previous on-side field management on the participants' knowledge of concussion.

The overall mark given out of 100 was also divided into descriptive data (12) and marks achieved on the questionnaire (88) in regards to knowledge. This was then analysed using (ANOVA) in relation to the year of study. The first analyses looked at descriptive data (12) in relation to year of study. The second analyses looked at the knowledge marks achieved on questionnaire (88) in regards to the year of study and the third analyses looked at the overall mark (100) in relation to the year of study.

The confidence intervals were 0.95 and statistical significance was accepted as $p < 0.05$.

3.3 LIMITATIONS OF THE STUDY

There were a number of limitations that came to light during the study. The major issue is that the questionnaire was only administered in English. This could lead to bias in the students who did not have English as their home language as the terminology used in the questionnaire was very specific for concussion. Another factor was that the data was not all collected at the same time during the year and the curricula of the Universities were not all stream lined to cover the work at the same time.

Other issues such as the students answering the questionnaire to the "best of their ability", having the opportunity to have field side experience and having to completed first aid training in a certain year of study can also limit the results of the study.

The study also only is currently valid for South Africa as no research regarding international curricula has been conducted.

Chapter 4

Results

4.1 DESCRIPTIVE CHARACTERISTICS

Seven universities were approached to participate in this study with five of these universities agreeing to take part. One university was excluded as only 20 students had indicated their willingness to participate, leaving a sample of four universities. One of the seven universities approached did not respond to requests for access to its students, while the students from another university were unavailable at the time of the data collection. Accordingly, a total of 344 students from four universities participated in this study (Figure 4.1).

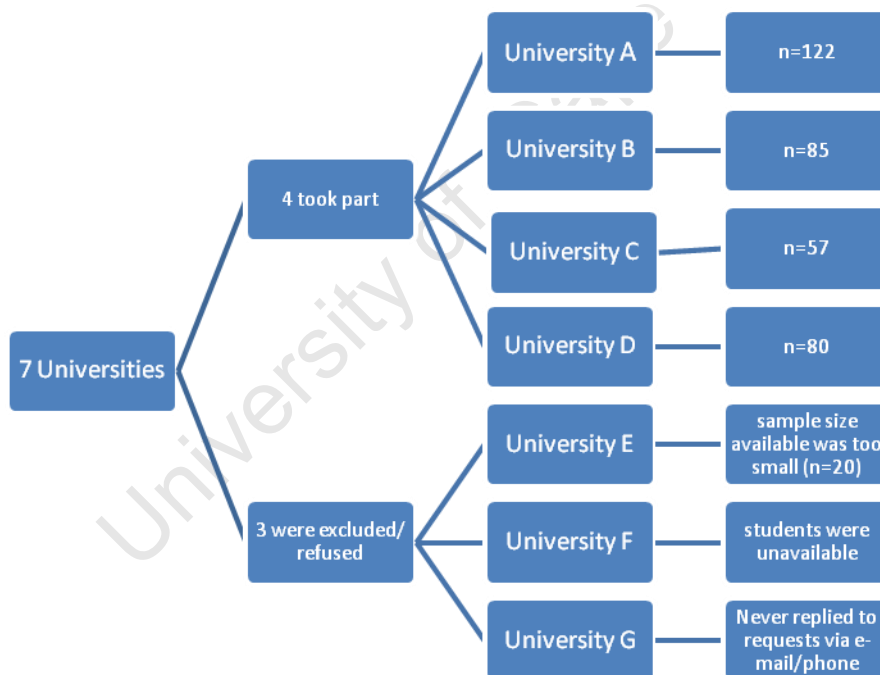


Figure 4.1 Flow diagram of recruitment process.

The majority of the participants were female (n = 269, 78.2%), while the average age of participants was 21.4 ± 1.6 years (range: 18 to 29 years). The participants were evenly distributed across the final three years of undergraduate study, with 34.3% of the participants in second year, 35.5% in third year, and 30.2% in fourth year. Two hundred and sixty-eight participants (77.9%) had completed first aid training. The majority of participants

had a Level 1 first aid qualification (74.7%), 13.8% had a Level 2 qualification while 11.5% had a Level 3 or higher qualification.

4.2 ON-FIELD PHYSIOTHERAPY EXPERIENCE

One hundred and forty-five of the participants (42.2%) had performed on-field physiotherapy. Of these, 52.1% had worked with clubs, 42.2% with high school teams, 2.8% with primary school teams, and 2.1% with professional teams. Of the 145 participants who had performed on-field physiotherapy, 114 (78.6%) had had their practice supervised while, of those supervised, 50% had been supervised for 80 to 100% of the time (Figure 4.2).

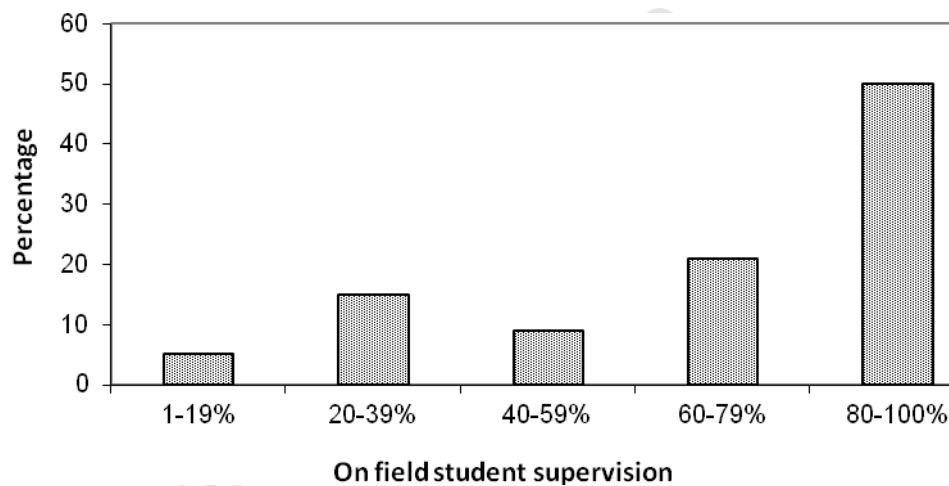


Figure 4.2 Percentage of time of on-field student supervision (n = 114).

4.3 EDUCATION AND TRAINING ON CONCUSSION

Three hundred and four participants completed the section relating to education and training on concussion. It emerged that the participants had obtained their knowledge on concussion from formal lectures (31.6%), television (25.7%), qualified physiotherapists (11.1%), fellow students (10.5%), courses (8.5%), print media (4.9%), the internet (4.2%), library resources (3.3%), and personal experience (0.3%). The majority of the participants

were aware of the importance of recognising concussion, with 81.2% of participants indicating this aspect as “very important” and 13.2% as “important”.

4.4 DIAGNOSIS OF CONCUSSION

The average mark for the diagnosis of concussion is 45.9%. Of the students who answered those questions that specifically addressed the mechanisms of concussion injury, only 34.1% were aware that concussion does not have to be caused by a direct blow to the head and 60.6% of students knew that concussion can be caused by linear acceleration-deceleration forces. The section included questions as to whether a direct injury was required in order to cause concussion and what type of forces would cause concussion. It emerged that 11.6% of students were aware of the correct answer to imaging and 80.2% of students were aware of the correct answers to the diagnostic questions. These questions dealt with issues including whether MRIs and other visualising imagery are conclusive diagnostic tools and what other diagnostics tools are available, for example, SCAT cards and balance tests. In addition, only 2% of the students were aware that concussion is no longer graded. Just under 36% of students possessed some knowledge of second impact syndrome, while 47.8% of the students understood that the diagnosis of concussion needs to be undertaken by a doctor in order to ensure that the correct diagnosis is made (Figure 4.3).

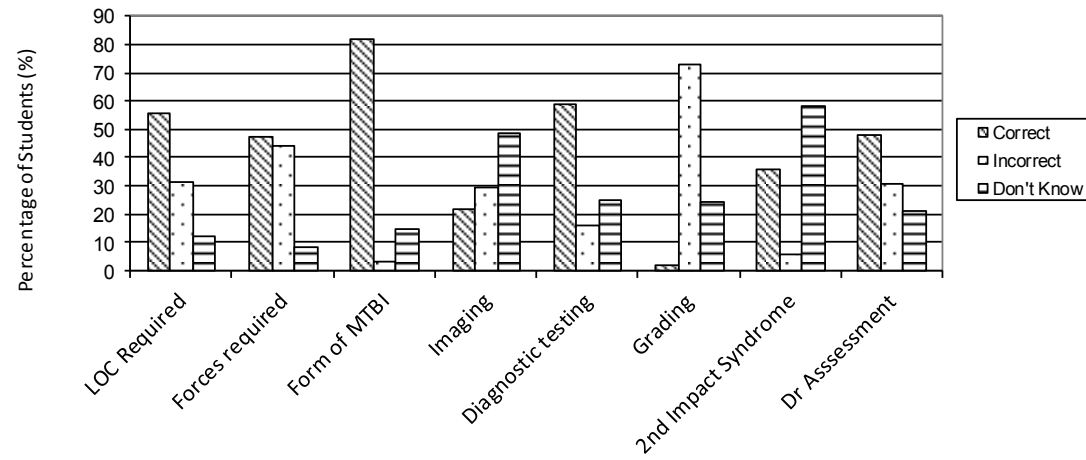


Figure 4.3 Percentage of correct, incorrect and don't know answers regarding the diagnosis of concussion.

The students were required to identify six symptoms of concussion from a list of 15 possible symptoms. These 15 possible symptoms included 10 correct answers and five incorrect answers. The students provided a total of 1892 answers. Of the 1892 answers provided, 96.1% correctly identified the symptoms of concussion. However, it must be noted that, as a result of the ratio of 2:1 for correct: incorrect answers there was a bias towards the correct answer. The five most frequently diagnosed correct symptoms of concussion included dizziness (93.9%), headaches (92.7%), balance impairment (88.7%), nausea (79.7%) and retrograde amnesia (52.9%) (Figure 4.4).

University of Cape Town

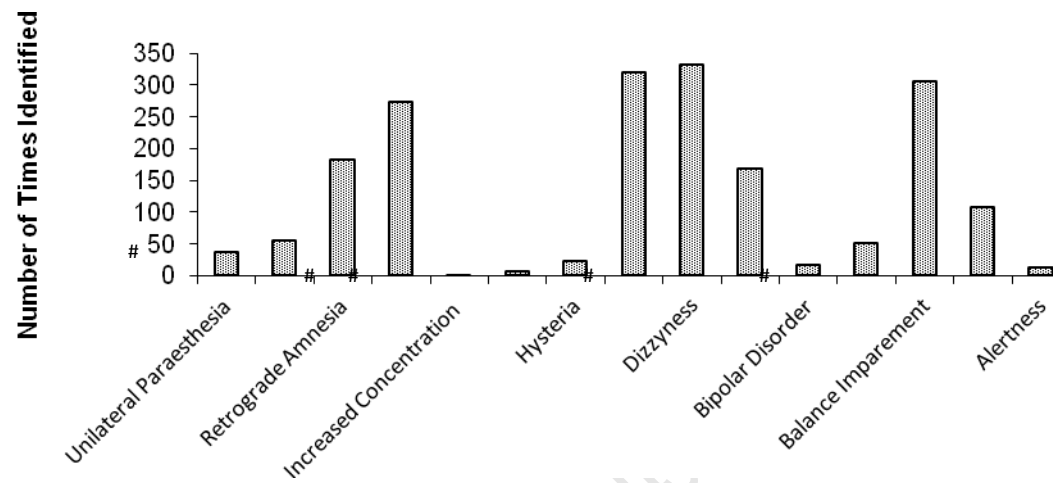


Figure 4.4 Concussion symptoms identified by students (# denotes incorrect symptoms of concussion which were answered by students).

4.5 MANAGEMENT OF CONCUSSION

The average correct mark for this section was 47.7%. Although 88.1% of students were aware that a player suffering from concussion must be removed from play immediately, only 30.3% correctly identified the fact that the severity of the concussion is not a factor in this decision. A relatively high proportion of students (27.1%) indicated that they allow a concussed player to continue if the player reported “feeling fine”. A large majority of students (68%) were either incorrect or not aware that Second Impact Syndrome was a risk if a second concussion was sustained in the same match.

The knowledge of the management of adolescent concussion was poor with only 22.2% of students being aware that there is a difference between treating adolescent and adult concussion. Another 43% of students were correct in indicating that, if an adolescent player was asymptomatic after 15 minutes, then the risk of re-injury was negligible. In addition, 52.1% of the students were either not aware or did not know that it is inappropriate to administer analgesic medicine post-concussion (Figure 4.5).

“Return to play (RTP) if the coach insisted” was considered the least appropriate principle of management once concussion has been diagnosed at the time of injury (44.3%) (Table 4.1). The next least appropriate form of management was “remove from play” with 21.4% of students providing that answer.

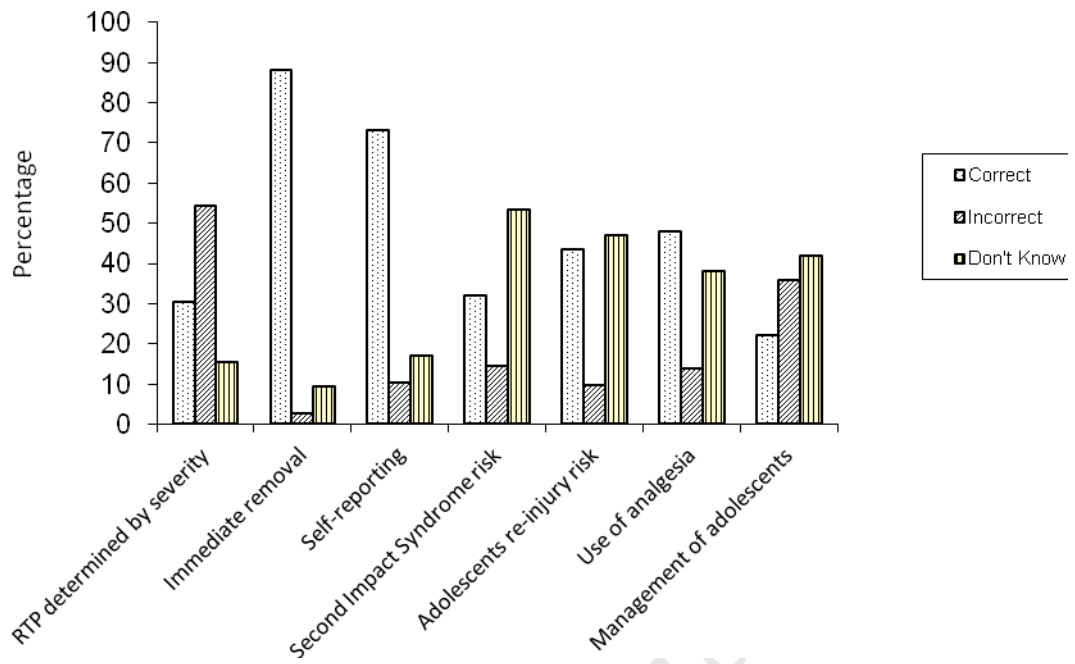


Figure 4.5 Frequencies of answers that are correct, incorrect or don't know for concussion management.

Table 4.1 Frequency of least appropriate principle to determine management at time of concussion. (336)

	Count	%
Continue to play if no LOC	69	20.5
Hospitalisation	29	8.6
Asymptomatic for 15 minutes – RTP	17	5.1
Remove from play	72	21.4
RTP if coach insists	149	44.4

4.6 CONSEQUENCES OF REPEATED CONCUSSION INJURIES

The average mark for this section was 29.6%. Relatively few students correctly identified that Post Concussion Syndrome may occur in both adults (22%) and children (19%), with only 9.4% of students being aware that death may result from Second Impact Syndrome. In addition, 45.4% recognised that Second Impact Syndrome is as a result of a player sustaining further concussion during a match or before the initial concussion resolved completely.

4.7 RETURN-TO-PLAY (RTP) PROTOCOLS

The average mark for this section was 63.2%. Two questions focused on RTP principles, namely Q 39 and Q40. Of the 344 students who completed these questions, 60.9% understood that a player must be clinically clear and have passed a neuropsychological testing before being allowed to RTP. In addition, 65.4% of the students correctly identified that concussion cases should be examined frequently by a doctor before an individual is cleared for play.

4.8 COMPARISONS BETWEEN DIFFERENT YEARS OF STUDY

4.8.1 Descriptive data

There were significant differences between the descriptive scores for the different years of study groups ($F(2,341) = 152.11, p < 0.05$). Figure 4.6 illustrates that the descriptive scores increased as the year of study increased.

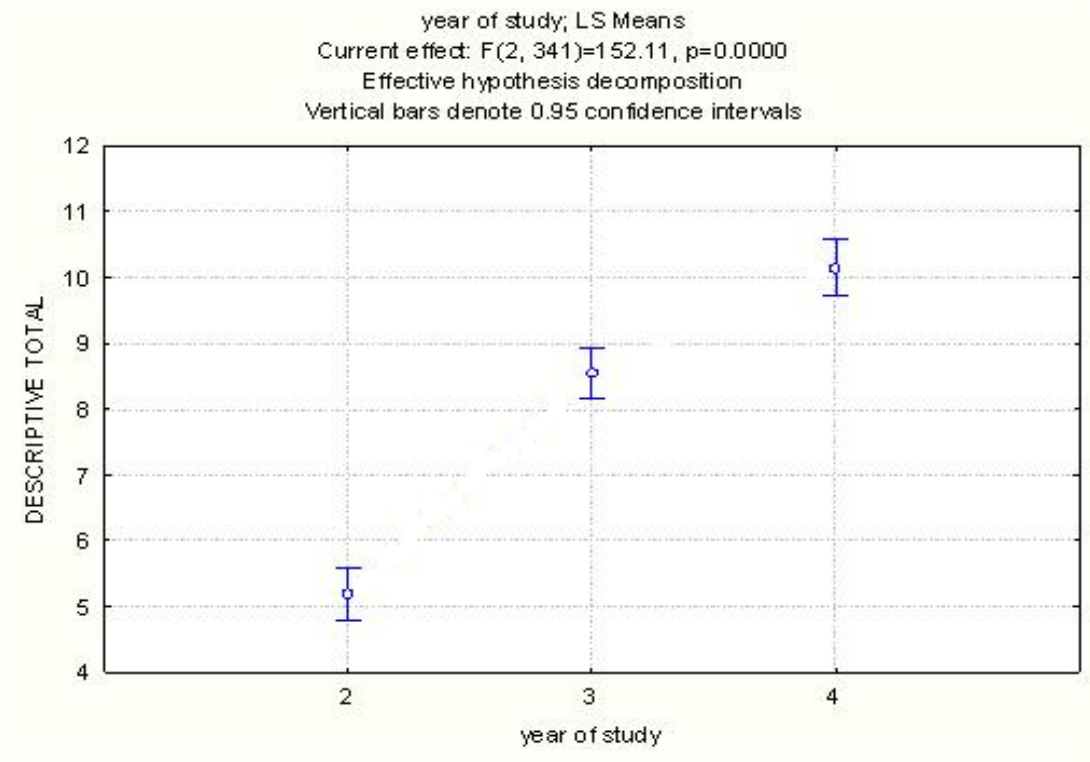


Figure 4.6 Relationship of year of study vs. descriptive total on questionnaires.

4.8.2 Concussion Knowledge scores

The total concussion knowledge scores were significantly different between the year of study groups ($F(2,341) = 15.93, p < 0.05$) (Figure 4.7). The scores increased as the year of study increased.

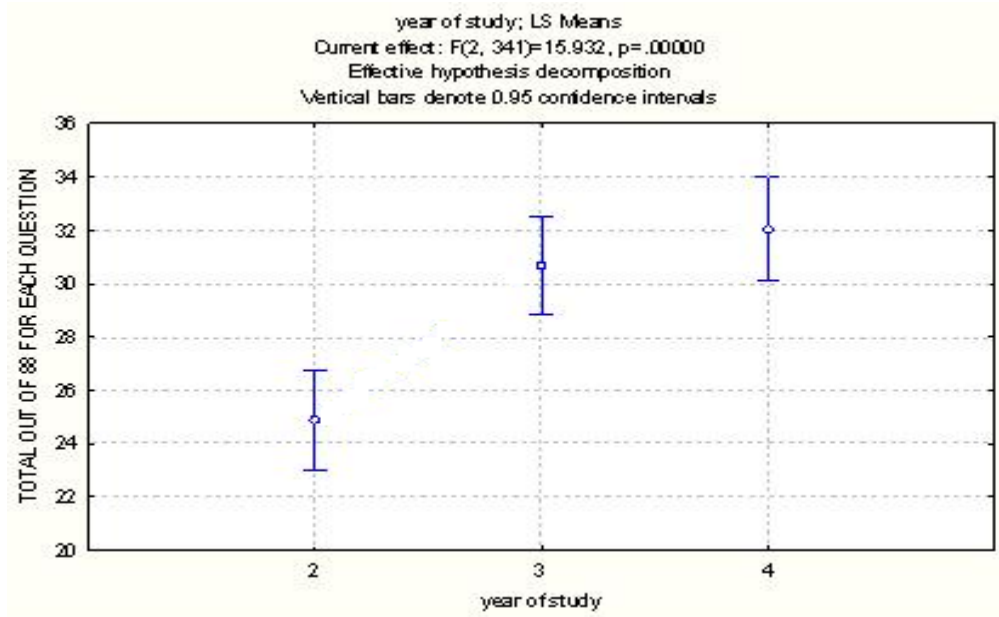


Figure 4.7 Concussion knowledge scores for second-, third- and fourth-year students (excluding descriptive scores)

4.8.3 Diagnosis, management, and knowledge of the consequences of concussion and RTP protocols

There were significant differences between the knowledge of second, third and fourth year students for the sections on the diagnosis ($F(2,341) = 16.50, p < 0.05$), management ($F(2,341) = 9.88, p < 0.05$) and RTP protocols ($F(2,341) = 13.19, p < 0.05$). There were, however, no significant differences between the knowledge of the consequences of concussion as regards the year of study.

The total questionnaire scores (descriptive information and marks obtained were significantly different for the different years of study ($F(2,341) = 36.67, p < 0.05$) (Figure 4.8).

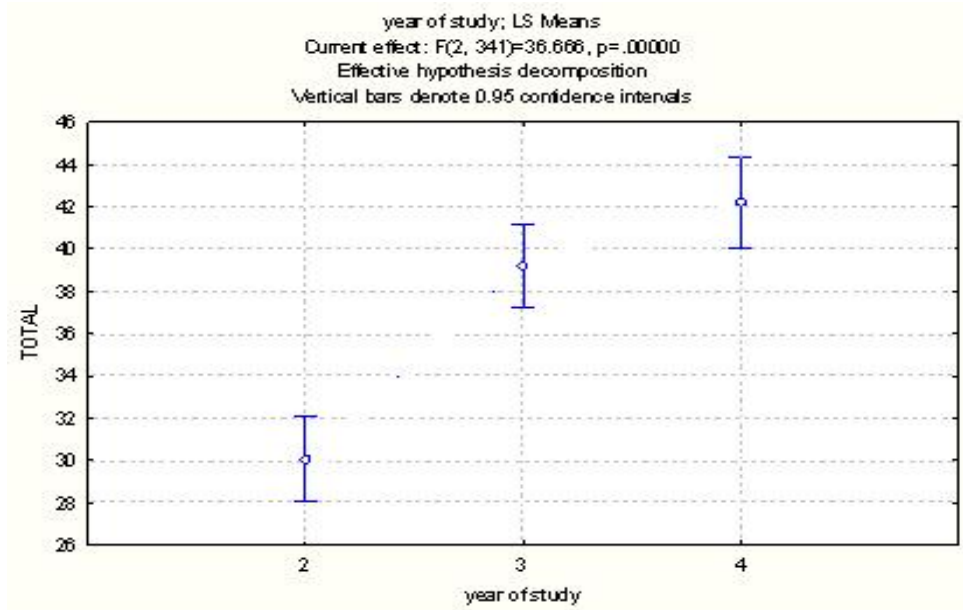


Figure 4.8 Total questionnaire scores achieved by each year of study.

4.9 ON-FIELD EXPERIENCE

There was a significant difference in the knowledge of diagnosis ($t=5.11$, $p<0.01$), management ($t=3.75$, $p<0.01$) and safe return ($t=2.92$, $p<0.01$) to play after a concussion between those groups of students who had had prior experience of working at sports events compared to those who had not. There was, however, no significant difference between the knowledge of the groups as regards the consequences of a concussion injury ($t=0.62$, $p>0.05$) (Table 4.2).

Table 4.2 Concussion knowledge scores (%) of students with on-field experience and those with no on-field experience. Data is expressed as mean \pm standard deviation (SD).

	Experience (Mean \pm SD)	No experience (Mean \pm SD)	T	P
Diagnosis	12.70 \pm 3.92	10.65 \pm 3.50	5.11	0.00001**
Management	12.12 \pm 6.47	9.58 \pm 6.02	3.75	0.0002**
Consequences	4.11 \pm 3.57	3.87 \pm 3.56	0.62	0.54
RTP	3.23 \pm 1.42	2.76 \pm 1.52	2.92	0.003**

** $p < 0.01$

4.10 PRACTICAL SUPERVISION

Those students who had been supervised by qualified personnel, for example, medical doctor or physiotherapist, achieved significantly higher concussion knowledge scores for the diagnosis of concussion as compared to those students who had not received any supervision ($t = 2.23$, $p < 0.05$). However, there was no significant difference between the scores of those students who had and had not received supervision as regards the management of concussion, the consequences of concussion, or RTP decisions (Table 4.3).

Table 4.3 Scores of those students who had and those who had not received supervision from qualified personnel.

	Supervision (Mean ± SD)	No supervision (Mean ± SD)	T	P
Diagnosis	13.53 ± 4.15	12.02 ± 3.60	2.23	0.03*
Management	12.68 ± 6.66	12.23 ± 6.41	0.39	0.69
Consequences	4.27 ± 3.62	3.87 ± 3.44	0.66	0.51
RTP	3.26 ± 1.45	3.20 ± 1.44	0.24	0.81

* $p < 0.05$

4.11 FIRST AID TRAINING

The concussion knowledge scores pertaining to the diagnosis of concussion ($t = 3.77$, $p < 0.01$); management of concussion ($t = 3.51$, $p < 0.01$); and knowledge of the consequences of concussion ($t = 2.03$, $p < 0.05$) were significantly lower for those students who had received prior first aid training, compared to those students with no prior first aid training. In addition, there was no significant difference in the knowledge of RTP protocols between those students who had and those without prior first aid training ($t = 1.61$, $p > 0.05$) (Table 4.4).

Table 4.4 Scores of those students who had and those who had not received first aid training.

	Prior first aid training (Mean ± SD)	No prior first aid training (Mean ± SD)	T	P
Diagnosis	10.45 ± 3.13	13.32 ± 3.90	3.77	0.0002**
Management	8.65 ± 6.68	13.07 ± 6.10	3.51	0.0006**
Consequences	2.97 ± 3.22	4.42 ± 3.60	2.03	0.04*
RTP	2.87 ± 1.80	3.33 ± 1.29	1.61	0.11

** $p < 0.01$; * $p < 0.05$

4.12 TOTAL CONCUSSION KNOWLEDGE SCORES FOR QUESTIONNAIRE

The total knowledge scores obtained in the questionnaire ranged from 7% to 76% with a mean score of $37\% \pm 12.25\%$. If the descriptive information was excluded (questions 1-12), the scores ranged from 4.6% to 73.5% with a mean of $33.1\% \pm 12.1$. These represented concussion knowledge scores as obtained from the completed questionnaires. Only one student achieved the required 75% mark.

Chapter 5

Discussion

The main aim of the study was to assess the knowledge of second, third and fourth year physiotherapy students in regards to concussion diagnosis, management and safe return to play. The results that will be discussed in this chapter will show that student's knowledge in regards to concussion is not sufficient to safely diagnose, manage and ensure safe return to play if a concussion occurs. A major objective was to assess if there were other specific factors like year of study, first aid, side of field experience and supervision by qualified physiotherapist that may predict better scores on the test. There were several of these factors that played a significant role in predicting the scores for the questionnaires.

It must also be stated that the universities curricula have not been thoroughly been reviewed for this study. This was due to lack of information regarding each universities curricula being available. Any conclusions drawn in regards to the influence the curricula may have are based on limited understanding of the curricula. This been said though the fact that the students knowledge in regards to concussion is poor needs to be attributed to education they have received.

5.1 QUESTIONNAIRE SCORES

The total knowledge of concussion scores differed significantly between the students in the different years of study (Figure 4.2). However, this is to be expected as students would have studied anatomy, physiology and sports injuries in greater depth as their courses progressed and they would be more likely to have had greater exposure to field side situations and qualified medical personnel.

5.2 ON-FIELD PHYSIOTHERAPY EXPERIENCE

There were significant differences found in the knowledge of diagnosis, management and guidelines for safe return to play after a concussion injury in those students with and those without prior experience of providing on-field physiotherapy at sporting events. This would indicate that students are learning experientially and obtaining concussion knowledge from practical sources such as on-field physiotherapy. Of the total number of participants, 43% had performed on-field physiotherapy but only 78.6% of these had had their practice supervised for up to 100% of the time (Figure 4.2). This indicates that a fifth of all students performing on-field physiotherapy were, for at least part of the time, under the supervision of the primary medical officer on site.

Because of potential lack of knowledge in the diagnosis of concussion, questions pertaining to specific numbers of concussions encountered by individual students were not included in the questionnaire. In view of the fact that the incidence of concussion is reportedly as high as 0.41 concussions per game, depending on the definition of injury and level of play, it is highly likely that students will be exposed to concussion injury at some stage during their practical experience (Pellman et al. 2004). This highlights the need to ensure that sufficient information is included in undergraduate curricula to ensure that such injuries are managed appropriately and that potentially catastrophic outcomes are prevented.

A potentially disturbing finding was the fact that the scores of students, both with and without prior experience of providing on-field physiotherapy, did not differ significantly as regards their knowledge of the consequences of concussion (Tables 4.1 and 4.2). Concussed athletes are at risk of developing complications following initial injury, particularly if correct guidelines for management are not followed. These include subdural haematoma, post-concussion syndrome, second impact syndrome, and death (Herring et al. 2010). Despite the fact that the students appeared to recognise the importance of concussion, the results of this study indicate that students were not necessarily aware of the potentially catastrophic outcomes of concussion although they had spent time providing on-field physiotherapy. This has implications for the safety of players under their care and suggests that more time should be allocated to formal lectures on concussion in undergraduate curricula.

It is possible that exposure to on-field physiotherapy practice prompts students to source information on potentially catastrophic conditions such as concussion. They source information because they would be aware they may encounter such conditions if they spent time on the field. Best (1988) found that student knowledge improves if students are given the correct, qualified supervision. This is supported by the finding that the students who received supervision from qualified personnel scored significantly better in the diagnosis of concussion than those students who had not received supervision (Table 4.2).

The lack of significant differences between the scores of those students who had received supervision and those who had not in terms of the management and consequences of concussion and RTP protocols, is likely to be due to the fact that the supervised student are not exposed to concussion situations on the side of the field. The management and consequences of the concussions, when dealt with, would take place away from the field of play and, therefore, students would not, in most cases, be present.

5.3 EDUCATION AND TRAINING ON CONCUSSION

It is important to investigate the sources from which the students receive information on concussion, as these sources will determine the quality of the information they receive. However, only 31.6% of the students had actually received the information from formal lectures. This is a matter of concern as formal lectures, as an integral aspect of their studies, should make up the bulk of the knowledge they obtain. With the universities also reporting that no or little time is devoted to formal lectures on concussion during the curricula it is clear that students need to obtain their knowledge from other sources. It must however be mentioned that only a small part of the sample size used in the study were fourth year students who would have been in a position to have formal education in concussion. Of the total number of students 11.1% had obtained concussion knowledge from qualified physiotherapists, 10.5% from fellow students and 9.1% from the print media and the internet. Despite the fact that this shows initiative on the part of the students the quality of the knowledge they receive may be questionable if one takes into account their overall results in the questionnaire.

An important factor that needs to be considered is that primary health care is the main emphasis currently in South Africa and most institutions spend a majority of time teaching the basics of primary health care. This emphasis is important as it highlights the needs of the greater population and not the minority of the population involved in contact sport. This means that teaching time that is available for conditions like concussion is limited.

The fact whether on field management should be include in the student's scope of practice is also a factor that needs to be discussed. If on field management is seen to only fall under a post-qualification scope of practice then the need to teach it at an undergraduate level is not as important. The problem that arises here is how to monitor it once the student has qualified. Maybe an internship in the field the student intends to go in post qualification would be a worthwhile recommendation.

5.4 DIAGNOSIS OF CONCUSSION

In this study, less than two thirds of the students were able to identify the mechanisms of concussion injury correctly (Figure 4.3). These findings have two important implications. Firstly, the immediate management of concussion injuries requires that basic first aid principles are followed. These include stabilising the head-injured player and ensuring airway, breathing and circulation are adequate. Brief on-field neuropsychological testing, such as Maddocks's questions, should then be administered and, if concussion is suspected, the player should be removed from the field immediately (Makdissi et al. 2010; Patricios et al. 2010). There is a widespread assumption that a direct impact to the head is necessary to cause a concussion injury. Accordingly, if students do not recognise that concussion may occur as a result of a sudden acceleration or deceleration of the head, which may, in turn, be as a result of a force applied elsewhere to the body, e.g. from collisions or falls (Wilberger et al. 2006; Kelly & Rosenberg 1997), they may be unaware that a concussion has occurred. They may, therefore, not follow the correct first aid and immediate management procedures that are required (Herring et al. 2010).

Secondly, it has been established that individuals who have sustained concussion injuries are at increased risk of further and potentially more catastrophic concussion injuries if exposed to further levels of head trauma, even at lesser levels than caused the initial concussion (Kelly et al. 1991). Accordingly, if students have not correctly identified that a concussion injury has been sustained and removed the player from the field, the player is at increased risk of sustaining second impact syndrome (Maroon et al. 2000). In such instances, death has been known to occur within two to five minutes, usually without there being sufficient time to stabilise a patient or transport the patient to an emergency department (Cantu 2003). The results of this study indicated that only 35.9% of the students had knowledge of about second impact syndrome (Figure 4.5).

In addition, only 2% of the students were aware that the grading of concussion injuries according to their supposed severity no longer takes place (Figure 4.5). While grading scales were initially thought to be useful in terms of augmenting the existing knowledge of concussion and its signs and symptoms, these scales had been established through clinical experience and lacked empirical supporting evidence (McClincy et al. 2006). Loss of consciousness (LOC), for example, is a poor prognostic indicator for concussion but was an important factor in the grading of concussion (Lovell et al. 1999; Leininger et al. 1990). However, the assumption still persists that LOC must have occurred for concussion to have been sustained and only 55.8% of the students in this study correctly identified that this was not, in fact, the case (Figure 4.5).

Previously accepted grading systems such as the American Association of Neurology (AAN: 1997) and Cantu (1986) make provision for grading depending on the age of the individual (Field et al. 2003). This indicates that there is a disparity between the way in which adolescents and adults must be treated. Of the total number of students, 22.2% were aware of the fact that there is a difference in the way in which adolescents and adults need to be treated. There was also a disparity in grading concussion although they appeared to think that concussion is still graded according to the Grade 1-3 system as only 2% got the answer in the questionnaire correct. This lack of clarity associated with the various grading systems may lead to the incorrect application of the guideline required to manage concussion, and the subsequent inappropriate management of the concussed player (Lovell et al. 1999).

There is mandatory exclusion periods based on the concussion grading. However, this mandatory exclusion period was not supported by recent consensus statements made in Vienna (2009) which proposed abandoning both grading terminology and the guidelines for the grading of concussion injuries (McCrory et al. 2009).

Of the total number of students, 96.1% correctly identified six symptoms of concussion from a list of fifteen possible symptoms (Figure 4.4). The five most frequently diagnosed symptoms were dizziness, headache, balance impairment, nausea and retrograde amnesia with these symptoms corresponding closely to those reported in the literature as the most frequently reported symptoms of concussion (Erlanger et al. 2003). This could be due to there being a methodological error in the study where there were ten correct answers and five incorrect answers in the questionnaire. With the poor overall results of the study it is very unlikely that the students would get such a high percentage if there was not a methodological error.

5.5 MANAGEMENT OF CONCUSSION

The management of concussion is not difficult if established protocols are followed. The majority of injuries will recover spontaneously over several days without any intervention as long as the injured athlete rests and follows a step wise approach back into sport (Guskiewicz et al. 2004; Aubry et al. 2002; Herring et al. 2010; Patricios et al. 2010). While 88.1% of the students in this study were aware that a player who has sustained a concussion injury should be removed from play immediately, almost 70% of the students were of the belief that this removal from play was dependent on the severity of the concussion, while 27.1% maintained that a player who self-reported feeling fine could be allowed to continue playing (Figure 4.5).

The grading of concussion according to apparent severity has been shown to be flawed (Erlanger et al. 2003) and players may also have under reported concussion injuries. They may have under reported concussion because they were unaware that they had sustained a concussion, particularly if LOC was not present, and also because they wanted to escape the

mandatory 3-week suspension from all competitions to which any player diagnosed with concussion is subjected if playing rugby (Marshall & Spencer 2001). Accordingly, it is clear that students should be educated regarding the possibility of players reporting that they 'feel fine' even if exhibiting a number of concussion symptoms to avoid exposing a concussed player to further potential brain impacts after the initial injury.

In addition, 68% of the students indicated that second impact syndrome was a consequence of repeated concussions during the same match, while only 32% appeared to realise that second impact syndrome may manifest as a result of a further concussion occurring in a subsequent match or training session, if an individual is still symptomatic from an earlier concussion (Bey & Ostick 2009; Cantu & Voy 1995; Kelly & Rosenberg 1997). Second Impact Syndrome involves brain herniation and death within minutes and, thus, it is essential that students be made aware of the need to prevent potential exposure to this condition. This, in turn, highlights the fact that the symptoms of a concussed player need to be fully resolved before the player is exposed to a graduated RTP protocol.

The students' knowledge of the management of adolescent concussion was also poor, with 56.5% of the students maintaining that the risk of sustaining further concussion is negligible if an adolescent is asymptomatic after 15 minutes of rest following a concussion injury. In addition, only 22% of the students were aware that concussion injuries should be managed differently in adults and adolescents (Figure 4.5). These results show that students are not aware of the risks involved in adolescent concussions. They would treat adults and adolescents the same which shows the students lack of knowledge regarding second impact syndrome.

Of the total number of students who took part in this study only 47.9% were aware that analgesic medicine post-concussion is inappropriate (Figure 4.5). Headaches occur in 30 to 90% of persons who are symptomatic after mild head injury (Minderhoud, Boelens, Huizenga & Saan 1980) and, paradoxically, headache prevalence and lifetime duration is greater in those individuals who have suffered mild head injury compared with those who have experienced more severe trauma (Lenaerts & Couch 2004).

There are, at present, no evidence-based pharmacological treatments that will benefit a concussed individual (McCrorry 2002). Pharmaceutical agents which may, potentially, influence the neurometabolic cascade, which is postulated as being central to the pathophysiology of concussion, include corticosteroids, calcium channel blockers, antioxidants, glutamate receptor antagonists, and hyperbaric oxygen therapy. Other interventions like hypothermia have also shown to have positive effects. Acute headaches may, however, be treated with mild analgesics that do not influence the potential for bleeding (e.g. acetaminophen), nausea may be treated with anti-emetics (e.g. cyclizine) and prolonged dizziness with anti-vertigo agents (e.g. cinnarizine) (Patricios et al. 2010). There is concern about the potential regarding medication rebound headaches with frequent use of over the counter medications (Evans & Mathew 2004) and, in many cases, such medications are of no greater use than is the passage of time. Accordingly, careful consideration should be given before recommending their use (Anderson, Heitger & Macleod 2006).

Physiotherapy students complete a course in pharmacology during their undergraduate studies and this gives them a basic insight into and understanding of the pharmacological actions and interactions of certain drugs with which they may come into contact. This should enable the students, at the very least, to know what should not be used to treat symptoms of concussion; for example aspirin may heighten the risk of increased bleeding (Patricios et al. 2010).

5.6 CONSEQUENCES OF REPEATED CONCUSSION

Of the students who participated in the study, only 9.4% were aware that death may result from second impact syndrome. This is of concern as the students are clearly not aware of the serious risks of concussion. However, 45.4% of the students knew that second impact syndrome may be caused by a concussion being sustained during a match or before the initial concussion has resolved. This highlights the importance of ensuring that, if a player is concussed, he/she is diagnosed correctly and, thus, not placed in a situation that may put him/her at risk of a second concussion. With so few students actually being aware of the risks involved with second impact syndrome and not all the students being supervised on

the side of the sports field, as reported earlier, there is a very definite danger to a player if concussed. This is due to the fact that the students will not necessarily be aware the player is concussed initially and will put them at risk of a secondary concussion by not pulling the player off the field.

5.7 RETURN-TO-PLAY PROTOCOLS

Of the students who participated in the study, 60.9% understood that a player must be clinically clear and have passed neurophysiological testing before being allowed to commence a structured RTP rehabilitation program. On the other hand, 65.4% of the students were aware that concussion cases should be examined frequently by a doctor before the individual is cleared for play. Return to play protocols involve the progressive exposure of the recovering individual to increasing degrees of exercise intensity while symptoms are carefully monitored (Guskiewicz et al. 2004; Aubry et al. 2002; Herring et al. 2010; Patricios et al. 2010).

Expert consensus guidelines recommend that players should not return to play until they have recovered totally from their concussive injury (Makdissi et al. 2010). The problem with this recommendation is that there are no direct, objective measures of brain function that definitively indicate return to normal and may guide return to play decisions. Nevertheless, normal neurological examination and neuropsychological data that indicates either a return to baseline or is comparable with age-appropriate norms may significantly assist this decision. In general, student physiotherapists do not have to decide on RTP protocols. It would, however, be beneficial that they were aware of the fact that brain function must return to normal before RTP. It must also be borne in mind that the fourth year students would have qualified soon after the questionnaire was completed. They would then be qualified physiotherapists and may, therefore, be in a situation in which they may make RTP decisions without gaining any further knowledge prior to making the decision.

In an era of increasing professionalism in sport, there is pressure on individuals to return to competition as soon as possible and it is likely that concussed players are returning to play

sooner than may be recommended. This may be as a result of a lack of knowledge of current guidelines and criteria on the part of both the individual him/herself and those surrounding the individual as well as pressure from sources including coaches, managers, parents and the media. However, 44.4% of the students recognised that “RTP if the coach insisted on it” was the least appropriate management principle but, this does not take into account pressure on both the student physiotherapist and on the players themselves if such a situation did arise. Clearly education on current guidelines and the potentially catastrophic implications of not following correct procedures is essential.

5.8 YEAR OF STUDY

There was a significant difference in all the concussion knowledge scores between the years of study with the fourth-year students performing significantly better than the second-year students (Figure 4.8). This may be attributed to the fact that fourth-year students possess better clinical reasoning as compared to second-year students as a result of the amount of time they spend in clinical settings. The reasoning should be that second-year students may observe but not be actively involved in providing fieldside management as their clinical rationalisation skills are not sufficient to determine what may be required at the time. The third-year students fared far better than the second-year students. As a result of the fact that the questionnaire was administered near the end of the academic year the third-year students had clearly had the opportunity to improve their clinical rationale. Although they did not score as well as the fourth-year students the third-year students fared far better than the second-year students. This suggests that time spent in clinical settings improves clinical reasoning.

The fourth year students at certain institutions had received some formal training in concussion, either as part of a sports injuries rotation or as a tutorial. That would also explain their superior scores in the test. It also became clear that the curricula covering concussion was not up to the required levels as only one student out of the 344 actually received the mark required to ensure competency in diagnosing, assessing and managing concussion. It may, thus, be an interesting exercise to examine the content of those courses

as the overall results in this study indicate that the students' knowledge of concussion was not sufficient to enable them to practise safe management.

5.9 FIRST AID TRAINING

Of the total number of students who participated in the study, 77.9 % had completed first aid training. This figure was surprisingly low in view of the fact that a first aid qualification is extremely useful for physiotherapy students who work at sporting events. Students complete first aid training as part of their course prior to commencing their practical classes. This is generally in their second or third year, depending on the syllabuses of individual universities. It is possible that some of the second-year students would, at a later date, do their first aid training. Up until the time they have completed their first aid training students should not be allowed to do field side work and even those third- and fourth-year students who have not done first aid training should not be allowed to carry out sports clinical work until this training has been completed.

While first aid is recognised as being essential to the safe management of sports injuries (Finch & Hennessy 2000), local sporting bodies tend to recommend, rather than stipulate, that a relevant first aid qualification is necessary for administering on-field medical services (Whitaker, Cunningham & Selfe 2006). In this study, those students who had received first aid training scored significantly worse in the diagnosis, management and knowledge of the consequences of concussion than students who had received no first aid training (Table 3.4). A previous study have found no significant relationship between the proportion of school Physical Education teachers with first aid training and the score for handling probable first aid scenarios (Abernethy et al. 2003). This means that there was no difference between first aid trained and non first aid trained personal when they had to perform a first aid scenario. In addition, studies have found that 39% of the coaches had passed administered first aid tests and 92% were certified in first aid (Ransone & Dunn-Bennett 1999). There were 27 to 33% of first aid qualified coaches who had passed a first aid test which actually assessed the coaches ability to perform first aid (Whitaker et al. 2006). This indicates that first aid training does not necessarily equip a person to perform first aid adequately and safely.

Accordingly, the results of this and previous studies indicate that first aid knowledge is not necessarily positively influenced by an individual current first aid certification. This raises the question about the quality and applicability to sport of widely available and nationally recognised first aid qualifications. It would appear that such courses are not providing sufficient information on the recognition and management of concussion injuries. This, in turn, highlights the fact that students who have received first aid certification are not necessarily proficient and safe in terms of performing on-field physiotherapy without supervision.

An interesting fact that should be kept in mind is what additional postgraduate training do newly qualified physiotherapists receive in regards to concussion. A great number of these newly qualified physiotherapists could be working with sports teams especially primary and high school pupils to try build up a client base. As shown throughout the discussion this young adolescent population is a very important group to be aware of the consequences of concussion. The question is could these newly qualified physiotherapists safely diagnose and manage concussion. A follow up study should be done in this regard to determine whether qualified physiotherapists have got sufficient knowledge to diagnose, assess and manage concussion.

This question will open up a whole new debate whether qualified physiotherapist should get an on-field post graduate certificate in acute sports injuries and until they have one they should not be allowed to give on-field assistance to sports teams or individuals. This is important as player safety is paramount. In the age of professional sport athletes are also assets to their teams. The fact that incorrect management of the athlete may have both short term and long term effects can lead to litigation against the physiotherapist if they are found to be negligent in their duties.

CHAPTER 6

Summary and Conclusions

High concussion injury rates have been well documented throughout this paper. Concussions pathophysiology has been shown to be a metabolic mismatch and not major structural changes. Therefore concussion cannot be diagnosed with the use of MRI or CT scans. The risk associated with concussion not being diagnosed, assessed and managed correctly has also been shown. It is therefore important to that the signs and symptoms of concussion are well known in order to diagnose concussion. The consequences if concussion is not diagnosed and managed correctly can have varied degree of severity. There can be no long term recourse in some instances or it can lead to second impact syndrome and death in adolescents if the second concussion occurs before the primary concussion had cleared.

The primary management of concussion is to ensure that no catastrophic events occur. This will mean that initially proper first aid be applied when the injury occurs. If there is any doubt whether the player is concussed the adage “if in doubt sit them out” is applied. Return to play follows a step wise progression once symptoms have cleared. If there are any recurrence of symptoms the player has to stay out 48 hours longer before returning to that phase where symptoms had re-occurred.

The aim of the study was to assess the knowledge of the students to diagnose, manage and ensure safe return to play of concussion injuries. The fact that only one student out of a total of 344 students actually achieved a “safe” pass mark, of 75%, for the questionnaire is a very worrying factor. This meant that 343 students from four universities could not ensure the safety of participants who fall under their supervision. This combined with the fact that only 50% of students reported having supervision for 80-100% of the time meant that the other 50% of students were directly responsible for the safety of the participants on the field at some point. These students were not equipped to make the correct decisions if called upon. In order to ensure the players safety at an event, students cannot be directly responsible for players without supervision. Another option would be to implement a side of field certificate. This can take the form of a first aid qualification with added information on topics like concussion.

The year of study also played a significant role in determining the competency of students to diagnose concussion with the fourth year students performing significantly better in the questionnaire than the second year students. This re-emphasises the fact that second year students must have clinical supervision at all time and they should never be placed in the position to have to diagnose a possible concussion.

A surprising finding in the study is that students that only 77.9% of all students had first aid training. This is low given the fact that all students should at least have first aid training. This figure can however be skewed by the fact that some second years might only do the training later on in their year prior to clinical hours starting. The students that did have first aid training scored significantly worse than those without first aid training on the questionnaire. This shows that first aid training is still not sufficient to operate on the side of the field without supervision which ones again highlights the need for a further qualification before doing side of field management.

6.1 RECOMMENDATIONS

- More formal teaching time be allocated to concussion at an undergraduate level.
- First aid qualification should not be deemed sufficient to allow students to perform on field first aid without supervision.
- Undergraduate students rendering first aid services on the side of the field should be supervised at all times.
- Implementation of the BokSmart program which deals with concussion. Students passing this program can then be allowed to perform first aid on the side of the field without supervision.
- Concussion knowledge of qualified physiotherapists warrants investigation.

Chapter 7

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Appendices

Appendix 1

Letters to head of departments at universities requesting permission to approach students



School of Health and Rehabilitation Sciences

Faculty of Health Sciences

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

F45 Old Main Building, Groote Schuur Hospital,

Dear Prof A. Stewart

29 July 2009

Request for Assistance with Research Study: The Knowledge of Physiotherapy Students in the Management of Concussion

I am an MPhil (Sports Physiotherapy) student at the University of Cape Town and I am writing to you to request assistance with the collection of data for the purposes of my dissertation .

The correct diagnosis and on-field management of concussion is essential to ensure the safety of athletes and to prevent the risk of associated complications. It has been noted that physiotherapy students regularly offer on-field physiotherapy services and, indeed, often provide the only medical service at sporting events. This is a cause for concern, particularly with regards to the safety of athletes, and when considering the scope of practice of physiotherapy students. Accordingly, I propose to investigate the knowledge of physiotherapy students as regards the diagnosis and management of concussion. The study

has been granted ethics approval by the Ethics and Research Committee of the Faculty of Health Sciences, University of Cape Town

I have developed a questionnaire aimed at assessing the knowledge of physiotherapy students as regards the diagnosis and on-field management of concussion. In addition, the questionnaire aims to test the students' understanding of the dangers and consequences of unrecognised concussion.

I hereby wish to request your permission, as Head of Department of Physiotherapy, at the University Of Cape Town to approach the second, third and fourth year undergraduate physiotherapy students, and request volunteers for the study.

I have requested similar access to students at the Universities of the Witwatersrand, Cape Town, and Pretoria in order to obtain a sufficient sample size to ensure statistical accuracy in the ensuing analyses. I wish to emphasise that the results from each institution will be kept in the strictest confidence and at no time will comparisons be made between institutions. In addition, this study will not examine any curriculum content. The primary aim of the study is merely to determine the knowledge and understanding of physiotherapy students with regards to concussion.

I have attached the questionnaire, together with an answer sheet for your information. The questionnaire should take approximately 20 minutes to complete.

Please contact me should you require any further information?

Thank you for considering this request.

Yours faithfully

David Milner

dawiemilner@hotmail.com

Tel: (011) 4762471

Fax: (011) 4761475

Mobile: 0824182658

Thesis supervisors: Theresa Burgess and Romy Parker

Email: theresa.burgess@uct.ac.za ; romy.parker@uct.ac.za

Appendix 2

INFORMED CONSENT

Information and consent form

Dear Participant

The Department of Physiotherapy at the University of Cape Town is currently conducting a study on the knowledge of physiotherapy students as regards the management of concussion. The study will involve your providing brief descriptive information on yourself and completing a questionnaire to determine your understanding of concussion. The questionnaire will remain totally anonymous. The results will be analysed and used as part of a final year thesis my third year Sports Physiotherapy Masters degree.

Potential risks:

There are no risks involved as the study is totally anonymous and is designed to examine the understanding of concussion of the respondent

Benefits:

The study will highlight whether there is a gap in the understanding and management of concussion at an undergraduate level. It is hoped that, by doing this, the study will allow for better knowledge on intervention at an undergraduate level.

Participant's rights:

You may, at any point, withdraw from the study for whatever reason.

If you have any questions regarding the study please feel free to ask such questions.

You will remain anonymous throughout the study and only the results of the study will be used.

Your responsibilities

Follow all reasonable instructions given to you as regards to the study.

Be truthful and honest in your input and do not do anything knowingly that will affect the results.

Inform the investigator of any pain and discomfort which you may experience at any point during the study.

Questions or concerns

All questions or concerns that the primary investigator is not able to deal with directly must please be forwarded to:

Theresa Burgess (021) 406 6171

Division of Physiotherapy

School of Health Sciences and Rehabilitation Sciences

University of Cape Town

Old Main Building

Groote Schuur Hospital

Anzio Road

Observatory

7725

or fax Att: T Burgess (021) 406 6323

Major ethical concerns must please be referred to:

Prof Marc Blockman (UCT Health Sciences Faculty Research Ethics Committee Chairperson)
(021) 406 6492

I,, hereby give consent to take part in the experimental procedure which has been approved by the University of Cape Town Ethics Committee. I undertake to abide by all the rules set out herein and I will do my utmost best to ensure that all feedback provided is truthful and accurate. The risk, benefits and procedures have been explained to me and I fully understand them. I also understand I have the right to withdraw from the experiment at anytime, for whatever reason. I have also informed the tester of any current medical condition from which I am suffering.

Signed on thisday of.....2009 at.....

.....

.....

Signature of volunteer

Print name

.....

.....

Signature of investigator

David Milner

Appendix 3

Questionnaire and mark allocation

Number in [] indicate marks given to each question.

Section A: Descriptive Information

Please tick in the appropriate box to indicate your answer:

1. Year of study.

Second [1]	Third [2]	Fourth [3]
------------	-----------	------------

2. Institution.

Johannesburg	Cape Town	Limpopo	Kwazulu/Natal
--------------	-----------	---------	---------------

3. Gender.

Male	Female
------	--------

4. Date of Birth.

Day	Month	Year
-----	-------	------

5. Have you ever been on duty at a rugby match?

Yes[1]	No [0]
--------	--------

6. If yes, at which level?

Primary school	High school	Club	Professional	Other
----------------	-------------	------	--------------	-------

If "Other", please specify.....

7. Were you supervised by qualified personnel, for example, physiotherapist, medical doctor or paramedic?

Yes [1]	No [0]
---------	--------

8. If "Yes", please indicate the percentage of times you were supervised:

0% to 19%	20% to 39%	40% to 59%	60% to 79%	80% to 100%
-----------	------------	------------	------------	-------------

9. Please select where you have learnt about concussion and indicate what you regard as the most important source of that information, the second most important, etc, e.g. if you learnt mostly from lectures, rank that 1 the second most important rate 2 and 3 for the third most important.

Lectures	Media: TV	Media: Print	Library
Qualified physio	Fellow students	Courses	Internet

10. Have you completed any first aid training?

Yes [3]	No [0]
---------	--------

11. If yes, at what level?

1 [1]	2 [2]	3 [2]	4 [2]	5 [2]
-------	-------	-------	-------	-------

12. How important do you think it is to recognise concussion?

Very important [2]	Important [1]	Undecided	Unimportant	Not very important
-----------------------	---------------	-----------	-------------	--------------------

Section B: Diagnosis

Please choose the most correct answer:

13. In order for a diagnosis of concussion to be made there must be a loss of consciousness.

Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree [2]
----------------	-------	-------------	--------------	--------------------------

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

Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree [2]
----------------	-------	-------------	--------------	--------------------------

15. Linear acceleration-deceleration forces may cause concussion.

Strongly agree [2]	Agree [1]	Do not know	Disagree	Strongly disagree
-----------------------	-----------	-------------	----------	-------------------

16. Concussion is also a form of "mild traumatic brain injury."

Strongly agree [2]	Agree [1]	Do not know	Disagree	Strongly disagree
-----------------------	-----------	-------------	----------	-------------------

17. The acute symptoms of concussion are indicative of structural changes to the brain and may be represented visually on a M.R.I.

Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree [2]
----------------	-------	-------------	--------------	--------------------------

18. Neuro-imaging studies (MRI and CAT scans) are always abnormal after a simple concussion.

Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree [2]
----------------	-------	-------------	--------------	-----------------------

19. From the list below, please select 6 symptoms of concussion. [maximum of 6 marks]

Dizziness [1]	Retrograde amnesia [1]	Anterograde amnesia [1]	Balance impairment [1]	Bilateral paraesthesia [1]
Increased concentration	Alertness	Bipolar disorder	Thirst [1]	Unilateral paraesthesia
Diplopia [1]	Headache [1]	Hysteria [1]	Increased awareness	Nausea [1]

20. A Sport Concussion Assessment Tool card (SCAT card) may be used to assist in the rapid, on-field assessment of concussion.

Strongly agree [2]	Agree [1]	Do not know	Disagree	Strongly disagree
--------------------	-----------	-------------	----------	-------------------

21. Routine cognitive questioning as to time, place and person (e.g. "What is your name?", "Where are you?" and "What time is it?") is a reliable test when making a rapid, on-field diagnosis of concussion.

Strongly agree [-2]	Agree [-1]	Do not know	Disagree [1]	Strongly disagree [2]
---------------------	------------	-------------	--------------	-----------------------

22. Computerised neuropsychological tests only are used for the sideline assessment for concussion.

Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree [2]
----------------	-------	-------------	--------------	-----------------------

23. Balance tests are used to assist in the assessment of concussion.

Strongly agree [2]	Agree [1]	Do not know	Disagree	Strongly disagree
-----------------------	-----------	-------------	----------	-------------------

24. Concussion may be graded as mild (grade 1), moderate (grade 2) or severe (grade3).

Strongly agree	Agree	Do not know	Disagree [1]	Strongly disagree [2]
----------------	-------	-------------	--------------	--------------------------

25. Second Impact Syndrome refers to a player suffering a second concussive injury in the same match or within a short period of the first concussion.

Strongly agree [2]	Agree [1]	Do not know	Disagree	Strongly disagree
-----------------------	-----------	-------------	----------	-------------------

26. The diagnosis of concussion is a clinical diagnosis requiring assessments by a doctor.

Strongly agree [2]	Agree [1]	Do not know	Disagree [-1]	Strongly disagree[-2]
-----------------------	-----------	-------------	---------------	-----------------------

Section C: Management

27. The immediate decision regarding whether a player may continue to play in the current match is determined by the severity of the concussion injury.

Strongly agree [-4]	Agree [-2]	Do not know	Disagree [2]	Strongly disagree [4]
------------------------	------------	-------------	--------------	--------------------------

28. A player suffering a concussive injury must be removed from play immediately.

Strongly agree [4]	Agree [2]	Do not know	Disagree [-2]	Strongly disagree [-4]
-----------------------	-----------	-------------	---------------	---------------------------

29. If a player reports "feeling fine" after a suspected concussive injury, he may continue to play.

Strongly agree [-4]	Agree [-2]	Do not know	Disagree [2]	Strongly disagree [4]
------------------------	------------	-------------	--------------	--------------------------

30. A player is only at risk for Second Impact Syndrome if injured a second time during the same match.

Strongly agree [4]	Agree [2]	Do not know	Disagree	Strongly disagree
-----------------------	-----------	-------------	----------	-------------------

31. If an adolescent concussed player is asymptomatic after 15 minutes of rest, the risk of re-injury in the same match is negligible.

Strongly agree [-4]	Agree [-2]	Do not know	Disagree [2]	Strongly disagree [4]
------------------------	------------	-------------	--------------	--------------------------

32. A player who suffered a concussion earlier in the season has returned to play and is suffering from persistent headaches. The treatment of choice is analgesics.

Strongly agree	Agree	Do not know	Disagree [2]	Strongly disagree [4]
----------------	-------	-------------	--------------	--------------------------

33. Management of an adult and an adolescent concussed player is exactly the same.

Strongly agree [4]	Agree [2]	Do not know	Disagree	Strongly disagree
-----------------------	-----------	-------------	----------	-------------------

34. Choose the least appropriate principle of management for a player who has been diagnosed with concussion at the time of injury (LOC=loss of consciousness; RTP=return to play).

Continue play if no LOC [4]	Hospitalisation [2]	Asymptomatic for 15 min; RTP	Remove from play	RTP if coach insists [4]
--------------------------------	------------------------	---------------------------------	---------------------	-----------------------------

Section D: Consequences

35. Choose the most likely consequence if an adult player suffers more than one concussion during a season.

No serious consequences	Death	Loss of consciousness	Second Impact Syndrome	Post concussion syndrome [4]
----------------------------	-------	--------------------------	---------------------------	---------------------------------

36. Choose the most likely consequence if an adolescent player suffers more than one concussion during a season.

No serious consequences	Death	Loss of consciousness	Second Impact Syndrome	Post concussion syndrome [4]
----------------------------	-------	--------------------------	---------------------------	---------------------------------

37. Choose the most likely consequence of Second Impact Syndrome.

Post concussion syndrome	Persistent headaches	Death [4]	Loss of consciousness [2]	All of the above
-----------------------------	-------------------------	-----------	---------------------------------	------------------

38. Choose the main predisposing factor to Second Impact Syndrome.

Second concussion in same match [4]	Second concussion in season	Second concussion in career	Second concussion before first has cleared [4]	All of the above
-------------------------------------	-----------------------------	-----------------------------	--	------------------

Section E: Return-to-play

39. If a concussed player were to be removed from play, select which of the following would assist in deciding when the player may return to play.

Asymptomatic at rest	Automatic 3 week lay-off	Asymptomatic at exertion [4]	Neuro-psychological testing [2]	Neuro-psychological test and clinically clear [6]
----------------------	--------------------------	------------------------------	---------------------------------	---

40. Most cases of concussion need to be assessed repeatedly by a doctor before the injured player is cleared for play

Strongly agree [2]	Agree [1]	Do not know	Disagree	Strongly disagree
--------------------	-----------	-------------	----------	-------------------

Appendix 4

SCAT Test

This tool represents a standardised method of evaluating people after concussion in sport and was produced as part of the Summary and Agreement Statement of the Second International Symposium on Concussion in Sport, Prague 2004

Sports concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological and biomechanical injury constructs that may be utilised in defining the nature of a concussive head injury include:

1. Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an 'impulsive' force transmitted to the head.
2. Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously.
3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury.
4. Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness

Post Concussion Symptoms

Ask the athlete to score themselves based on how they feel now. It is a recognised fact that a low score may be normal for some athletes, but clinical judgment should be exercised to determine if a change in symptoms has occurred following the suspected concussion event.

It should be recognized that the reporting of symptoms may not be entirely reliable. This may be as a result of the effects of a concussion or because the athlete's passionate desire to return to competition outweighs their natural inclination to give an honest response.

Remember, concussion should be suspected in the presence of ANY ONE or more of the following:

- Symptoms, for example, headache, or
- Signs such as loss of consciousness, or
- Memory problems

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

The SCAT Card

(Sport Concussion Assessment Tool)

Athlete Information

What is a concussion? A concussion is a disturbance in the function of the brain caused by a direct or indirect force to the head. Concussion may result in a variety of symptoms (See those listed below) and may, or may not, involve memory problems or loss of consciousness.

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

Post Concussion Symptom Scale

	None	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		
Balance problems or dizzy	0 1 2 3 4 5 6		
Nausea or vomiting	0 1 2 3 4 5 6		
Vision problems	0 1 2 3 4 5 6		
Hearing problems / ringing	0 1 2 3 4 5 6		
"Don't feel right"	0 1 2 3 4 5 6		
Feeling "dinged" or "dazed"	0 1 2 3 4 5 6		
Confusion	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		
Drowsiness	0 1 2 3 4 5 6		
Fatigue or low energy	0 1 2 3 4 5 6		
More emotional than usual	0 1 2 3 4 5 6		
Irritability	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		

(follow up symptoms only)

Sadness	0 1 2 3 4 5 6
Nervous or Anxious	0 1 2 3 4 5 6
Trouble falling asleep	0 1 2 3 4 5 6
Sleeping more than usual	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
Other: _____	0 1 2 3 4 5 6

What should I do?

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

The Balance Error Scoring System (BESS)

Obtain Preseason Baseline Score; Compare with Post-Concussion Score

The Balance Error Scoring System (BESS) provides a portable, cost-effective and objective method of assessing static postural stability. The BESS may be used to assess the effects of mild head injury on static postural stability. Information obtained from this clinical balance tool may be used to assist clinicians in making return to play decisions following mild head injury. The BESS may be performed in almost all environments and takes approximately 10 minutes to conduct. The balance-testing regime consists of three stances on two different surfaces. The three stances are double leg stance, single leg stance and tandem stance. The two different surfaces include both a firm (ground) and a foam surface. The athlete's stance should consist of the hands on the iliac crests, eyes closed and a consistent foot position, depending on the stance. Shoes should not be worn.

Errors:

- Moving the hands off the hips**
- Opening the eyes**
- Stepping, stumbling or falling**
- Abduction or flexion of the hip beyond 30°**
- Lifting the forefoot or heel off of the testing surface**
- Remaining out of the proper testing position for longer than 5 seconds**

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

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

In the double leg stance, the feet are flat on the testing surface, approximately pelvic width apart. In the single leg stance position, the athlete is to stand on the nondominant leg with the contra-lateral limb held in approximately 20° of hip flexion, 45° of knee flexion and neutral position in the frontal plane. In the tandem stance testing position, one foot is placed in front of the other with the heel of the anterior foot touching the toe of the posterior foot. The athlete's non-dominant leg is in the posterior position. Leg dominance should be determined by the athlete's kicking preference.

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

B.E.S.S. SCORECARD

Count Number of Errors. Max of 10 each stance/surface	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dominant foot at back)		
TOTAL SCORES: Total each column		

BESS TOTAL: _____

(Firm + Foam total)

Administering the BESS: Establish baseline score prior to the commencement of the athletic season. After a concussive injury, re-assess the athlete and compare to baseline score. Consider return to

activity only if scores are comparable to baseline score. Use together with Standardised Symptom Scale Checklist. (www.knowconcussion.org/pdfs/bess/pdf)

Appendix 6

Concussion monitoring chart

SYMPTOMS	TIME OF INJURY	2-3 HRS POST	24 HRS POST	48 HRS POST	72 HRS POST
Blurred vision					
Dizziness					
Drowsiness					
Excess sleep					
Easily distracted					
Fatigue					
Foggy feeling					
Fell down					
Headache					
Inappropriate reactions					
Irritability					
L OC					
Loss of orientation					
Memory problems					
Nervousness					
Personality changes					

Poor balance					
Poor concentration					
Ringing in ears					
Sadness					
Seeing stars					
Sensitivity to light					
Sensitivity to noise					
Sleep disturbances					
Vacant stare					
Vomiting					

The above may be graded from 0 to 6 with 0 indicating no symptoms present, 1 mild, 3 moderate and 6 most severe (Guskiewicz2006)

Appendix 7

Maddock's Scale

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?

(Maddocks, Dicker & Saling 1995).

University of Cape Town

Appendix 8

Form FHS011: Study deviation

2012 -02- 13

Instructions

- Forms to be downloaded from the Administrative Forms web page at <http://web.ut.ac.za/opts/research/ethics/>
- A protocol deviation is a one time, unintentional action or process that departs from the HREC-approved protocol, identified retrospectively after the event occurred. Use this form to report only major protocol violations. Minor violations can be included in the annual progress report. See 'Study Exceptions and Study Deviations — Pointers for Researchers' on the HREC website for further information.

1. Protocol information

Date	8/2/2012
HREC REF Number	REC/359/2007
Protocol number (if applicable) & Project Title	PHYSIOTHERAPY COURSE'S KNOWLEDGE OF THE DIAGNOSIS, ASSESSMENT AND MANAGEMENT OF CONCUSSION
Principal Investigator	JAMES HUNTER
Department / Office Internal Mail Address	PHYSIOTHERAPY

2. Protocol deviation description

Please describe the deviation below, including the reason why the deviation occurred.

CHANGE OF P.I. THE ORIGINAL P.I. DID NOT COMPLETE COURSE. THE CHANGE OCCURRED PRIOR TO CONTACT WITH ANY SUBJECTS OR INSTITUTIONS

3. Follow-up actions

3.1 Please describe any follow-up action(s) taken or planned as a result of this deviation e.g. DSMH meeting, report to sponsor, informing participants.

NEW P.I. APPROVED

3.2 Please describe what action(s) have or will be taken to prevent similar deviations in future.

THE NEW PI WILL COMPLETE THE PROJECT

4. Principal Investigator's acknowledgement of responsibility


This signature indicates the PI has reviewed the deviation, taken appropriate follow-up action and is planned or plans to implement preventive steps where possible.

Signature of PI:		Date:	9/2/2012
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HREC office use only (FWA00001557; RPR00001935)

This serves as acknowledgement of a protocol deviation as described above.

PP

Signature Chairperson of the HREC:		Date:	14.2.12
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RESEARCH ETHICS COMMITTEE
2012-02-13
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN