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Sports Concussion Knowledge and Clinical Practices:

A Survey of South African Chiropractors with a Special Interest in Sports

A dissertation submitted to the Faculty of Health Sciences,
University of Johannesburg, Johannesburg,
in partial fulfilment of the requirements for the degree of Master of Technology

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25/10/2019

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Declaration

I, Kayleigh Elan Posthumus, declare that this dissertation is my own, unaided work. It is being submitted as partial fulfilment for a Master’s Degree in Technology, in the programme of Chiropractic, at the University of Johannesburg. It has not been submitted before for any degree or examination at any other University or Technicon.

Kayleigh Elan Posthumus

On this day

[Signature]

2019
Dedication

I dedicate this dissertation to my mother, Jennifer, who taught me perseverance and fieriness of spirit. To my siblings, Kirby and Ahren, as well as my brother in law, Anthony, from whom I drew continuous strength. No words or actions will ever be enough to adequately express my gratitude for the love, support and encouragement you have all given. To my uncle, Aubrey, who played an important role in making my studies possible.

I have achieved tremendous heights because I have always stood on the shoulders of giants, I am eternally grateful to you all.
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- The chiropractic community of South Africa, for their contribution during the data collection process.
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- My family, friends and colleagues, for all their support.
Abstract

Background
The current level of knowledge, training in detection, diagnosis, and management of concussion within the South African chiropractic profession is largely unknown.

Aim
The primary aim of this research was to ascertain knowledge of concussion signs, symptoms and management practices amongst South African chiropractors.

The secondary aim of this research was to assess knowledge and clinical practice differences between chiropractors who have undergone additional training in the field of sport chiropractic subject matter versus those without additional training.

The primary objective was, through the gathering of data, to determine the necessity of mandates and training in evaluation and management of concussion. The data was intended to be of benefit to both local chiropractic training institutions as well as international organizations such as The International Federation of Sports Chiropractic (FICS) in determining the education requirements of chiropractors in concussion.

Research methodology
The study used a random cohort sampling method by way of electronic descriptive questionnaire.
The study took place within South Africa and questionnaires were distributed via email to members of the Allied Health Professions Council (AHPCSA), Chiropractic Association of South Africa (CASA) and Chirosport South Africa.

The study's population sample comprised registered chiropractors with a special interest in sports chiropractic.

Results and discussion

Theoretical questioning scores were high amongst the sample whilst a low level score of correctness for the entire sample was seen for practical questions.

Overall, participants who were identified as being equipped with additional training scored higher than those without additional training.

Conclusion and recommendations

The study described poor scoring for practical questions. Participants who had additional training scored higher in the distributed survey. Male participants were more likely to have additional training compared to their female counterparts.
# Table of Contents

Declaration 2  
Affidavit 3  
Dedication 4  
Acknowledgments 5  
Abstract 6  
List of Figures 10  
List of Tables 12  
List of Appendices 13  

Chapter One: Introduction 14  
1.1 Problem Statement 14  
1.2 Aim of the Study 16  
1.3 Potential Outcomes of This Study 17  

Chapter Two: Literature Review 18  
2.1 Introduction 18  
2.2 Gross Anatomy 18  
2.3 Terminology 28  
2.4 Biophysics of Concussion 29  
2.5 Acute Pathophysiology of Concussion 31  
2.6 Chronic Traumatic Encephalopathy 32  
2.7 History of Concussion 33  
2.8 Concussion Assessment Tools 33  
2.9 Management of Concussion 38  
2.10 Previous Studies on Concussion Knowledge 39  
2.11 Concussion in Sport 42  
2.12 Sports Chiropractic Training and Certificates 43  

Chapter Three: Methodology 45  
3.1 Introduction 45  
3.2 Study Design 45  
3.3 Subjective Data 47  
3.4 Data Analysis 47  
3.5 Statistical Analysis 48
## Sports Concussion Knowledge and Clinical Practices

### Chapter Four: Results

1. **Introduction**
2. **Demographics of Sample Group**
3. **Concussion Knowledge, Diagnosis and Management**
4. **Sample Group Behavioural Trends**

### Chapter Five: Discussion

1. **Introduction**
2. **Sample Demographics**
3. **Overall Concussion Knowledge of the Sample Group**
4. **Comparative Analysis of Groups in Sample Population**
5. **Overall gaps in knowledge**

### Chapter Six: Conclusion and Recommendations

1. **Conclusions on Findings**
2. **Recommendations**
3. **Recommendations for Further Studies**
4. **Conclusions**

### References

Appendices
List of Figures

Figure 1.1 Mayo TBI-Classification system (Sharp & Jenkins, 2015) 14
Figure 2.1 Lateral view of the skull (Gilroy et al., 2016) 19
Figure 2.2 Meninges in situ (Gilroy et al., 2016) 20
Figure 2.3 Meninges of the brain superior view (Gilroy et al., 2016) 21
Figure 2.4 Brain removed to demonstrate left anterior oblique view of dural folds (Gilroy et al., 2016) 22
Figure 2.5 Lateral view of cerebral cortex indicating different lobes (Gilroy et al., 2016) 23
Figure 2.6 Midsagittal of diencephalon and brainstem (Gilroy et al., 2016) 24
Figure 2.7 Cellular layers of cerebral cortex (Gilroy et al., 2016) 25
Figure 2.8 Midsagittal view indicating cerebral white matter (Gilroy et al., 2016) 26
Figure 2.9 Pathways of the CNS (Gilroy et al., 2016) 27
Figure 2.10 Transverse view of the brain indicating both white and grey matter (Gilroy et al., 2016) 27
Figure 4.1 Clustered column indicating gender distribution of sample and groups. 51
Figure 4.2 Clustered column indicating experience distribution 52
Figure 4.3 Clustered column graph indicating theoretical knowledge 53
Figure 4.4 Clustered column indicating diagnosis and management 54
Figure 4.5 Clustered column graph indicating post-concussion knowledge 55
Figure 4.6 Clustered Column indicating concussion tool knowledge 57
Figure 4.7 Clustered column indicating age of patients seen by population group 58
Figure 4.8 Clustered graph indicating frequency of cases seen 59
Figure 4.9 Clustered column indicating trends in history taking 60
Figure 4.10 Clustered column indicating comfort levels in recognizing and diagnosing concussion 61
Figure 4.11 Clustered column indicating comfort levels of treating concussion between groups in the sample 62
Figure 4.12 Clustered column indicating correct diagnoses in case studies 63
List of Tables

Table 2.1 Summary of available training 43
Table 5.1 Table indicating correlation of participants with additional training being registered with Chirosport South Africa 65
Table 5.2 Table indicating gender distribution of sample 66
Table 5.3 Table indicating overall theoretical concussion knowledge 68
Table 5.4 Table indicating differences in concussion knowledge and clinical practices between population groups 69
List of Appendices

Appendix A: Information letter 86
Appendix B: Consent form 91
Appendix C: Online questionnaire 92
Appendix D: Permission letter (Chirosport SA) 106
Appendix E: Certificate of release for marking 107
Appendix F: Turnitin originality report 108
Appendix G: Approval letters from Research Ethics Committee and Higher Degrees 128
Chapter One: Introduction

1.1 Problem Statement

A concussion is described as a complex pathological physiological process affecting the brain with or without neuro-pathological damage. In most cases, the mechanism of injury (MOI) is a blow to the head which can cause either direct or indirect injury to the brain (Sharp & Jenkins, 2015).

It should be mentioned that the term concussion holds little diagnostic value and it has been proposed that it be replaced by the term traumatic brain injury (TBI) as per the Mayo traumatic brain injury (TBI) classification system recommended by David Sharp and Peter Jenkins (2015). See Figure 1.1.

Figure 1.1 Mayo TBI-Classification system (Sharp & Jenkins, 2015)
It is problematic to separate concussion and TBI as separate pathophysiologic entities, due to the MOI being identical. This leads to there being no prior reason to think that concussion and TBI can be distinguished from one another. It also becomes unclear on how a clinician may decide between the two when diagnosing a patient as the symptoms have no distinct diagnostic separation.

The term concussion often implies a benign set of symptoms which tend to resolve spontaneously. The assumed transience of symptoms is problematic as patients often have long-term effects, which imitates the similar post-concussive symptoms after TBI of varying severities. All these factors lead to circulatory diagnosis and prognostication, often resulting in a patient being inappropriately reassured about the benign nature of their symptoms with lack of investigation (Sharp & Jenkins, 2015).

Although it was not an aim of this research to describe and clarify diagnostic labels, in evaluating clinician knowledge it was valuable to identify the impact the use of the term “concussion” has on the management of a patient.

Overall, the term concussion lacks diagnostic precision and may encourage a lazy diagnostic approach (Sharp & Jenkins, 2015). Concussion, however, remains an accepted term in literature and for all intent and purposes, this research used the term concussion to refer to both symptomatic TBI (sTBI) and mild TBI (mTBI).

The current levels of knowledge, including training in detection, diagnosis, and management of concussion, within the South African chiropractic profession are largely unknown. The description of the trends regarding the separating of concussion and TBI and of the trends regarding these areas of knowledge has been used to highlight gaps in knowledge which may lead to inaccurate diagnoses and a mismanagement of the syndrome.
Adequate evaluation, diagnosis, knowledge, and management of concussion amongst primary care physicians are imperative as it is a common occurrence with potentially serious complications (Johnson et al., 2013).

Due to the MOI associated with mTBI, symptoms of cervicalgia and muscle spasm may encourage injured sportsmen to access a sports chiropractor for treatment. Data which can evaluate and describe the efficiency of diagnosis and adequate treatment is therefore important. Investigation could highlight any gaps in knowledge and practice amongst chiropractors who treat sports injuries, and in particular, concussion, which allows for improvement and changes in procedure protocol (Johnson et al., 2013).

**1.2 Aim of the Study**

The primary aim of this research was to ascertain knowledge of the concussion and mild traumatic brain injury signs, symptoms and management practices of concussion amongst South African chiropractors.

The secondary aim of this research was to assess knowledge and clinical practice differences between chiropractors who have undergone additional training in the field of Sport chiropractic subject matter versus those with no additional training.
1.3 Potential Outcomes of This Study

The intended outcomes of this survey were to ascertain potential gaps in subject knowledge and management amongst South African chiropractors, compare knowledge between those *with additional training* and those *without* to determine any significant statistical differences and possible associations.

Through gathering of data, determine the necessity of mandates and training in evaluation and management of concussion, as well as to gather data that may benefit both local chiropractic training institutions as well as international organizations such as FICS in the education of chiropractors in the subject of concussion.

Furthermore, potential identification of gaps in knowledge and discrepancies between those *with additional training* and those *without additional training* can assist in providing data which can focus training programmes and highlight possible shortfalls. This can in turn be used to formulate mandates and training assessments.

Finally, this study may also be used as a comparison to our global counterparts.
Chapter Two: Literature Review

2.1 Introduction

This chapter serves to give detail on previously published literature and research in order to provide background for this study. Basic mechanisms and pathophysiology of concussion will be covered. Emphasis will be placed on previous studies which evaluated trends in physician knowledge about concussion.

2.2 Gross Anatomy

2.2.1 Skull

The skull serves to protect the brain (See Figure 2.1). It is comprised of 22 bones that form its 2 main segments: the neurocranium, which contains the brain, meninges and proximal parts of the cranial nerves and the viscerocranium, which is made up of the facial bones. There are 7 associated bones: the auditory ossicles (3 in each middle ear) and the hyoid bone (Moore, Dalley, Agur, 2014).
The brain and spinal cord are enveloped by 3 membranous connective tissues layers called *meninges* which aim to protect the brain. These form a framework for arteries, veins and venous sinuses, and enclose a space known as the subarachnoid space, which is vital to the normal and healthy functioning of the brain (See Figure 2.2 and Figure 2.3).
The subarachnoid space acts to support and cushion the brain and spinal cord as well as perform functions normally performed by the lymphatic system (Moore et al., 2014).

The layers include:
The dura mater is the outermost layer which is richly innervated by sensory fibres. The dura also forms thick connective tissue folds that separate brain regions and lobes.

The arachnoid mater is a fine, web-like avascular membrane directly beneath the dural surface; the space between the arachnoid mater and beneath the underlying pia mater is referred to as the subarachnoid space and contains cerebrospinal fluid (CSF).

The pia mater is a delicate membrane that directly envelops the brain and spinal cord (Moore et al., 2014).

Figure 2.2 Meninges in situ (Gilroy et al., 2016)
2.2.3 Dural folds

Dural folds are fibrous sheets that are formed by the internal layers of the dura that project from the external periosteal layer of the dura. The dural folds divide the cranium into compartments and serve as a mechanical support for the brain (see Figure 2.4) (Moore et al., 2014).

The dural folds constitute:

The *flax cerebri* is the largest dural fold and is continuous with *tentorium cerebelli*. This separates the left from the right hemispheres of the brain.

The *tentorium cerebelli* is the second largest dural fold. This separates the occipital lobes of the cerebral hemispheres from the cerebellum.
The concave anteromedial border of the *tentorium cerebelli* is free and produces a gap called the tentorial notch through which the brainstem; midbrain, pons and medulla oblongata pass.

The *falx cerebelli* is a vertical dural fold which separates the cerebellar hemispheres.

![Diagram of brain with labels](image)

**Figure 2.4- Brain removed to demonstrate left anterior oblique view of dural folds (Gilroy et al., 2016)**

The *diaphragma sellae* is the smallest of the dural folds. It encloses the pituitary gland within its fossa and has an aperture for the passage of the infundibulum and hypophyseal veins (Moore *et al.*, 2014).

### 2.2.4 Brain

The brain is contained within the neurocranium and has the following subdivisions:

The *telencephalon/Cerebrum (cerebral hemispheres)* is responsible for sensory processing (see **Figure 2.5**).
Sports Concussion Knowledge and Clinical Practices

The brainstem acts to convey both motor and sensory information from the body and autonomic and motor information to peripheral targets. The cerebellum coordinates smooth motor activities and processes muscle position (see Figure 2.6) (Moore et al., 2014).

The most notable feature is the 2 large cerebral hemispheres which can be partitioned into 5 lobes (see Figure 2.5) (Moore et al., 2014):

1. Frontal
2. Parietal
3. Occipital
4. Temporal
5. Limbic
6. Insula

Figure 2.5 Lateral view of cerebral cortex indicating different lobes (Gilroy et al., 2016)
2.2.5 Histological structure of the cerebrum

Cerebral cortex - grey matter

The cerebral cortex is covered and composed of involuted grey matter folds. Grey matter is a collection of neurons, glial cells, blood vessels, and connective tissue. Additionally, grey matter is found as aggregations within the cerebral hemispheres, referred to as nuclei or ganglia (Wen & Chklovskii, 2005; Missankov, 2012).
For descriptive purposes the cortex can be divided into 6 layers moving from most external to internal (see Figure 2.7) (Missankov, 2012):

1. Molecular layer

2. External granular layer

3. External pyramidal layer

4. Internal granular layer

5. Internal pyramidal layer

6. Polymorphic (multiform) layer

**Figure 2.7 Cellular layers of cerebral cortex (Gilroy et al., 2016)**
Internal cerebral structure - white matter

The core of the cerebral hemispheres consists of white matter (See Figure 2.10). White matter consists of myelinated axons/fibres supported by neuroglia. These fibres run in multiple directions and can be divided into the projection, association and commissural fibres (see Figure 2.8 and Figure 2.9) (Missankov, 2012).

Figure 2.8 Midsagittal view indicating cerebral white matter (Gilroy et al., 2016)
Sports Concussion Knowledge and Clinical Practices

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projection fibers</td>
<td>Connect the cerebral cortex to subcortical centers, either ascending or descending (Fornix = special projection tract of the limbic system)</td>
</tr>
<tr>
<td>Ascending fibers</td>
<td>Connect subcortical centers to the cerebral cortex</td>
</tr>
<tr>
<td>Descending fibers</td>
<td>Connect the cerebral cortex to deeper/lower centers</td>
</tr>
<tr>
<td>Association fibers</td>
<td>Connect different cortical areas within one hemisphere (see C)</td>
</tr>
<tr>
<td>Commissural fibers</td>
<td>Connect similar cortical areas in both hemispheres (see D) (= interhemispheric association fibers); Corpus callosum = largest commissural tract in the brain</td>
</tr>
</tbody>
</table>

**Figure 2.9 Pathways of the CNS (Gilroy et al., 2016)**

**Figure 2.10 Transverse view of the brain indicating both white and grey matter (Gilroy et al., 2016)**
2.3 Terminology

Concussions are complex, representing a variety of mechanisms and types of injuries (Dashnaw, Petraglia & Bailes, 2012; Hoshizaki, Ouer, Post, Koncan & Rousseau, 2018).

The Zurich Consensus Statement on Concussion in Sports described a concussion as “a complex pathological physiological process affecting the brain” with or without neuropathological damage (Sharp & Jenkins, 2015).

In most cases, the mechanism of injury is a blow to the head which can cause either direct or indirect injury to the brain. The group also suggested that concussion and mTBI be considered distinct entities. (Sharp & Jenkins, 2015).

In contrast, the American Academy of Neurology’s guidelines for sports concussion defines a concussion as “a clinical syndrome of biomechanically induced alteration of brain function, typically affecting memory and orientation, which may involve loss of consciousness”. Although the latter definition does not separate it from mTBI, the group noted a lack of consensus in the use of the term, with an overlap in the use of concussion and mild TBI (Taylor et al., 2017).

Consequently, a concussion is currently used in two main ways:

1. To describe a distinct pathophysiological entity with its own diagnostic and management implications, mainly seen in the context of sporting injuries; and

2. To describe a constellation of symptoms that arise after different types of TBI (Sharp & Jenkins, 2015).
2.4 Biophysics of Concussion

A concussion is believed to involve both primary and secondary phase injuries.

2.4.1 Primary phase injury

Primary injury represents the moment of impact which involves translation of kinetic energy and force vectors in either a linear, rotational or combination mechanism of movement. Primary phase injury involves both coup and contrecoup injury. Two basic equations can be used to understand and visualize how these forces result in head and consequently brain acceleration (Dashnaw et al., 2012; Hoshizaki, Ouer, Post, Koncan, & Rousseau, 2018):

\[ \text{Force} = \text{mass} \times \text{acceleration} \]

The above equation quantifies linear forces, whereas the equation below will quantify the instances where there is torque.

\[ \text{Torque} = \text{moment of inertia} \times \text{angular acceleration} \]

Both linear and angular brain accelerations have been shown to be the most predictive variables for a head injury. In order to calculate the sum kinetic energies of the struck patient and the striking object, the law of conservation of energy must be considered. That is, the sum will be equal to the total linear and angular energy imparted to the patient’s head plus the energy which is dissipated from the head. Therefore:

\[ \text{Kinetic energy} = \frac{1}{2} \text{mass} \times (\text{velocity})^2 \]
It is important to note that in these equations, mass, as well as velocity, has substantially increased, i.e., the mass of athletes and the velocities at which the impacts occur (Dashnaw, et al. 2012).

Along with the biophysics of concussion and understanding the velocities of collisions, it is, in fact, the change in velocity (acceleration-deceleration) that is of importance. The brain is suspended within a CSF-filled space and has a certain degree of movement being only relatively supported/tethered at intervals via the *falx* and *tentorium cerebelli* and contained within the rigid skull (Dashnaw, et al., 2012).

The brain can accelerate and collide with the skull within this reserve volume (Dashnaw *et al.*, 2012). It is this velocity change that largely accounts for the *coup-countercoup* injury (Drew & Drew, 2004). The brain and CSF have a density difference of 4% and although it may seem negligible, this difference is enough to result in the denser CSF continuing in the direction of movement whilst the less dense brain parenchyma is displaced in the opposite direction.

### 2.4.2 Secondary phase injury

Secondary injury relates to both immediate and delayed cellular events which include ultrastructural damage, ionic changes and neurotransmission effects, and neuroinflammation amongst other things. Increasingly, research has documented the long-term consequences of low-magnitude head impacts that present no immediate consequences but increase one’s risk for the second impact syndrome and have the potential to present serious progressive neurodegeneration (Dashnaw, *et al.*, 2012).

Notable effects within cerebral blood flow and the blood-brain barrier (BBB) have also been cited in contributing to the pathophysiology of secondary brain injury (Powell, 2001; Dashnaw, *et al.*, 2012).
These effects are thought to be related to the shear forces acting on neurons which result in axonal disruption; although it is best described in more severe models of TBI, it plays an important role in mTBI (Dashnaw et al., 2012).

Molecular changes to cellular protein, metabolic response to changes in the semipermeable membrane, damage to white matter and/or vascular structures, and skull fracture all interfere with the functions of the brain. This supports the notion that repetitive concussion and trauma-induced protein changes (TIPC), as well as high-energy injuries, lead to psychiatric disorders and cognitive deficits (Dashnaw, et al., 2012).

Concussions are complex, representing a variety of mechanisms and types of injuries with overlapping and inconsistent symptoms (Dashnaw et al., 2012).

### 2.5 Acute Pathophysiology of Concussion

Despite the exact pathophysiology being unknown, research shows that moderate to severe brain injury causes a complex cascade of neurochemical changes in the brain. By deduction, it is thought that concussion follows a similar pathophysiological pathway as TBI (Patricios, Kohler & Collins, 2010; Tremblay, Pascual-Leone & Théoret, 2018). The pathways begin with the ionic influx and glutamate release, progress to an energy crisis, cytoskeletal damage, axonal dysfunction, altered neurotransmission, and inflammation and finally end in cell death.
2.6 Chronic Traumatic Encephalopathy

Chronic traumatic encephalopathy (CTE) was discovered by a forensic neuropathologist, Bennet Omalu (Omalu, DeKosky, Minster, Kamboh, Hamilton, & Wecht, 2005).

Omalu, DeKosky, Minster, Kamboh, Hamilton, and Wecht (2005), described the findings of a well-known American professional football player's brain histology who suffered from CTE as a result of sport-related head collisions. It has been described as long term cumulative exposure to repeated concussive or sub-concussive injury and related to overall reduction in brain volume, enlargement of the lateral third ventricles, thinning of the corpus callosum, cavum septum pellucidum and neuronal loss of cerebellar tonsils (Longhi, Saatman, Fujimoto, Raghupathi, Meaney, Davis, McMillan, Conte, Laurer & Stein 2005; McKee & Daneshvar, 2015).

There is an increasing concern that these types of injuries may be linked to a form of tauopathy: cerebral deposition of Tau protein. It has become a hallmark of CTE and is linked to consequent brain damage resulting in the progressive decline of memory and executive functioning. It is often associated with mood and behaviour changes that may progress to dementia. (Omalu et al., 2005; Patricios et al., 2010; Serrano-Pozo, Frosch, Masliah & Hyman 2011; Reger, Poulos, Buen, Giza, Hovda & Fanselow 2012; Giza & Hovda, 2014).

Cognitive dysfunction related to CTE is most marked in boxers, although subtle cortical manifestations have been noted in rugby players, American football players and soccer players (Dashnaw et al., 2012; Giza & Hovda, 2014).

As with most neurodegenerative conditions, CTE can only be definitively
diagnosed post-mortem and no consensus criteria or biomarkers currently exist (Giza & Hovda, 2014).

2.7 History of Concussion

Concussion symptoms typically present immediately after injury but may be delayed by several hours and usually subside within 72 hours. Most concussions resolve spontaneously within 7-10 days, although recovery may be prolonged in children (Scorza et al., 2012).

Traditionally, concussion monitoring was focussed on the recovery phase. Recently the role of cognitive function, although being inconsistently described, has become increasingly important as it appears to resolve independently of other symptoms. This raises concern for additional injury following the resolution of symptoms (Collins & Misukanis, 2005; Scorza et al., 2012; Gallucci, 2013; Johnson. et al., 2013; Olson et al., 2016). Factors which predict recovery are poorly defined and are extrapolated from data linked to more severe traumatic brain injuries.

Recent studies suggest that prolonged headaches (more than 60 hours following head injury), fatigue, tiredness, mental fogginess and the presence of more than 3 symptoms during presentation are linked to a more prolonged recovery (Scorza, Raleigh & O’Connor, 2012; Gallucci, 2013; Porcher et al., 2013; Kennedy et al., 2017; Mullally, 2017; Reneker, 2017; Boutis et al. 2018; Rowe et al., 2018).

2.8 Concussion Assessment Tools

Current evaluation of concussion involves numerous assessments, most of which increase in sensitivity and specificity only when combined with other assessment tools. All current assessment tools are most accurate
when baseline measurements are available for comparison (Patricios et al., 2010).

Types of assessment tools include:

2.8.1 Symptom checklist:

Most commonly used and although they are quick and cost-effective and have good sensitivity, symptoms may be delayed or were present at baseline and therefore caution must be applied (Scorza et al., 2012).

2.8.2 Neurophysiological tests:

These are labour intensive and designed to detect subtle cognitive deficits. These tests are not validated and there is no data to suggest they affect outcomes when used to guide return to play (Scorza et al., 2012).

1. Manual
   - Trial making- This includes asking the patient to connect a series of dots while maintaining accuracy
   - Digital symbol substitution- Involves the patient filling in a series of symbols correctly coded
   - Association test- Results may be affected by psychiatric disorders and are best interpreted when compared to a baseline.

2. Computer-based (These types of tests have little validity and no data to suggest they affect outcomes on return to play)
   - HeadMinder- This web-based test automates measures of attention, reaction speed, and memory, to name a few. It, however, has limited baseline data for children younger than 12
• ImPACT- This is an online test that consists of baseline testing and post-injury testing.

### 2.8.3 Postural stability testing:

This has high sensitivity for concussion diagnosis but has limited data to substantiate its use in monitoring recovery. Sensory Organization Test (SOT) is the preferred test but is not portable and therefore Balance Error scoring system (BESS) is most often used on the side-line (Gallucci, 2013; Kosoy & Feinstein, 2018; Littleton et al., 2015; Scorza et al., 2012).

1. BESS (Balance Error scoring system)– This test makes use of a firm floor and then a foam pad. The patient is asked to perform different stances on each of the surfaces while being marked if any errors are noted, i.e., the patient is unable to maintain balance.

2. SOT- This test measures ground reaction forces on a force plate while systematically disrupting the sensory selection process (Ruhe, 2014).

### 2.8.4 Sideline assessment tools:

The sideline assessment tools are simple and assess various domains in the initial concussion assessment. They are frequently used in the monitoring of recovery. Standardized Assessment of Concussion (SAC) is often used immediately following an injury to evaluate orientation, memory, concentration and delayed recall and it is validated as a sideline tool.

Sport Concussion Assessment Tool (SCAT) is a combination of multiple assessment tools (symptom checklist, concentration and memory tasks (Maddock’s questions), SAC, BESS, and Glasgow coma scale). Although it is not validated, it is widely used and is considered
the most comprehensive sideline tool. (Sport Concussion Assessment Tool, 2013; Gallucci, 2013; Littleton et al., 2015; Scorza et al., 2012).

2.8.5 Investigating concussion

1. Neuroimaging

CT and MRI are standard investigations for concussive injury. Whilst CT is sensitive for a skull fracture and focal brain injuries in moderate to a severe concussion, it lacks sensitivity to vascular and white matter injuries such as a diffuse axonal injury which is frequently encountered even in a mild concussion. Both axonal and vascular injury are important prognostic factors (Sharp & Jenkins, 2015).

Specific MRI techniques such as gradient-echo and susceptibility weighted imaging can identify microbleeds which act as a stable marker of white matter injury following a concussion. Additionally, these types of MRI are helpful in giving a more complete assessment of white matter structure and therefore should now form part of the routine radiological investigation into concussive injuries (Ledig, Heckemann, Hammers, Lopez, Newcombe, Makropoulos, Lötjönen, Menon & Rueckert, 2015; Sharp & Jenkins, 2015).

2. Blood and cerebrospinal fluid investigations

Hypothalamic-pituitary dysfunction is common in the acute phase of concussive injury and should, therefore, be screened for in patients with persistent symptoms. Levels of CSF biomarkers include tau and neurofilament light polypeptide which are elevated acutely. The
measuring of CSF is, however, an unlikely investigation and thus there is a requirement for a blood marker.

Unfortunately, blood biomarkers for concussion are less convincing than that of CSF, although recent studies have shown an increase in tau levels in plasma following mild concussion in ice-hockey players (Shahim, Tegner, Wilson, Randall, Skillbäck, Pazooki, Kallberg, Blennow & Zetterberg, 2014; Sharp & Jenkins, 2015).

3. Genetic association to inflammatory and apoptotic signalling pathways in concussion

There are few prognostic factors which allow us to determine concussion duration and severity. Neuroinflammation is necessary to promote healing in the central nervous system; however, a prolonged or overactive response can have detrimental effects (McFie, Abrahams, Patricios, Suter, Posthumus & September, 2018).

Mc Fie et al., (2018) stated that there was a significant association between functional neuroinflammatory related IL-1B rs16944 C>T and IL-6 rs1800795 G>C polymorphisms.

Furthermore, the associations observed with the inferred interleukin allele construct suggest that the I polymorphisms might have had an additive modulating effect on concussion symptom severity (Mc Fie et al., 2018).

Biomarkers for concussion may be useful in identifying those at risk for prolonged deficits as well as providing insight into the underlying pathophysiology (Mc Fie et al., 2018).
2.9 Management of Concussion

Traditionally, management of concussion involves avoiding reading, texting, gaming, television, and telephones. Contrary to older studies, recent texts suggest early physical activity is beneficial and assist in decreasing the rate of persistent post-concussive symptoms (Kosoy & Feinstein, 2018; Patricois, Ardern, Hislop, Aubry, Bloomfield, Broderick, Clifton, Echemendia, Ellenbogen & Falvery, 2018).

The cognitive test is important and although strenuous cognitive activities should be avoided, moderate cognitive activity has shown to have the same effect on post-concussive symptoms as complete rest. Cognitive activities may be incrementally increased, as tolerated, 5 days following the injury (Kosoy & Feinstein, 2018).

The paucity of evidence gives little guidance as to the treatment of post-concussive symptoms although general treatment involves nonsteroidal anti-inflammatories, triptans for migraine and headache, metoclopramide for headaches and nausea and it is generally accepted that narcotic analgesics should be avoided (Scorza et al., 2012; Mullally, 2017).

Caution must be taken with the prescription of medications to avoid rebound effects, and antidepressants may be used for patients who experience frequent headaches more than two weeks after the injury (Scorza et al., 2012; Mullally, 2017).

Controlled trials have not suggested that spinal manipulation for post concussive cervicogenic or migraine headaches seem to be non-responsive (Mullally, 2017). This is also in line with Moreau et al., (2015) who states that additional research is required to develop and define the parameters of manual therapy in the management of mTBI.
2.10 Previous Studies on Concussion Knowledge

Available sources have described knowledge and practices of chiropractors within the USA and Canada (Moreau, Nabhan & Walden, 2015; Kazemi, Bogumil & Vora, 2017; Taylor, Ponce & Dyess, 2017).

Studies conducted within South Africa have described rugby related injuries, including but not limited to a concussion, and the management protocols thereof (McAlery, 2014).

Caryn McAlery (2014)

McAlery (2014) does not directly aim to describe the knowledge and practices related to concussion within the South African chiropractic profession. The study does describe the treatment protocols performed by chiropractic interns under the supervision of qualified chiropractors within the confines of the Student Chiropractic Sports Council at the "Rugby Rush Tournament" 2014 in Durban.

The study only reported 8 (1% of all primary complaints) concussions over the duration of the tournament which lasted three days. The study did not record the treatment protocol for any of the concussions. Furthermore, no referrals were made. Although 21 (2.9%) patients were not permitted continuation to play, it is inconclusive whether the concussed patients formed part of the 2.9% who were prohibited from further play.

William Moreau (2015)

Moreau et al., (2015) was the first to describe the knowledge-base and clinical practices within the chiropractic profession, although similar studies have been performed in the fields of paediatrics, neurology and fourth-year medical students.
Although there is strong agreement that concussion should be medically evaluated, there is less consistency on the use of the Sideline Concussion Assessment Tool (SCAT), the use of manual therapy as treatment and the timing of manual treatment following concussive injury.

Moreau et al., (2015) states that as public awareness of sports concussion improves the number of reported concussion cases increases and it becomes increasingly important that sports athletes are evaluated and managed correctly as the accumulative effects of concussion have been well researched and documented.

**David Taylor (2017)**

Taylor et al., (2017) describes the prevalence of concussion as an epidemic, with concussion or mTBI comprising 70-90% of all treated brain injuries.

Following on from Moreau et al., (2015), Taylor explains that the reported low recognition rate from primary care physicians (PCP) is in part responsible for the underreporting of concussion.

Both Taylor et al., (2017) and Moreau et al., (2015) state that the current prevalence and primary MOI necessitate that all PCP have the necessary knowledge to recognize, evaluate and treat a concussion.

**Mohsen Kazemi (2017)**

Despite chiropractors not currently being recognized as being at the forefront of diagnosing concussion, second to emergency physicians, chiropractors see the highest rates of concussion-related patients. Additionally, chiropractors are often the first to interact with post-
concussion patients who were involved in a motor vehicle accident. This is largely due to symptoms that correlate to primary complaints which present to chiropractic rooms.

The study by Kazemi et al., (2017) found that all respondents could correctly define both the term and the mechanism of concussion. Additionally, respondents understood that concussion was a functional disturbance that could not be identified on standard neuroimaging. This suggests that the chiropractic profession is capable of being first-line-care for concussed patients.

Respondents of the survey identified uncommon symptoms less successfully, such as tinnitus, which may be a consequence of lack of literature. Symptoms which were less common were often identified as a separate diagnosis or even because of direct trauma rather than a consequence of concussion (Kazemi et al., 2017).

The largest gap in knowledge concerned the long-term consequences of repetitive concussion, namely Parkinsonism, which was often not related as a consequence of concussion. These findings may be the result of the link between Parkinsonism and concussion being nascent, research between the two being more present in specific sports such as boxing and wrestling. Alternatively, the link could have been missed due to current education on the connection being limited (Kazemi et al., 2017).

Kazemi et al., (2017) had a small population sample and made comparisons between three groups; chiropractic interns, qualified chiropractors and finally, qualified chiropractors with additional training in concussion. Naturally, the latter was found to be better adept in the recognition, diagnosis, and management of concussion.
2.11 Concussion in Sport

According to Clay, Glover & Lowe (2012), there is a risk of concussion in almost every sport, albeit with varying frequencies.

Risk factors include the roles of the positions played in any given sport, being a younger athlete and being female.

The overall incidence of concussion ranges from 0.1 to 21.5/1000 athletic exposures based on a study which reviewed sports including football, rugby, hockey, lacrosse, and soccer (Clay, Glover, Lowe, 2012).

Concussion incidence was highest in Canadian junior ice-hockey players and lowest in swimming and diving. Although American football did not have the highest incidence, the sport remains a concern due to a large number of participants (Clay et al., 2012).

Overall, the line-backer in football is subject to more frequent concussions. Athletes tend to experience 68.5% of their concussions during competitions, a rate which is 3-14 times higher compared to practice times (Clay et al., 2012).

Younger athletes appear to have a higher incidence despite less exposure and fewer repeated concussions. The research appears to be counterintuitive as one would expect lower injury capture due to less medical staff coverage. Immature neuroanatomy and less technical play are postulated to be accountable for the higher frequency of concussion in younger athletes (Schulz, Marshall, Mueller, Yang, Waever, Kalsbeek & Bowling, 2004; Clay et al., 2012).

Sex differences in concussion incidence seem to be related more to anatomical differences in height, weight, head and neck size or strength.
rather than player contact. Although male players sustained far more impact than females, females consistently had higher rates of concussion (Clay et al., 2012).

There is little to suggest that protective gear helps prevents concussion and may give athletes a false sense of protection (Clay et al., 2012).

2.12 Sports Chiropractic Training and Certificates

2.12.1 Available training

Table 2.1 Summary of available training

<table>
<thead>
<tr>
<th>Institution</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>FICS</td>
<td>International Certificate in Sports Chiropractic (ICSC)</td>
</tr>
<tr>
<td>American Chiropractic Board of Sports Practitioners (ACBSP)</td>
<td>Certified Chiropractic Sports Physician (CCSP)</td>
</tr>
<tr>
<td>ACBSP</td>
<td>Diplomate American Chiropractic Board of Sports Physicians (DACBSP)</td>
</tr>
<tr>
<td>Royal College of Chiropractic Sports Sciences (Canada)</td>
<td>Fellow of the Royal College of Chiropractic Sports Sciences (FRCCSS(C))</td>
</tr>
</tbody>
</table>

2.12.2 FICS pre-2019 curricula equivalent certifications

1. International Chiropractic Sport Science Diploma (ICSSD)
2. Internationally Certified Chiropractic Sports Practitioner (ICCSP)
2.12.3 Course Overview

1. ICSC

The latest incarnation of the FICS training program, introduced March 2019. There are 10 modules, each of which has a pass mark of 80%. The course includes out-of-clinic experience which requires the practitioner to document 50 different athletic injuries or publish in a sports-related publication. The course has a deadline of 3 years.

The ‘head injuries in sport’ section is newly updated and necessary for an individual with ICCSP certification to upgrade to the ICSC certification (ICSC program information, 2019).

2. CCSP®

The program consists of a minimum of 100 hours of course work provided by an accredited postgraduate program through an accredited Chiropractic College (ACBSP CCSP Certification candidates handbook, 2019).

3. DACBSP®

This program consists of a minimum of 200 hours of course work. In order to qualify for the examination leading to the DACBSP certification, the Doctor of Chiropractic must have completed the initial 100-hour course and passed the examination leading to the designation CCSP®. The DACBSP certification encompasses a minimum of 300 total academic contact hours plus completion of the practical and publication requirements (ACBSP CCSP Certification candidates’ handbook, 2019).
Chapter Three: Methodology

3.1 Introduction

This chapter explains how the study was conducted.

3.2 Study Design

The study used a random cohort sampling method by way of an electronic descriptive questionnaire (Appendix C). The study took place within South Africa and questionnaires were distributed via email to members of AHPCSA, CASA and Chirosport.

3.2.1 Participant recruitment

Participants were recruited from Allied Health Professions Council of South Africa (AHPCSA) and the Chiropractic Association of South Africa (CASA) who have members that may have an additional certification but are not necessarily a part of Chirosport South Africa. Participants were also recruited from Chirosport South Africa, of whom all members have a special interest in sport.

The study population sample comprised of chiropractors with a special interest in sports chiropractic, FICS qualified sports chiropractors or chiropractors with any additional concussion certification. Prospective participants were made aware of the research with the assistance of AHPCSA, CASA and Chirosport South Africa (Appendix D) who have contact with the respective registered members (Appendix C). Participants were informed on the components of the study (Appendix A) and consent
was sought (Appendix B). Participants were given the opportunity to participate based on the inclusion criteria.

### 3.2.2 Sample Selection and Size

Chiropractors were sought from 3 organizations. Both CASA and Chirosport members are included in those registered with AHPCSA which has 830 members. CASA has 544 registered members and Chirosport South Africa has 90. Members who met the criteria were invited to participate in the study.

### 3.2.3 Inclusion Criteria

To participate in this study, willing participants must have complied with the following criteria:

- Qualified chiropractors who are registered with AHPCSA

The rest of the criteria was aimed at ensuring a sample population who had relevance to the research question:

- Qualified chiropractors who have a special interest in sport
- Qualified chiropractors who are registered with Chirosport South Africa
- Qualified chiropractors whom are FICS certified (ICCSD/ICCSP/ICSC)
- Qualified chiropractors with additional certifications or training in concussion
3.2.4 Exclusion Criteria

It follows that participants who do not qualify via the inclusion criteria were excluded.

3.3 Subjective Data

An online survey, using the platform questionpro® through STATKON, was used to conduct this study.

The questionnaire was adapted to Lamb, 2016; Kazemi et al., 2017 and Taylor et al., 2017. Questions were also adapted from research studies by Sharp & Jenkins, 2015 and Moreau et al., 2015.

For the purpose of the study, questions were adapted slightly in order to suit the sample population and the research question. STATKON was consulted in the adaption of these questions to ensure statistical validity and viability of the research study. The report of incidence, demographic and knowledge were taken on goodwill with the understanding and expectation that the participants would answer accurately and truthfully.

3.4 Data Analysis

The data was gathered by means of an online questionnaire using questionpro®. The raw data was downloaded and coded using Microsoft Excel spreadsheet. Prior to statistical analysis, the data was verified for consistency and accuracy. Descriptive statistics were provided and categorical analysis appropriate for the sample size and nature of the variables were used to address the research question.
3.5 Statistical Analysis

Data obtained from the study was presented using graphs and tables with the assistance of a statistician at STATKON.

To ensure the research question was answered, the data was analysed using SPSS version 25.0.

Frequency tables were used to measure correct and incorrect answers from the sample group. In addition, cross tabulation and T-test was used to evaluate the data, make comparative analysis and demonstrate the observations between the two population groups within the sample.

3.6 Ethical Considerations

Participants were informed about the design and conduct of the study as well as their confidentiality, anonymity, and consent. Participant names and personal details were not used in the study. Participants read the electronically distributed information letter (Appendix A) and were requested to click on the survey link if they consented to be a participant. Consent was again requested once in the survey itself (Appendix B and C).

If participants required further information regarding consent and privacy, they were free to contact me or my supervisor. They were assured that there was no way that the researcher will be able to track information back to the participant. Participants were informed that their participation was voluntary and that they were free to withdraw at any stage. In addition to this, the use of STATKON ensured the desired response rate by allowing
study participants to claim continuous professional development (CPD) points.

Extensive research was done into the current literature to ensure survey content validity. The results of the study were made available to the participants. As this study took the form of an online survey which was completed in the participants’ own time, no risks were identified.

This study was approved by the Faculty of Health Sciences Higher Degrees Committee (HDC) and the Research Ethics Committee (REC) (Appendix G). Furthermore, this study was submitted to an anti-plagiarism software, Turnitin and a similarity index of 13 % was generated (Appendix F).
Chapter Four: Results

4.1 Introduction

The study used a random cohort sampling method by way of electronic questionnaire which was sent out twice to 830 chiropractors. A total respondent number of 140 chiropractors participated.

For some questions, not all 140 responses were valid. However, they were recorded and assessed where possible. A footnote has been included under all questions were there were less than 140 valid reposes.

All were registered with AHPCSA. The total sample of participants (n=140) were separated into two groups defined by additional training, over and above the master’s degree in chiropractic offered in South Africa, versus those with no additional training. Compared throughout the study, based on whether additional training was attained:

- Those who had additional sports chiropractic training (FICS): ICSC, ICCSP and ICCSD 21% (n=30)
- (Other) : CCSP, DACSP and FRCCSS 5% (n=7)
- Those with no additional training (Special interest in sports) 74% (n=104)

Those with additional training made up 26% (n=37) of the sample and those with no additional training made up 74% (n=104) of the sample.

This chapter presents the results of the analysis of the data collected from this sample group. It begins by describing cross-tabulated demographic characteristics of the sample, followed by a cross-tabulated description of concussion knowledge and management before presenting cross-tabulated behavioural trends of the sample.
4.2 Demographics of Sample Group

4.2.1 Gender

As demonstrated in Figure 4.1, the sample group is almost equally split between male and female, 52% (n=73) and 47% (n=65). There was a significant association between gender and receipt of additional training, with male chiropractors being more likely to report further training; 33% of male chiropractors have additional training compared to 17% of their female counterparts ($\chi^2=4.413, df=1, p=0.036$).

**Figure 4.1 Clustered column indicating gender distribution of sample and groups.**
4.2.2 Years of Experience

Participants were split into ≥5< years’ experience groups. The ≥5years group made up most of the sample. The <5 years group made up 38% (n=52) of the sample, compared to ≥5 years who made up 62% (n=85).

Of the 52 with <5years experience, 19.2% (n=10) had additional training, compared to the ≥5years group where 29% (n=25) had additional training.

Figure 4.2 Clustered column indicating experience distribution
4.3 Concussion Knowledge, Diagnosis and Management

4.3.1 Theoretical knowledge

The sample population scored similarly in theoretical knowledge questions. A discrepancy was noted in questions related to mechanism of injury ($\chi^2 = 6.224$, df=1, $p=0.013$) and the relation to impact or non-impact injury ($\chi^2 = 5.776$, df=1, $p=0.016$). The group with no additional training scored significantly lower compared to the group with additional training.

Figure 4.3 Clustered column graph indicating theoretical knowledge

![Clustered column graph indicating theoretical knowledge](image)
4.3.2 Concussion Diagnosis and management

Both groups within the sample scored poorly in the number of symptoms required for a concussion diagnosis, identification of symptoms related to mTBI, appropriate management of concussion and the implementation of the return-to-play-protocol, regardless of additional training or not.

Although there was a difference in the knowledge of frequency of Loss of Consciousness (LOC) in concussion, it was not statistically significant. Both groups scored highly regarding the diagnosis of concussion not requiring a LOC.

Figure 4.4 Clustered column indicating diagnosis and management
4.3.3 Post-Concussion Knowledge, Diagnosis and Management

The group with additional training scored significantly higher in the identification of post concussive symptoms;

Additional training scored 83% (n=29) compared to 56% (n=58) of the non-additional training ($\chi^2 = 7.901$, df=1, $p=0.005$).

The overall results within the sample as well as the lack of discrepancy between the groups with additional training versus those without may indicate a lack in knowledge regarding post-concussive syndrome and the long-term consequences of concussion or alternatively controversy related to the duration and presence of consequences.

Figure 4.5 Clustered column graph indicating post-concussion knowledge

<table>
<thead>
<tr>
<th>Identified post concussive symptoms</th>
<th>Duration of post concussive syndrome and second impact symptoms</th>
<th>Concussion and related long term sequelae</th>
<th>Upper cervical spine injuries can mimic symptoms of concussion and post concussive syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional training</td>
<td>82,9</td>
<td>60</td>
<td>54,3</td>
</tr>
<tr>
<td>No additional training</td>
<td>56,3</td>
<td>63,1</td>
<td>45,6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>74,3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>68</td>
</tr>
</tbody>
</table>
4.3.4 Knowledge of Concussion assessment tools

Both population groups scored poorly in their familiarity levels regarding concussion tools. Those who had additional training still scored almost twice as high (mean score 18.51) as those who did not (mean score 6.5).

The most recently published concussion tools, SCAT 3 and 5, scored most familiar in the population with additional training, while the graded symptom checklist scored most familiar in the group with no additional training.

The only statistical significance found was regarding knowledge of Zurich guidelines. The group with additional training scored 24.3% (n=8) compared to those without additional training, 2% (n=2). \( \chi^2 = 38.25, \text{ df}=4, p=0.000 \).

A compounding significance was found regarding practitioners referring to clinical guidelines/Zurich consensus statement. Those with additional training scored 43% (n=15) compared to those without additional training who scored 10.7% (n=7). \( \chi^2 = 17.689, \text{ df}=1, p=0.000 \).
Figure 4.6 Clustered Column indicating concussion tool knowledge

<table>
<thead>
<tr>
<th>Concussion Tool</th>
<th>Additional Training</th>
<th>No Additional Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graded symptom checklist</td>
<td>14.3</td>
<td>12.8</td>
</tr>
<tr>
<td>SCAT 5</td>
<td>35.3</td>
<td>9.9</td>
</tr>
<tr>
<td>SCAT 3</td>
<td>36.4</td>
<td>5</td>
</tr>
<tr>
<td>SCAT 2</td>
<td>15.2</td>
<td>5.1</td>
</tr>
<tr>
<td>BESS</td>
<td>12.5</td>
<td>4.1</td>
</tr>
<tr>
<td>IMPACT</td>
<td>5.8</td>
<td>5</td>
</tr>
<tr>
<td>SAC</td>
<td>12.2</td>
<td>6.1</td>
</tr>
<tr>
<td>ACE</td>
<td>9.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Zurich guidelines</td>
<td>24.3</td>
<td>2</td>
</tr>
<tr>
<td>Post-concussion symptom scale</td>
<td>20</td>
<td>10.9</td>
</tr>
<tr>
<td>Mean score</td>
<td>18.51</td>
<td>6.5</td>
</tr>
</tbody>
</table>
4.4 Sample Group Behavioural Trends

4.4.1 Age distribution of patients seen by population groups

There is an almost identical distribution of patient demographics that are seen by both groups. There is a slight skewing of the patient demographic leaning more towards patients that are older than 19 years old.

Figure 4.7 Clustered column indicating age of patients seen by population group
4.4.2 Frequency of concussion cases seen by population groups

Both population groups scored similarly in the frequency of concussions seen in practice. Most of the sample saw fewer than 12 cases per year. There was a large portion within both populations that reported having never seen concussion in practice.

Figure 4.8 Clustered graph indicating frequency of cases seen

![Clustered graph indicating frequency of cases seen](image)
4.4.3 Trends in history taking by population groups

Both population groups scored highly in the frequency of questions asked related to cognitive symptoms during the evaluation of concussion, while only moderately high when related to questions directed towards the family or friends of the patient.

Figure 4.9 Clustered column indicating trends in history taking

<table>
<thead>
<tr>
<th>Inquiry about cognitive symptoms on evaluation of impact injuries</th>
<th>Inquiry about cognitive symptoms on evaluation of MVA injuries</th>
<th>On evaluation of sports impact or motor vehicle accident injuries, I ask family members or friends about cognitive symptoms, memory loss and personality or emotional changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional training</td>
<td>Additional training</td>
<td>Additional training</td>
</tr>
<tr>
<td>86,4</td>
<td>85,7</td>
<td>65,7</td>
</tr>
<tr>
<td>No additional training</td>
<td>No additional training</td>
<td>No additional training</td>
</tr>
<tr>
<td>86,4</td>
<td>91,3</td>
<td>61,2</td>
</tr>
</tbody>
</table>
4.4.4 Comfort levels of population groups in recognizing and diagnosing concussion.

Overall, both populations scored equally low for comfort levels in recognizing and diagnosing concussion. Both groups scored highest for being most comfortable in diagnosing mild concussion. See Figure 4.10.

**Figure 4.10 Clustered column indicating comfort levels in recognizing and diagnosing concussion**
Both groups reported low levels of comfort in treating concussion. Within the population of additional training, not one participant reported being very comfortable in treating concussion.

Overall, there was a large portion in each group that reported not being comfortable at all in treating concussion 28% (n=39).

Figure 4.11 Clustered column indicating comfort levels of treating concussion between groups in the sample

<table>
<thead>
<tr>
<th>Comfort levels of treating concussion</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very comfortable</td>
<td>0</td>
</tr>
<tr>
<td>Comfortable</td>
<td>28.6</td>
</tr>
<tr>
<td>Moderately comfortable</td>
<td>25.7</td>
</tr>
<tr>
<td>A little comfortable</td>
<td>25.7</td>
</tr>
<tr>
<td>Not at all comfortable</td>
<td>20</td>
</tr>
<tr>
<td>Additional training</td>
<td>1.9</td>
</tr>
<tr>
<td>No additional training</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>26.2</td>
</tr>
<tr>
<td></td>
<td>25.2</td>
</tr>
<tr>
<td></td>
<td>31.1</td>
</tr>
</tbody>
</table>
4.4.6 Case Studies

The entire sample group had similarly high scores for 2 out of 3 scenarios. Only scenario 2 saw the population group who had no training scoring slightly lower than that of the group with additional training.

**Figure 4.12 Clustered column indicating correct diagnoses in case studies**

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Mean score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional training</td>
<td>82,9</td>
<td>71,4</td>
<td>91,4</td>
</tr>
<tr>
<td>No additional training</td>
<td>83,5</td>
<td>65</td>
<td>90,3</td>
</tr>
</tbody>
</table>
Chapter Five: Discussion

5.1 Introduction

In this chapter, the results obtained from the data analysis processes carried out in chapter 4 are further discussed.

Based on the analysis, the following research questions were identified:

1. What is the level of understanding and clinical practice of chiropractors in South Africa regarding concussion?
2. What are the differences in concussion knowledge and clinical practices of chiropractors with additional training compared to those with no additional training?
3. Were there deficits in knowledge within the sample and is there a significant difference between the two groups?

5.2 Sample Demographics

The total targeted sample was 830 chiropractors. 140 chiropractors participated, all of whom were registered with AHPCSA and 33% (n= 46) of whom were registered with Chirosport South Africa.

Not all chiropractors have a special interest in sport, and generally it is unknown who has this special interest, thus making this sub-group of chiropractors an unknown sample population. We can estimate the number by looking at the number of members registered with the sports interest group Chirosport South Africa, but it would not be an accurate number of total representation of chiropractors within South Africa.
Analysis described the correlation of additional training and being registered with Chirosport; A statistical significance was found for participants registered with Chirosport South Africa, who made up 34 % (n=46) of the sample.

Chirosport South Africa members were almost 3 times as likely as those who were not registered to have additional training in sports chiropractic ($\chi^2 = 21.414$, df=1, p=0.000).

**Table 5.1 Table indicating correlation of participants with additional training being registered with Chirosport South Africa**

<table>
<thead>
<tr>
<th>Are you currently registered with Chirosport South Africa?</th>
<th>Additional training</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>Count</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>% within Additional training</td>
<td>65,7%</td>
</tr>
<tr>
<td>No</td>
<td>Count</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>% within Additional training</td>
<td>34,3%</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>% within Additional training</td>
<td>100,0%</td>
</tr>
</tbody>
</table>

*not all participants answered this question*
5.2.1 Gender

The sample was split 46% female (n=65) and 52% male (n=73). Cross-tabulations revealed that although there was only a slightly higher predominance of males in the sample group, when we looked at those who had additional training; there was a greater disparity between the genders. Only 17% of females (n=11) had additional training compared to 33% of males (n=24). See Table 5.2. The disparity may point towards historical hegemonic patriarchy that persists within sports governance as well as sexism which contributes towards a rough entry into the sports arena for women (Senne, 2016). A compounding barrier to entry may lie in family planning and parental roles. Laws which favour maternal leave of absence and men being seen as breadwinners lead women toward higher levels of parental duties over their male counterparts, often at the cost of career advancements (Levs, 2015).

**Table 5.2 Table indicating gender distribution of sample**

<table>
<thead>
<tr>
<th></th>
<th>Q12 Q4 Gender</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Additional training Yes</td>
<td>Count</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>% within Q12 Q4 Gender</td>
<td>17,2%</td>
</tr>
<tr>
<td>No</td>
<td>Count</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>% within Q12 Q4 Gender</td>
<td>82,8%</td>
</tr>
<tr>
<td>Total</td>
<td>Count</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>% within Q12 Q4 Gender</td>
<td>100,0%</td>
</tr>
</tbody>
</table>

*not all participants answered this question*
5.2.2 Years of experience

- <5 years:
  - Percent in sample: 38% (n=52)
  - Percent in group with training: 19% (n=10)
- ≥5 years:
  - Percent in sample: 62% (n=85)
  - Percent in group with training: 29% (n=25)

This result lacks statistical significance and the slight discrepancy may be attributed to practitioners with more years’ experience being more likely to be able to afford the training compared to those just starting out. Another factor may include that ICCSP is not rolled out on an annual basis and practitioners who have been in practice for fewer years may have missed a training cycle.

5.3 Overall Concussion Knowledge of the Sample Group

It should be noted that in order to achieve valid statistical analysis, questions that displayed low level correctness were omitted. For these questions, both groups scored poorly and indicate a gap in knowledge despite 26% (n=37) of the sample having *additional training*. See Table 5.3.

Questions which showed low level correctness included knowledge on:

1. Post concussive symptoms
2. Mild concussion resulting in long term sequelae
3. Signs and symptoms of concussion
4. Number of symptoms required to diagnose concussion
5. Appropriate management of concussion
6. Identification of red flags that predict the potential for prolonged recovery
7. Correct implementation of graduated return-to-play
Based on these questions, it may suggest that the general areas which display poor knowledge include the identification of signs, symptoms and red flags for concussion, and more significantly, the identification, management and understanding of post-concussive syndrome and its consequences.

Table 5.3 Table indicating overall theoretical concussion knowledge

<table>
<thead>
<tr>
<th></th>
<th>Number of questions correct (max could be 20 correct responses)</th>
<th>Percent questions correct for 20 knowledge questions</th>
<th>Number of questions correct, removing questions with low correctness (max could be 13 correct responses)</th>
<th>Percent questions correct for 13 knowledge questions (seven questions with low correctness omitted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Valid 140</td>
<td>140</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>Missing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>12,49</td>
<td>62,43</td>
<td>8,94</td>
<td>68,74</td>
</tr>
<tr>
<td>Median</td>
<td>13,00</td>
<td>65,00</td>
<td>9,00</td>
<td>69,23</td>
</tr>
<tr>
<td>Mode</td>
<td>15,00</td>
<td>75,00</td>
<td>12,00</td>
<td>92,31</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3,36</td>
<td>16,80</td>
<td>2,48</td>
<td>19,09</td>
</tr>
</tbody>
</table>
5.4 Comparative Analysis of Groups in Sample Population

5.4.1 Differences in concussion knowledge and clinical practices between population groups

Despite the overall low correctness score for questions for both populations of the sample, evaluation of table 1 compared to table 2 shows that participants from the group who had additional training scored higher overall and had a lower standard deviation than those who had no further training. See Table 5.4.

**Table 5.4 Table indicating differences in concussion knowledge and clinical practices between population groups**

<table>
<thead>
<tr>
<th>Additional training</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of questions correct (max could be 20 correct responses)</td>
<td>Yes</td>
<td>35</td>
<td>13,8000</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>103</td>
<td>12,0680</td>
</tr>
<tr>
<td>Percent questions correct for 20 knowledge questions</td>
<td>Yes</td>
<td>35</td>
<td>69,0000</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>103</td>
<td>60,3398</td>
</tr>
<tr>
<td>Number of</td>
<td>Yes</td>
<td>35</td>
<td>9,8857</td>
</tr>
</tbody>
</table>
**Sports Concussion Knowledge and Clinical Practices**

<table>
<thead>
<tr>
<th>questions correct, removing questions with low correctness (max could be 13 correct responses)</th>
<th>No</th>
<th>103</th>
<th>8,6408</th>
<th>2,54317</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent questions correct for 13 knowledge questions (seven questions with low correctness omitted)</td>
<td>Yes</td>
<td>35</td>
<td>76,0440</td>
<td>15,58371</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>103</td>
<td>66,4675</td>
<td>19,56288</td>
</tr>
</tbody>
</table>

*not all participants answered all these questions*

5.4.2 Differences in concussion diagnosis and management between population groups

The sample reported very low frequencies of cases of concussion seen in practice. *Not one participant* from the group with *additional training* reported seeing one case per week; 1 person from the group without additional training reported seeing one case per week.

The frequency of concussion cases seen by both groups was fewer than 12 per year. 43% (n=59), a large portion of the sample (both groups), reported never having seen a concussion case.
Both groups in the sample population scored high in asking the patient pertinent history questions regarding cognitive symptoms. However, when asked to report if the same questions were directed toward the family and friends of the patient both groups scored 20% lower.

It raises an interesting point of discussion as patients are not always aware of the cognitive symptoms related to concussion or post-concussion syndrome.

It is therefore important to direct these questions to family and friends who could possibly give a more accurate description of cognitive symptoms.

Although further analysis and study would have to be conducted to conclude reasons for this, it may be that patients attend their appointment with a chiropractor unaccompanied and it is therefore challenging to have family and friends available for inquiry.

It is worth noting that the group with training reported higher frequencies (5%, n=5) in inquiring about cognitive symptomology when evaluating MVA symptom history versus impact injuries. Additionally, this frequency was 6% (n=64) higher in the group without training for the same question. This could suggest that the group without training perceives impact injuries as less severe.

Research into the overall incidence and prevalence of concussion within South Africa has largely been described within the sports environment, and particularly within rugby due the contact nature of the sport. Research into incidence and prevalence as well as other factors of concussion has been impaired by differences in definition along with ethical considerations in evaluating and managing concussion. For these reasons, describing trends in incidence and management is largely broad and subjective. The consequences of less inquiry into impact injuries proves illogical as concussion and mTB is a danger in non-sport MOI.

Having said this, the incidence of concussion within rugby in South Africa has ranged from 22% to 50% in High school rugby alone (Patricios et al.,
2010). This significant statistic suggests that inquiry into impact injury should at the very least equal to that of MVA injuries especially when we consider vulnerability within this age group alone (Adolescents) (Clay et al., 2013).

Comfort levels in diagnosing concussion were reported equally low in both groups of the sample. Mild concussion was reported as most comfortably diagnosed by those without additional training, 36% (n=37), while those with additional training reported that they were most comfortable diagnosing severe concussion.

Together with the reported low levels of comfort, these results could suggest that the group without training reported mild concussion as most comfortable to diagnose as the severity and risk involved for both the patient and doctor is less.

Conversely, the group with additional training may have reported severe concussion as their most comfortable 53% (n=18) to diagnose as the presentation may be more severe and hence more obvious to recognize. Given the aforementioned poor knowledge of red flags and post-concussion symptoms, this was a concerning finding in the data. It may suggest that participants are overestimating some of their knowledge which could lead to practitioner negligence.

The sample also reported low levels of comfort in treating concussion. Not one participant from the group with additional training reported being very comfortable in treating concussion. The rest of the sample was evenly distributed between being comfortable and not at all comfortable in treating concussion. In general, those with additional training were on average more comfortable in varying degrees in treating concussion. Less of the additional training group reported being not at all comfortable compared to those with no additional training.
5.4.3 Differences in concussion tool knowledge between population groups

Although the group with additional training scored twice as high as the group with no additional training, overall knowledge of concussion assessment tools was low in both groups; the group with additional training scored a mean of 19% (n=26) for familiarity of moderate to very familiar within the concussion assessment tools. The group without additional training scored a mean of 7% (n=9).

The group with additional training was most familiar with recently published concussion assessment tools (SCAT 3 and SCAT 5). The group without training was most familiar with the graded symptom checklist.

The greatest difference in knowledge was demonstrated in the familiarity of Zurich guidelines where the group with additional training scored 22% (n=6) more than those without additional training.

As the vast majority of these tools can be found online at no cost, availability of the assessment tools would not appear to be the reason for the lack of familiarity and may rather suggest that knowledge about the available tools and their availability may be the cause. Following on from the overall poor scores in identifying signs and symptoms; it could be that practitioners may be uncertain on when to apply the appropriate use of these assessment tools.

Further investigation into reasons for practitioners being unfamiliar with concussion assessment tools would assist in understanding where the disconnect lies.
5.4.4 Differences in post-concussion knowledge and clinical practices

The group with additional training scored statistically higher 83% (n=29) compared to 56% (n=58) of the non-additional training ($x^2= 7.901$, df=1, p=0.005).

Both groups scored similarly low regarding the duration and long-term sequelae of concussion. This indicated a lack of knowledge in this area and the possible consequence of post-concussive patients being inadequately diagnosed and treated. As stated in the introduction, even mild concussion can have detrimental long-term effects, so it is imperative that a PCP have appropriate knowledge.

5.4.5 Differences in behavioural or clinical practices in population groups.

The sample population all reported a diverse patient base that was not heavily distributed towards any patient age group. Children (12 years and under) were the least frequently seen by the sample while age groups from 19-56 and older were reported as the most frequently seen age groups.

Both groups within the sample had almost identical distributions of patient age groups.

5.5 Overall gaps in knowledge

As stated in 5.1, the entire sample population scored statistically low in recognition and diagnosis of concussion, post-concussion sequelae and management, as well as red flags that would indicate a prolonged or poor prognosis. Additional training and familiarity with concussion assessment tools may be of value to bridge this knowledge gap.
Chapter Six: Conclusion and Recommendations

6.1 Conclusions on Findings

The following sections present the conclusions pertaining to the findings that were made in Chapter 4 and further discussed in Chapter 5.

From this study, it can be concluded that participants who had additional training were more likely to score higher in the distributed survey. Additionally, participants registered with the chiropractic sports interest group, Chirosport South Africa, were more likely to have undertaken additional training. Male participants were more likely to have had additional training compared to female counterparts.

Theoretical questioning scores were high amongst both groups within the sample. Questions related to identification and number of symptoms, red flags and appropriate management scored lowest in both groups. Despite this, participants who have had additional training were more likely to answer questions about mechanism of concussion, symptoms, MOI and post-concussion questions correctly.

Participants with additional training report higher level of familiarity with SCAT5, SCAT3, SCAT2 and Zurich guidelines and are more likely to have referred to 2012 Zurich consensus statements. This appears to be largely due to further training through FICS.
6.2 Recommendations

Based on the findings of the current study, the following recommendations are made about the trends of concussion knowledge and management:

- Practitioners with sport chiropractic treatment and management certification should be required to complete regular practical sessions, as is the case with first aid courses, to ensure that they are kept up to date with resource material. Familiarity and competency in recognizing, diagnosing and managing concussion is essential when dealing with field side management.
- Chiropractic associations could investigate making a summary of concussion assessment tools, as well as research results, available to their members.
- Basic concussion assessment should be included as part of student clinical training.
- Associations which manage sports practitioners could make concussion consensus statements available to members.
- Practitioners with special interest in sport chiropractic management and treatment should seek additional training, especially in concussion knowledge, to increase diagnostic and management accuracy.

6.3 Recommendations for Further Studies

It is suggested that the following studies be conducted based on the research gaps that were identified during this study:
• More detailed questioning on where practitioners without additional training obtain most of their information on concussion.
• Studies into the comparison of impact, non-impact and sports related concussion. Additionally, the perceived relative severity of these three different MOI.
• Studies into the reasons in disparity within sports chiropractic training between male and female practitioners.
• Further studies into the knowledge of concussion consensus statements and their distribution.

6.4 Conclusions

The study made important findings and associations. Among them, knowledge on recognition, appropriate management and post-concussion knowledge is lacking despite additional training. Although concussion consensus statements and assessment tools have been published, most practitioners remain unfamiliar with the tools and with appropriate management protocols. Overall, practitioners with additional training prove more competent than those without. However, practitioners still lack vital knowledge which raises concern on whether patients are receiving adequate management regarding concussions.

Participants registered with Chirosport were associated with having done additional training and it would therefore appear that these types of interest groups do play a role in encouraging and advancing competent practitioners. Having said this, the disparity between numbers of male and female practitioners with additional training could be improved upon and accreditting bodies may want to investigate where the gap lies and how to ensure increased parity.

A disconnect exists. All practitioners that responded to the survey had a special interest in sports chiropractic management and treatment.
Surprisingly, only 26% (n=37) had undertaken *additional training* vs 74% (n=104) without additional training. Many practitioners with an interest in sport describe themselves as “sports chiropractors”, those with *additional training* will list their additional qualifications after their names, but neither of these aspects is controlled. A potential risk to patients is posed, when patients who access a practitioner calling themselves a “sports chiropractor” (without checking for additional qualifications) may be under the assumption that they are being treated by someone more appropriately skilled, yet the chiropractor may not have the necessary training to qualify them for accurately diagnosing concussion. Even amongst the group with *additional training*, there was a clear lack of practical knowledge. It seems clear that there is a necessity for mandates and training in evaluation and management of concussion. Stricter guidelines and legislation could assist in ensuring the implementation of more stringent training, especially with regard to concussion, and especially before practitioners can describe themselves as “sports chiropractors”, thus ensuring safer practice.
Sports Concussion Knowledge and Clinical Practices

References


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Computational, Cognitive, Clinical Neuroimaging Laboratory, Division of Brain Sciences, Faculty of Medicine, Imperial College London, Hammersmith Hospital Campus, London & UK David J Sharp, Peter O Jenkins.


adults presenting to three Canadian emergency departments: Missed opportunities. American journal of emergency medicine,


Taylor, D.N., Ponce, F.J. & Dyess, S.J. (2017). Survey of primary contact medical and chiropractic clinicians on self-reported knowledge and


Appendices

Appendix A: Information letter

DEPARTMENT OF CHIROPRACTIC
RESEARCH STUDY INFORMATION LETTER

Date:

Good Day

My name is Kayleigh Posthumus. I WOULD LIKE TO INVITE YOU TO PARTICIPATE in a research study on “Sports Concussion Knowledge and Clinical Practices: A survey of South African Chiropractors with a Special Interest in Sports”.

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. Please go through the information letter; I am available to answer any questions you have. The study is part of a research project being completed as a requirement for a Master's Degree in Chiropractic through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to describe knowledge, training and treatment protocols of concussion by sports chiropractors within South Africa.
The broader aim of this research is to determine the necessity of mandates and training in evaluation and management of concussion as well as to gather data that may benefit both chiropractic training institutions as well as international organizations such as FICS in the education of chiropractors in concussion.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions I will be happy to answer them for you.

DO I HAVE TO TAKE PART? No, you don’t have to. It is up to you to decide to participate in the study. I will describe the study and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form.

WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE? All willing participants who have met the inclusion criteria will be given a research study questionnaire (Appendix C) which should take 10-15 minutes to complete. Only successfully completed questionnaires will be used for the purpose of this study.

WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY? If you decide to participate, you are free to withdraw your consent at any time without giving a reason and without any consequences. If you wish to withdraw your consent, you should inform me as soon as possible.

IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME: There will be neither remuneration nor expenses.
RISKS INVOLVED IN PARTICIPATION: There are no anticipated risks.

BENEFITS INVOLVED IN PARTICIPATION: There are no anticipated benefits other than a gain in knowledge.

WILL MY PARTICIPATION IN THIS STUDY BE KEPT CONFIDENTIAL? Yes. Names on the questionnaire/data sheet will be removed once analysis starts. All data and back-ups thereof will be kept in password protected folders and/or locked away as applicable. Only I or my research supervisor will be authorized to use and/or disclose your anonymized information in connection with this research study. Any other person wishing to work with your anonymized information as part of the research process (e.g. an independent data coder) will be required to sign a confidentiality agreement before being allowed to do so.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY? The results will be written into a research report that will be assessed. In some cases, results may also be published in a scientific journal. In either case, you will not be identifiable in any documents, reports or publications. You will be given access to the study results if you would like to see them, by contacting me.

WHO IS ORGANISING AND FUNDING THE STUDY? The study is being organized by me, under the guidance of my research supervisor at the Department of Chiropractic at the University of Johannesburg. This study will be self-funded.

WHO HAS REVIEWED AND APPROVED THIS STUDY? Before this study was allowed to start, it was reviewed in order to protect your interests. This review was done first by the Department of Chiropractic, and then secondly by the Faculty of Health Sciences Research Ethics.
Sports Concussion Knowledge and Clinical Practices

Committee at the University of Johannesburg. In both cases, the study was approved.

WHAT IF THERE IS A PROBLEM? If you have any concerns or complaints about this research study, its procedures or risks, and benefits, you should ask me. You should contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Kayleigh Posthumus
+27 84 840 1320
kayleighposthumus@gmail.com

You may also contact my research supervisor:
Dr. Irmarie Landman
dirkiel@uj.ac.za

You may also contact my research co-supervisor:
Dr. Glen Paton
gjpchiro@gmail.com

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. Christopher Stein
Tel: 011 559-6564
Email: cstein@uj.ac.za

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its
procedures, risks, and benefits, you should communicate with me using any of the contact details given above.

Researcher:
Kayleigh Posthumus
Appendix B: Consent form

DEPARTMENT OF CHIROPRACTIC
RESEARCH CONSENT FORM

Concussion Knowledge and Clinical Practices: A Survey of South African Chiropractors with a Special Interest in Sports

Please initial each box below:

☐ I confirm that I have read and understood the information letter dated for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to take part in the above study.

__________________________________  ________________________  __________
Name of Researcher                  Signature of Researcher         Date
The current knowledge, training in detection, diagnosis and management of concussion within the South African chiropractic profession is largely unknown. By sharing your knowledge and experience of treating concussion you will be making an empirical contribution to our understanding of the treatment of concussion by chiropractic professionals. Your response will be combined with others in order to establish common and best practice methods of detection, diagnoses and management of concussions.

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given below.

Researcher: Kayleigh Posthumus
Cell number: (+27)84 840 1320
Email: kayleighposthumus@gmail.com
DEPARTMENT OF CHIROPRACTIC RESEARCH CONSENT FORM

I confirm that I have read and understand the information letter for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

1. Yes
2. No - please read the information letter before proceeding

I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

1. Yes
2. No - please read the information letter before proceeding

I agree to take part in the above study.

1. Yes
2. No

Personal information

1. Are you currently registered with the Allied Health Professions Council of South Africa?
   1. Yes
   2. No

2. Have you completed any further sports chiropractic training? ***
   1. Yes, International federation of sports chiropractic (FICS): ICSC, ICCSP and ICCSD
2. Yes, Other: CCSP, DACSP and FRCCSS
3. NONE: special interest in sports

2a. If yes, please indicate the specific training certification. Select all applicable answers.***
   1. ICCSP
   2. ICSSD
   3. CCSP
   4. DACSP
   5. FRCCSS

3. Are you currently registered with ChiroSport South Africa?
   1. Yes
   2. No

4. Gender
   1. Female
   2. Male
   3. Prefer not to say

5. Years of experience as a chiropractor **
   1. < 5 years
   2. ≥ 5 years

6. Please state your credentials and any additional specializations or certifications
7. Patient demographic (select all applicable) **
   1. Children (12 years and under)
   2. Adolescents (13-18 years)
   3. Young adults (19-35 years)
   4. Middle aged (36-55 years)
   5. Older adult (56 years and older)

Concussion knowledge and management

1. Please select the definition of concussion *
   1. A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces (80%, n=112)
   2. Loss of consciousness for <5 minutes after an impact to the head
   3. A structural brain injury caused by mild traumatic force that transiently decreases cerebral blood flow
   4. Don't know

2. Is concussion classified as brain injury? *
   1. Yes, there is a functional disturbance that cannot be seen on standard neuroimaging (84%, n=118)
   2. No, there is no abnormality seen on standard neuroimaging
   3. Yes, there is a structural abnormality seen on standard neuroimaging
   4. Don't know

3. Which is true regarding the mechanism of concussion? *
   1. A whiplash effect to the brain caused by an impact to any part of the body (68.6%, n=96)
   2. Direct physical damage to the brainstem
3. Localized damage to the brainstem
4. Localized damage to the prefrontal cortex
5. Localized damage to the hippocampus
6. Don't know

4. Which of the following is true? *
   1. Less than 1/3 of concussions involve loss of consciousness (LOC) (70%, n=98)
   2. A period of unconsciousness is necessary for the diagnosis of a concussion
   3. Over 2/3 of all concussions involve LOC
   4. 1/3 to 2/3 of all concussions involve LOC
   5. Don't know

5. Post concussive patients may present with: (select all applicable responses) (62.1%, n=87)
   1. Fatigue
   2. Insomnia
   3. Change in balance
   4. Weakness
   5. Paraesthesia's
   6. Don't know

6. Which of the following signs and symptoms are recognized as results of mild brain trauma? (Select all applicable responses) (38.6%, n=54)
   1. Irritability
   2. Tachycardia
   3. Sleep disturbance
   4. Light sensitivity
   5. Sound sensitivity
   6. Convulsions
   7. Weakness
8. Depression
9. Memory problems
10. Headache
11. Don't know

7. Please rate your level of familiarity with the graded symptoms checklist **
   1. Not at all familiar
   2. Slightly familiar
   3. Somewhat familiar
   4. Moderately familiar
   5. Extremely familiar

8. How many symptoms are required to diagnose a concussion? *
   1. One (8.6%, n=12)
   2. Two
   3. Three
   4. Five or more
   5. Don't know

9. Please rate your level of familiarity with the clinical tools below: **

<table>
<thead>
<tr>
<th></th>
<th>Not at all familiar</th>
<th>Slightly familiar</th>
<th>Somewhat familiar</th>
<th>Moderately familiar</th>
<th>Very familiar</th>
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<tbody>
<tr>
<td>SCAT 5</td>
<td></td>
<td></td>
<td></td>
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<td>SCAT 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCAT 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Please rate your level of familiarity with the post-concussion symptom scale:
   1. Not at all familiar
   2. Slightly familiar
   3. Somewhat familiar
   4. Moderately familiar
   5. Extremely familiar

11. What is the appropriate management of concussion? (Select all applicable responses) (20%, n=28) *
   1. Every concussion individual should see a physician
   2. A stepwise increase in exercise and activity if symptomatic
   3. Physical rest is recommended after concussion
   4. Mental rest is recommended after concussion
   5. Signs and symptoms should be monitored for increased severity
   6. Full neurological exam at initial assessment is recommended
   7. The standard mini mental status at initial assessment is an adequate cognitive test
   8. MRI of the brain is mandatory
   9. CT of the brain is mandatory
   10. Don't know
12. What are red flags that predict potential for prolonged recovery or are factors that warrant further investigation? (Select all applicable responses) *(Percentage of participants who got all answers correct: 31.4%, n=44)*

1. Nosebleed
2. Number and duration of symptoms *(16.6%, n=23)*
3. Age *(9.6 %, n=13)*
4. Repeated concussions occurring with progressively less impact *(15%, n=12)*
5. Slower recovery after each successive concussion *(16%, n=22)*
6. Repeated concussions over time *(16.9%, n=24)*
7. Concussions in close succession *(17.4 %, n=24)*
8. Being hit on the left side of the head
9. Don't know

13. What are the long-term consequences of repetitive concussion? (Select all appropriate response options) *

1. Dementia *(12.6%, n=18)*
2. Depression *(10.6%, n=15)*
3. Headaches *(14.8%, n=21)*
4. Increased risk of haemorrhagic stroke
5. Death or disability with second concussion before recovery from first concussion *(8.2%, n=11)*
6. Increased risk of schizophrenia
7. Prolonged fatigue *(9.6%, n=13)*
8. Impairment of concentration *(15.3%, n=21)*
9. Parkinsonism *(5.8%, n=8)*
10. Chronic Traumatic Encephalopathy *(9.9%, n=14)*
11. Don't know
14. Please select your responses to the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Somewhat disagree</th>
<th>Neither agree nor disagree</th>
<th>Some what agree</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>Don't know</th>
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<td>Concussion injuries can result from impact or non-impact injuries to the head</td>
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<td>To be diagnosed, concussion must be accompanied by a loss of consciousness</td>
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<td>Post concussive syndrome and second impact syndrome symptoms are always of a short duration</td>
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<td>Mild concussion cannot result in long term sequelae</td>
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<td>Upper cervical spine injuries can mimic symptoms of concussion and post concussive syndrome</td>
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<td>Patients always have self-awareness of whether they incurred a concussion</td>
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15. Same day return to play after concussion should never be permitted regardless of age, severity or activity levels: **
   1. True (92.1%, n=128)
   2. False
   3. Don't know

16. During the implementation of a graduated return-to-play protocol, an athlete who experiences symptoms after the completion of a step may progress to the next step if symptoms resolve within 24 hours **
   1. Strongly disagree
   2. Disagree
   3. Somewhat disagree
   4. Neither disagree nor agree
   5. Somewhat agree
   6. Agree
   7. Strongly agree
   8. Don't know

Practitioner practice trends **

1. How frequently do you manage concussions?
   1. At least 1 case per week
   2. 1-3 cases per month
   3. Fewer than 12 cases per year
   4. Never

2. How would you describe your level of comfort in recognizing and diagnosing mild, moderate or severe concussion? **
## Sports Concussion Knowledge and Clinical Practices

<table>
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<tr>
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<th>Very comfortable</th>
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<td>Mild concussion</td>
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3. How would you describe your level of comfort in treating concussion? **
   1. Very comfortable
   2. Comfortable
   3. Moderately comfortable
   4. A little comfortable
   5. Not at all comfortable

4. On evaluation of sports impact injuries, I inquire about cognitive symptoms:
   1. Never
   2. Rarely
   3. Sometimes
   4. Often
   5. Every time

5. On evaluation of motor vehicle accident injuries, I inquire about cognitive symptoms:
   1. Never
   2. Rarely
   3. Sometimes
   4. Often
   5. Every time
6. On evaluation of sports impact or motor vehicle accident injuries, I ask family members or friends about cognitive symptoms, memory loss and personality or emotional changes:
   1. Never
   2. Rarely
   3. Sometimes
   4. Often
   5. Every time

7. Do you refer/have you ever referred to the clinical practice guidelines and/or similar resources such as the 2012 Zurich consensus statement when managing concussions?
   1. Yes
   2. No

If yes, please list the clinical guidelines and/or similar resources you have referred to:
Case studies

1. A 16-year-old male presents 2 days following a helmet-to-helmet collision with another player during football practice. He had no symptoms following the collision and he finished the practice. He is complaining of a moderate headache that began the day following the collision. His mother reports that he has been more irritable than normal. How likely would you be to diagnose this patient with a concussion? **
   1. Very likely
   2. Somewhat likely
   3. Somewhat unlikely
   4. Very unlikely

2. A 14-year-old male presents 4 days following a wrestling meet. The patient reports being flung to the ground and landing on his upper back and shoulders. The patient experienced an initial headache and neck pain. His symptoms have progressively worsened since the injury. He reports that his pain and headache increase when he tries to practice with his team. How likely would you be to diagnose this patient with a concussion? **
   1. Very likely
   2. Somewhat likely
   3. Somewhat unlikely
   4. Very unlikely

3. A 12-year-old female reports 1 week following a head injury. She reports colliding with a teammate while attempting to head a soccer ball. Her only signs/symptoms were an initial mild headache lasting several
hours and a small “goose egg”. She did not seek medical care after the injury. The following day, she returned to school and completed a practice with no symptoms. She states that she has had difficulty sleeping since the injury and has been experiencing a feeling of mental “fogginess” and an inability to focus. How likely would you be to diagnose this patient with a concussion? **

1. Very likely
2. Somewhat likely
3. Somewhat unlikely
4. Very unlikely

*Kazemi et al., 2017;  
**Lamb, 2016;  
***Moreau et al., 2015;  
****Sharp & Jenkins, 2015;  
*****Taylor et al., 2017

You have reached the end of the questionnaire. In order to obtain Continued Professional Development (CPD) points you will be redirected to a new page to enter your personal details. This new page has been created to protect your anonymity i.e. your responses to this questionnaire cannot be linked to your response to the CPD page. Please click the ‘DONE’ button to be redirected to the new page to enter your details to get CPD points.
Appendix D: Permission letter (Chirosport SA)

9 January 2019

To whom it may concern,

Please note that the executive committee of Chirosport South Africa has given Miss Kayleigh Posthumus permission to distribute her research survey to our membership.

If you require any further information you are welcome to contact me at admin@chirosport.co.za

Kind regards,

Dr Gillian Johnston
Treasurer | Chirosport South Africa
admin@chirosport.co.za
Appendix E: Certificate of release for marking

FACULTY OF HEALTH SCIENCES
CERTIFICATE OF RELEASE

SUBMISSION OF A RESEARCH:
MINI-DISSERTATION ☒
DISSERTATION
THESIS

FOR EXAMINATION IN THE DEPARTMENT OF CHIROPRACTIC

STUDENT NUMBER: 201300050

NAME OF CANDIDATE: Kayleigh Elan Posthumus

RESEARCH QUALIFICATION REGISTERED FOR: MTech Chiropractic

I, D M LANDMAN (Supervisor) for the above student, hereby approve and release for examination his mini-dissertation/dissertation/thesis entitled:

Sports Concussion Knowledge and Clinical Practices: A Survey of South African Chiropractors with a Special Interest in Sport

It is certified to be his/her own work.

[Signature]
09/09/2019

SUPERVISOR DATE

*In the event a supervisor for a doctoral thesis objects to the thesis being submitted for examination, he/she must provide a written statement motivating this. This statement is to be submitted by the doctoral candidate, together with his/her thesis.
This ruling does not apply to masters’ candidates, whose dissertation may not be submitted without the express permission of the Supervisor and Co-supervisor.
Appendix F: Turnitin originality report

9/5/2019

Turnitin Originality Report

Dissertation by KE POSTHUMUS

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   http://www.uaf.edu/apa/2012/11/15/p123.html

2. 1% match (internet from 03-Jun-2016)
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   Newsletter-July-2015.pdf

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   Submitted to Queen Mary and Westminster College on 2008-08-29

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8. < 1% match (internet from 23-Aug-2018)

9. < 1% match (internet from 24-Feb-2013)
   Submitted to Louisiana Tech University on 2013-02-24

10. < 1% match (internet from 06-Jul-2014)
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    anatomical-view-part-88-65-2008-pdf

11. < 1% match (student papers from 12-Sep-2017)
    Submitted to Higher Education Commission Pakistan on 2017-09-12

12. < 1% match (internet from 01-Mar-2015)

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Sports Concussion Knowledge and Clinical Practices

Chapter One: Introduction 1.1 Problem Statement A

A concussion is described as a complex pathological physiological process affecting the brain

with or without neuro-pathological damage. In most cases, the mechanism of injury (MOI)

10ls a blow to the head which can cause either direct or indirect injury to the brain

(Sharp & Jenkins, 2015). It should be mentioned that the term concussion holds little diagnostic value and it has been proposed that it be replaced by the term traumatic brain injury (TBI) as per the Mayo traumatic brain injury (TBI) classification system recommended by David Sharp and Peter Jenkins (2015). See Figure 1. Figure 1: Mayo TBI Classification system (Sharp & Jenkins, 2015) It is problematic to separate concussion and TBI as separate pathophysiological entities, due to the MOI being identical. This leads to there being no prior reasoning to think that concussion and TBI can be distinguished from one another. It also becomes unclear on how a clinician may decide between

the two when diagnosing a patient as the symptoms have no distinct diagnostic separation. The term concussion often implies a benign set of symptoms which tend to

resolve spontaneously. The assumed transience of symptoms is problematic as patients often have long-term effects, which imitates the similar post-concussive symptoms after TBI of varying severities. All these factors lead to circulatory diagnosis and prognostication; often resulting in a patient being inappropriately reassured about the benign nature of their symptoms with lack of investigation. Although it was not an aim of this research to describe and clarify diagnostic labels, in evaluating clinician knowledge it was valuable to discuss impact

of the use of the term “concussion” has on the management of

a patient. Overall, the

term concussion lacks diagnostic precision and

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may encourage a lazy diagnostic approach (Sharp & Jenkins, 2015). Concussion, however, remains an accepted term in literature and for all intents and purposes, this research used the term concussion to refer to both symptomatic mTBI (pTBI) and mild TBI (mTBI). The current levels of knowledge, including training in detection, diagnosis, and management of concussion, within the South African chiropractic profession are largely unknown. The description of the trends regarding the separating of concussion and TBI and of the trends regarding these areas of knowledge has been used to highlight gaps in knowledge which may lead to inaccurate diagnoses and a mismanagement of the syndrome (Coles, 2005; Johnson, Green, Nelson, Moreau & Nhan, 2013; Shure, Picone, Cordero & Campbell, 2013; Gergen, 2015; Moreau, Nhan & Warten, 2015; Kazemi, Biorgum & Vora, 2017; Taylor, Ponce & Dysess, 2017). Adequate evaluation, diagnosis, knowledge, and management of concussion amongst primary care physicians are imperative as it is a common occurrence with potentially serious complications (Johnson et al., 2013). Due to the MOI associated with mTBI, symptoms of cervicalgia and muscle spasm may encourage injured sportsperson to access a sports chiropractor for treatment. Data which can evaluate and describe the efficiency of diagnosis and adequate treatment is therefore important. Investigation could highlight any gaps in knowledge and practice amongst chiropractors who treat sports injuries, and in particular, concussion, which allows for improvement and changes in procedure protocol (Johnson et al., 2013).

51.2 Aim of the Study The primary aim of this research was to ascertain knowledge of the concussion and practices of concussion amongst South African chiropractors. The secondary aims of this research were to assess knowledge and clinical practice differences between chiropractors who have undergone additional training in the field of Sport chiropractic subject matter versus those with no additional training. The tertiary aim was to determine the necessity of mandating and training in

gather data that may benefit both local chiropractic training institutions as well as international organizations such as The International Federation of Sports Chiropractic (IFOSC) in the education of chiropractors in the subject of concussion. 1.3 Potential Outcomes of This Study The intended outcomes of this survey were to ascertain potential gaps in subject knowledge and management amongst South African chiropractors. Additionally, this research aimed to compare knowledge between those with additional training and those without to determine any significant statistical differences and possible associations. Furthermore, potential identification of gaps in knowledge and discrepancies between those with additional training and those without additional training, can assist in providing data which can focus training programmes and highlight possible shortcomings. This in turn could be used to formulate strategies and training assessments. Finally, this study may also be used as a comparison to our global counterparts.

5Chapter Two: Literature Review 2.1 Introduction This chapter serves to give detail on previously published literature and research

4proximal parts of the cranial nerves and the

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viscerocranium, which is made up of the facial bones. There are 7 associated bones: the auditory ossicles (3 in each middle ear) and the hyoid bone (Moore, Dalley, Agur, 2014).

Gillroy et al., 2016) 2.2.2 Meninges of the brain

The brain and spinal cord are enveloped by 3 membranous connective tissues called meninges which aim to protect the brain. These form a framework for arteries, veins and venous sinuses, and enclose a space known as the subarachnoid space, which is vital to the normal and healthy functioning of the brain.

(see Figure 3 and Figure 4). The subarachnoid space acts to support and cushion the brain and spinal cord as well as perform functions normally performed by the lymphatic system (Moore et al., 2014). The layers include: The dura mater is the outermost layer which is richly innervated by sensory fibres. The dura also forms thick connective tissue folds that separate brain regions and lobes. The arachnoid mater is a fine, web-like avascular membrane directly beneath the dural surface; the space between the arachnoid mater and beneath the underlying pia mater is referred to as the subarachnoid space and contains cerebrospinal fluid (CSF). The pia mater is a delicate membrane that directly envelops the brain and spinal cord (Moore et al., 2014). Figure 3 - Meninges in situ

brain superior view (Gillroy et al., 2016) 2.2.3 Dural folds Dural folds are fibrous sheets that are formed by the internal layers of the dura that project from the external peristeal layer of the dura. The dural folds divide the cranium into compartments and serve as a mechanical support for the brain (see Figure 5) (Moore et al., 2014). The dural folds constitute: The tentorium cerebelli. This separates the left from the right hemispheres of the brain. The tentorium cerebelli

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Sports Concussion Knowledge and Clinical Practices

7 is the second largest dural fold.

This

4 separates the occipital lobes of the cerebral hemispheres from the cerebellum. The

4 concave anteromedial border of the tentorium cerebelli is free and produces a gap called the tentorial notch through which the brainstem, midbrain, pons and medulla oblongata pass. The

Tentorium cerebelli is a vertical dural fold

7 which separates the cerebellar hemispheres. The diaphragma sellae is the smallest of the dural folds. It encloses the pituitary gland within its fossa

4 and has an aperture for the passage of the infundibulum and hypophyseal veins

(Moore et al., 2014). Figure 5: Brain removed to demonstrate left anterior oblique view of dural folds (Gilroy et al., 2016) 2.2.4 Brain The brain is contained within the neurocranium and has the following subdivisions. The telencephalon (Cerebrum (cerebral hemispheres)) is responsible for sensory processing (see Figure 7). The brainstem acts to convey both motor and sensory information

14 from the body and autonomic and motor information to peripheral targets.

The cerebellum coordinates smooth motor activities and processes muscle position

(see) (Moore et al., 2014). The most notable feature is the 2 large cerebral hemispheres which can be partitioned into 5 lobes (see Figure 8) (Hibberne et al., 2014).


Insula Figure 6: Lateral view of cerebral cortex indicating different lobes (Gilroy et al., 2016) Figure 7: Midline cut of diencephalon and brainstem (Gilroy et al., 2016) 2.2.5 Histological structure

43 of the cerebrum Cerebral cortex- grey matter The cerebral cortex is

covered and composed of inviolate grey matter. Grey matter is a collection of neurons, glial cells, blood vessels, and connective tissue. Additionally, grey matter is found as aggregations within the cerebral hemispheres, referred to as nuclei or ganglia (Wen & Chiodoletti, 2005; Miskinov, 2012). For descriptive purposes the cortex can be divided into 6 layers moving from most external to internal (see Figure 8) (Miskinov, 2012):

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Sports Concussion Knowledge and Clinical Practices


Figure 8: Cellular layers of cerebral cortex (Gilroy et al., 2016) Internal cerebral structure

42White matter The core of the cerebral hemispheres consists of white matter.

White matter consists of myelinated axons/fibres supported by neuroglia. These fibres run in multiple directions and can be divided into the projection, association and commissural fibres (see Figure 9 and Figure 10 (Messnerova, 2012). Figure 9: Midsagittal view indicating cerebral white matter

12(Gilroy et al., 2016) Figure 10: Pathways of the

CNS

12(Gilroy et al., 2016) Figure 11: Transverse view of the

brain indicating both white and grey matter (Gilroy et al., 2016). 2.3 Terminology Concussions are complex, representing a variety of mechanisms and types of injuries (Dishaw, Petrigle & Babies, 2012; Hooshmand, Quer Post, Koncan & Rousseau, 2018). The Zurich Consensus Statement on Concussion in Sports described a concussion as:

*"a complex pathological physiological process affecting the brain with or without neuropathological damage (Sharp & Jenkins, 2015). In most cases, the mechanism of injury is a blow to the head which can cause either direct or indirect injury to the brain. The group also suggested that concussion and mTBI be considered distinct entities. (Sharp & Jenkins, 2015).

In contrast, the American Academy of Neurology’s guidelines for sports concussion defines a concussion as: a clinical syndrome of biomechanically induced alteration of brain function, typically affecting memory and orientation, which may involve loss of consciousness. Although the latter definition does not separate it from mTBI, the group noted a lack of consensus in the use of the term, with an overlap in the use of concussion and mild TBI.

(Taylor et al., 2017). Consequently, a
Sports Concussion Knowledge and Clinical Practices

9/5/2019

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Concussion is currently used in two main ways: 1. To describe a distinct pathophysiological entity with its own diagnostic and management implications, mainly seen in the context of sporting injuries; and 2. To describe a constellation of symptoms that arise after different types of TBI.

(Neaple & Jenkins, 2015). 2.4 Biophysics of Concussion A concussion is believed to involve both primary and secondary phase injuries. 2

4.4.1 Primary phase injury Primary injury represents the moment of impact which involves translation of kinetic energy and force vectors in either a linear, rotational or combination mechanism of movement. Primary phase injury involves both coup and contrecoup injury. Two basic equations can be used to understand and visualize how these forces result in head and consequently brain acceleration.

(Dashnow et al., 2012; Hoshizaki, Ouac, Post, Kannan, & Rousseau, 2018). Force = mass X acceleration. The above equation quantifies linear force, whereas the equation below will quantify the resistance where there is torque.

19. Torque = moment of inertia X angular acceleration

Both linear and angular brain accelerations have been shown to be the most predictive variables for head injury. Therefore, kinetic energy = 1/2 mass X (velocity)^2. It is important to note that in these equations, mass, as well as velocity, has substantially increased. i.e., the mass of athletes and the velocities at which the impacts occur (Dashnow, et al., 2012). Along with the biophysics of concussion and understanding the velocities of collisions, it is, in fact,

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Sports Concussion Knowledge and Clinical Practices

The change in velocity (acceleration-deceleration) that is of importance. The brain is suspended within a CSF-filled space and has a certain degree of movement being only relatively supported and tethered at intervals via the falx and tentorium cerebelli and contained within the rigid skull (Dashnow, et al., 2012).

The brain can accelerate and collide with the skull within this reserve volume (Dashnow, et al., 2012). It is this velocity change that largely accounts for the coup-countercoup injury (Drew & Drew, 2004). The brain and CSF have a density difference of 4% and although it may seem negligible, this difference is enough to result in the denser CSF continuing in the direction of movement whilst the less dense brain parenchyma is displaced in the opposite direction. Secondary phase injury. Secondary injury relates to both immediate and delayed cellular events which include ultrastructural damage, ionic changes and neurotransmission effects, and neuroinflammation amongst other things. Increasingly, research has documented the long-term consequences of low-magnitude head impacts that present no immediate consequences but increase one’s risk for the second impact syndrome and have the potential to present serious progressive neurodegeneration (Dashnow, et al., 2012). Notable effects within cerebral blood flow and the blood-brain barrier (BBB) have also been cited contributing to the pathophysiology of secondary brain injury (Powell, 2001; Dashnow, et al., 2012). These effects are thought to be related to the shear forces acting on neurons which result in axonal disruption, although it is best described in more severe models of TBI. It plays an important role in mTBI (Dashnow, et al., 2012). Molecular changes to cellular protein, metabolic response to changes in the semi-permeable membrane, damage to white matter and vascular structures, and skull fracture all interfere with the functions of the brain. This supports the notion that repetitive concussion and trauma induce protein changes (TIPIC), as well as high-energy injuries, lead to psychiatric disorders and cognitive deficits (Dashnow, et al., 2012). Concussions are complex, representing a variety of mechanisms and types of injuries with overlapping and inconsistent symptoms (Dashnow, et al., 2012). 2.5 Acute Pathophysiology of Concussion Despite the exact pathophysiology being unknown, research shows that moderate to severe brain injury causes a complex cascade of neurochemical changes in the brain. By deduction, it is thought that concussion follows a similar

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117
Sports Concussion Knowledge and Clinical Practices

pathophysiological pathway as TBI (Patrick, Kohler & Collins, 2010; Tremblay, Pascal-Leone & Théorêt, 2018). The pathways begin with the ionic influx and glutamate release, progress to an

energy crisis, cytoskeletal damage, axonal dysfunction, altered neurotransmission, and inflammation and finally end in cell death.

Chronic Traumatic Encephalopathy (CTE) was discovered by a forensic neuropathologist, Bennet Omalu. Omalu, DeKosky, Minkter, Kambhoj, Hamilton, & Wecht, 2005, described the findings of a well-known American professional football player’s brain pathology who suffered from CTE as a result of sport-related head collisions. It has been described as long term cumulative exposure to repeated concussive or sub-concussive injury and related to overall

reduction in brain volume, enlargement of the lateral third ventricles, thinning of the corpus callosum, cavum septum pellucidum and neuronal loss of cerebellar tonsils

(Longhi, Saitman, Fujimoto, Raghubath, Mauey, Davis, McMillan, Conte, Launer & Stein, 2005; McKee & Decosmo, 2015). There is an increasing concern that these types of injuries may be linked to a form of tauopathy, triplet deposition of tau protein. It has become a hallmark of CTE and is linked to consequent brain damage resulting in the progressive decline of memory and executive functioning. It is often associated with mood and behaviour changes that may progress to dementia. Omalu et al., 2005; Patrick et al., 2010; Serrano-Pozo, Frosch, Masliah & Hyman

Giza & Hovda, 2014). Cognitive dysfunction related to CTE is most marked in boxers, although subtle corticol manifestations have been noted in rugby players, American football players and soccer players (Dashnaw et al., 2012; Giza & Hovda, 2014). As with most neurodegenerative conditions,

CTE can only be definitively diagnosed post-mortem

and no consensus criteria or biomarkers currently exist (Giza & Hovda, 2014). 2.7 History of Concussion Concussion symptoms

typically present immediately after injury but may be delayed by several hours and usually subside within ~72 hours. Most concussions resolve spontaneously within 7-10 days, although recovery may be prolonged in children

(Scorsone et al., 2012). Traditionally, concussion monitoring was focussed on the recovery phase. Recently the role of cognitive function, although being inconsistently described, has become increasingly important as it appears to resolve

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Sports Concussion Knowledge and Clinical Practices

Factors which predict recovery are poorly defined and are

1. Extrapolated from data linked to more severe traumatic brain injuries.

2. Recent studies suggest that prolonged headaches (more than 60 hours following head injury), fatigue, tiredness, mental fogginess and the presence of more than 3 symptoms during presentation

are linked to a more prolonged recovery (Scorza, Raleigh & O’Connor, 2012; Gallicci, 2013; Porcher et al., 2013; Kennedy et al., 2017; Mulholy, 2017; Ranekor, 2017; Boulis et al., 2016; Rowe et al., 2018). 2.8 Concussion Assessment Tools: Current evaluation of concussion involves numerous assessments, most of which increase in sensitivity and specificity only when combined with other assessment tools. All current

1. Assessment tools are most accurate when baseline measurements are available for comparison

(Potracos et al., 2015). Types of assessment tools include: 2.8.1 Symptom checklist: Most commonly used and although they are quick and cost-effective and have good sensitivity, symptoms may be delayed or were present at baseline and therefore caution must be applied (Scorza et al., 2012). 2.8.2 Neurophysiological tests: These are labour intensive and designed to detect subtle cognitive deficits.

1. These tests are not validated and there is no data to suggest they affect outcomes when used to guide return to play

(Scorza et al., 2012). 1. Manual ? Trial making: This includes asking the patient to connect a series of dots while maintaining accuracy. Digital symbol substitution involves the patient filling in a series of symbols correctly coded. Association test: Results may be affected by psychiatric disorders and are best interpreted when compared to a baseline. 2. Computer-based: These types of tests have little validity and no data to suggest they affect outcomes or return to play. 2. Impact. This web-based test automates measures of attention, reaction speed, and memory, to name a few. It, however, has

1. Limited baseline data for children younger than 12

1. IMACI: This is an online test that consists of baseline testing and post-injury testing. 2.8.3 Postural stability testing: This has high sensitivity

1. For concussion diagnosis but has limited data to substantiate its use in monitoring recovery. Sensory Organization Test (SOT) is the preferred test but is not portable and

therefore Balance Error Scoring system (BESS) is most often used on the side-line (Gallicci, 2013; Kowsy & Feinsten, 2018; Litteton et al., 2015; Scorza et al., 2012). 1. BESS (Balance Error Scoring system): This test makes use of a firm floor and then a foam pad. The patient is asked to perform different stance on
each of the surfaces while being marked if any errors are noted, i.e., the patient is unable to maintain balance. 2. SOT: This test measures ground reaction forces on a force plate while systematically disrupting the sensory selection process (Rune, 2014). 2.6.4 Sideline assessment tools: The sideline assessment tools are simple and assess various domains in the initial concussion assessment. They are frequently used in the monitoring of recovery.

4. Standardized Assessment of Concussion (SAC) is often used immediately following an injury to evaluate orientation, memory, concentration and delayed recall and is validated as a sideline tool.

3. Sport Concussion Assessment Tool (SCAT) is a combination of multiple assessment tools (symptom checklist, concentration and memory tasks (Maidock’s questions), SAC, BESS, and Glasgow coma scale). Although it is not validated, it is widely used and is considered the most comprehensive sideline tool.

(Sport Concussion Assessment Tool, 2013; Galuccio, 2013; Littleton et al., 2015; Scarza et al., 2012). 2.8.5 Investigating concussion 1. Neuroimaging CT and MRI are standard investigations for concussion injury. Whilst CT is sensitive to skull fracture and focal brain injuries in moderate to severe concussion, it lacks sensitivity to vascular and white matter injuries such as a diffuse axonal injury which is frequently encountered even in a mild concussion. Both cerebral and vascular injuries are important prognostic factors (Sharp & Jenkin, 2015). Specific MRI techniques such as gradient-echo and susceptibility weighted imaging can identify microbleeds which act as a stable marker of white matter injury following a concussion. Additionally, these types of MRI are helpful in giving a more complete assessment of white matter structure and therefore should now form part of the routine radiological investigation into concussive injuries (Ludig, Heckemann, Hammers, Lopez, Newcombe, Makropoulos, Löbbner, Menon & Rueckert, 2015; Sharp & Jenkin, 2015). 2. Blood and cerebrospinal fluid investigations: Hypothalamic-pituitary dysfunction is common in the acute phase of concussion injury and should, therefore, be screened for in patients with persistent symptoms. Levels of CSF biomarkers include tau and neurofilament light polypeptide which are elevated acutely. The measuring of CSP is, however, an unlikely investigation and thus there is a requirement for a blood marker. Unfortunately, blood biomarkers for concussion are less convincing than that of CSF, although recent studies have shown an increase in tau levels in plasma following mild concussion in ice-hockey players (Brahim, Tegnor, Wilton, Randulf, Skilblad, Pazuzko, Kalberg, Bannow & Zetvärnberg, 2014; Sharp & Jenkin, 2015). 3. Genetic association with inflammatory and apoptotic pathways in concussion: There are few prognostic factors which allow us to determine concussion duration and severity. Neuroinflammation is necessary to promote healing in the central nervous system; however, a prolonged or overactive response can have detrimental effects (McFie, Abrahams, Patrikios, Suter, Posthumus & September, 2018). McFie et al. (2018) stated that there was a significant association between functional knockout-related IL-1β rs16944 C>T and IL-6 rs1800795 G>C polymorphisms. Furthermore, the associations observed with the inferred interleukin-1β and cytokine-suggest that the IL-1 polymorphisms might have had an additive modifying effect on concussion symptom severity (McFie et al., 2018).

Biomarkers for concussion may be useful in identifying those at risk for prolonged deficits.
as well as providing insight into the underlying pathophysiology (McFie et al., 2016). 2.9 Management of Concussion Traditionally, management of concussion involves avoiding reading, tasting, gaming, television, and telephones. Contrary to older studies, recent texts suggest early physical activity is beneficial and assist in decreasing the rate of persistent post-concussive symptoms (Koshy & Feinstein, 2018; Pancoast, Ardern, Harlop, Aubry, Bloomfield, Broderick, Echemendia, Ellenbogen & Falvey, 2018). The cognitive test is important and although strenuous cognitive activities should be avoided, moderate cognitive activity has shown to have the same effect on post-concussive symptoms as complete rest. Cognitive activities may be incrementally increased, as tolerated, 5 days following the injury (Koshy & Feinstein, 2018). The paucity of evidence gives little guidance as to the treatment of post-concussive symptoms although general treatment involves nonsteroidal anti-inflammatories, tightness for migraine and headaches, metadromes for headaches and nausea and it is generally accepted that narcotic analgesics should be avoided (Sooza et al., 2012; Mullaney, 2017). Caution must be taken with the prescription of medications to avoid rebound effects, and antidepressants may be used for patients who experience frequent headaches more than two weeks after the injury (Sooza et al., 2012; Mullaney, 2017). Controlled trials have not suggested that spinal manipulation for post-concussive cervicocerebral or migraine headaches seem to be non-responsive (Mullaney, 2017). This is also in line with Moreau et al., (2015) who states that additional research is required to develop and define the parameters of manual therapy in the management of mTBI. 2.10 Previous Studies on Concussion Knowledge Available sources have described knowledge and practices of chiropractors within the USA and Canada (Moreau, Nahban & Walden, 2015; Kazemi, Boqouni & Yona, 2017; Taylor, Porco & Dyess, 2017). Studies conducted within South Africa have described rugby related injuries, including but not limited to a concussion, and the management protocols thereof (McAvery, 2014). 2.10.1 Carolyn McAvery (2014) McAvery (2014) does not directly aim to describe the knowledge and practices related to concussion within the South African chiropractic profession. The study does describe the treatment protocols performed by chiropractic interns under the supervision of qualified chiropractors within the confines of the Student Chiropractic Sports Council at the “Rugby Bash Tournament” 2014 in Durban. The study only reported 8 (1% of all primary complaints) concussions over the duration of the tournament which lasted three days. The study did not record the treatment protocol for any of the concussions. Furthermore, no referrals were made. Although 21 (2.3%) patients were not permitted continued play, it is inconclusive whether the concussion patients formed part of the 2.3% who were prohibited from further play. 2.10.2 William Moreau (2015) Moreau et al., (2015) was the first to describe the knowledge-base and clinical practice within the chiropractic profession, although smaller studies have been performed in the fields of paediatrics, neurology and fourth-year medical students. Although there is strong agreement that concussion should be medically evaluated, there is less consistency on the use of manual therapy as treatment and the timing of manual treatment following concussive injury. Moreau et al., (2015) states that as public awareness of sports concussion improves the number of reported concussions cases increases and it becomes increasingly important that sports professionals are educated and managed correctly as the accumulative effects of concussion have been well researched and documented. 2.10.3 David Taylor (2017) Taylor et al., (2017) describes the prevalence of concussion as an epidemic, with concussion or mTBI comprising 70-90% of all treated brain injuries. Following on from Moreau et al., (2015), Taylor explains that the reported low recognition rate from primary care physicians (PCP) is part responsible for the underreporting of concussion. Both Taylor et al., (2017) and Moreau et al., (2015) state that the current prevalence and primary MDI necessitate that all a concussion. 2.10.4 Mohsen Kazemi (2017) Despite chiropractors not currently being recognized as being at the forefront of diagnosing concussion, second to emergency medicine, chiropractors see the highest rates of concussion-related patients. Additionally, chiropractors are often the first to interact with post-concussion patients who were involved in a motor vehicle accident. This is largely due to symptoms that correlate to primary complaints which present to chiropractic rooms. The study by Kazemi et al., (2017) found that all respondents could correctly define both the term and the mechanism of concussion. Additionally, respondents understood that concussion was a functional disturbance that could not be identified on standard neuroimaging. This suggests that the chiropractic profession is capable of being first-line care for concussed patients. Respondents of the survey identified uncommon symptoms less

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121
Sports Concussion Knowledge and Clinical Practices

Successfully, such as trinitus, which may be a consequence of lack of literature. Symptoms which were less common were often identified as a separate diagnosis or even because of indirect trauma rather than a consequence of concussion (Kozami et al., 2017). The largest gap in knowledge concerns the long-term consequences of repetitive concussion, namely Parkinsonism, which was often not related as a consequence of concussion. These findings may be the result of the link between Parkinsonism and concussion being nascent, research between the two being more present in specific sports such as boxing and wrestling. Alternatively, the link could have been missed due to current education on the connection being limited (Kozami et al., 2017). Kozami et al., (2017) had a small population sample and made comparisons between three groups: chiropractic interns, qualified chiropractors and finally, qualified chiropractors with additional training in concussion. Naturally, the latter was found to be better adept

39th the recognition, diagnosis, and management of concussion. 2.11
Concussion in


49there is a risk of concussion in almost every sport,

about with varying frequencies. Risk factors include the role’s positions played in any given sport, being a younger athlete and being female. The overall

29incidence of concussion ranges from 0.1 to 21.5/1000 athletic exposures

based on a study which reviewed sports including football, rugby, hockey, lacrosse, and soccer (Clay, Glover, Lowe, 2012). Concussion incidence was highest in Canadian junior ice-hockey players and lowest in swimming and diving. Although American football did not have the highest incidence, the sport remains a concern due to a large number of participants (Clay et al., 2012). Overall, the line-backer in football is subject to more frequent concussions. Athletes tend to experience 69.5% of their concussions during competitions, a rate which is 3.44 times higher compared to practice times (Clay et al., 2012). Younger athletes appear to have a higher incidence despite less exposure and fewer repeated concussions. The research appears to be counterintuitive as one would expect fewer injury capture due to less medical staff coverage, immature neuroanatomy and less technical play are posited to be accountable for the higher frequency of concussion in younger athletes (Schultz, Marshall, Mee, Yang, Weaver, Karlsson & Bowling, 2004, Clay et al., 2012). Sex differences in concussion incidence seem to be related more to anatomical differences in height, weight, head and neck size or strength rather than player contact. Although male players sustained for more impact than females, females consistently had higher rates of concussion (Clay et al., 2012). There is little to suggest that protective gear helps prevent concussion, and may give athletes a false sense of protection (Clay et al., 2012). 2.12 Sports Chiropractic Training and Certificates 2.12.1

Available training Institution Certification FICS International Certificate in Sports Chiropractic (KCS)

Johannesburg

Royal

College of Chiropractic Sports Sciences (Canada) Fellow of the Royal College of Chiropractic Sports Sciences

(FRCCSS(C)) Table 1: Summary of available concussion training 2.12.2 FICS pre-2019 curricula equivalent certifications 1. International Chiropractic Sport Diploma (ICSD) 2. Internationally Certified
Chapter Three: Methodology

3.1 Introduction

This chapter explains how the study was conducted. A study design was used as a random cohort sampling method by way of an electronic descriptive questionnaire (Appendix C). The study took place within South Africa and questionnaires were distributed via email to members of AHPCSA, CASA, and Chicospport. 3.2.1 Participant recruitment

Participants were recruited from Allied Health Professions Council of South Africa (AHPCSA) and the Chiropractic Association of South Africa (CASA) who have members that may have an additional certification but are not necessarily a part of Chicospport South Africa. Participants were also recruited from Chicospport South Africa, of whom all members have a special interest in sport. The study population sample comprised of chiropractors with a special interest in sports chiropractic. FICS qualified sports chiropractors or chiropractors with any additional certification. Prospective participants were made aware of the research with the assistance of AHPCSA, CASA and Chicospport South Africa (Appendix D) who have contact with the respective registered members (Appendix C).

Participants were informed on the components of the study (Appendix A) and consent was sought (Appendix B). Participants were given the opportunity to participate based on the Inclusion criteria. 3.2.2 Sample Selection and Size

Chiropractors were sought from 3 organizations. Both CASA and Chicospport members are included in those registered with AHPCSA. CASA has 544 registered members and Chicospport South Africa has 50. Members who met the criteria were invited to participate in the study. 3.2.3 Inclusion Criteria

To participate in this study, willing participants must have complied with

at least one of the following criteria, with the first criteria being essential. 3.2.4 Exclusion Criteria

It follows that participants who do not qualify via the inclusion criteria were excluded. 3.3 Subjective Data

An online survey, using the platform questionpro© through STATXON, was
used to conduct this study. The questionnaire was adapted to Lumby, 2016; Kazemi et al., 2017 and Taylor et al., 2017. Questions were also adapted from research studies by Sharpe & Jenkins, 2015 and Moreau et al., 2015. For the purpose of the study, questions were adapted slightly in order to suit the sample population and the research question. STATION was consulted in the adoption of these questions to ensure statistical validity and viability of the research study. The report of incidence, demographic and knowledge were taken on good will with the understanding and expectation that the participants would answer accurately and truthfully.

Data Analysis
The data was gathered by means of an online questionnaire using Questionpro®. The raw data was downloaded and coded using Microsoft Excel spreadsheet. Prior to statistical analysis, the data was verified for consistency and accuracy. Descriptive statistics were provided and categorical analysis appropriate for the sample size and nature of the variables were used to address the research question. Statistical Analysis

Data obtained from the study was presented using graphs and tables with the assistance of a statistician at STATION. To ensure the research question was answered, the data was analysed using SPSS version 25.0. Frequency tables were used to measure correct and incorrect answers from the sample group. In addition, cross tabulation and T-test was used to evaluate the data, make comparative analysis and demonstrate the observations between the two population groups within the sample.

Ethical Considerations

As well as their confidentiality, anonymity, and consent. Participant names and personal details were not used in the study. Participants read the electronically distributed information letter (Appendix A) and were requested to click on the survey link if they consented to be a participant. Consent was again requested once in the survey itself (Appendix B and C). If participants required further information regarding consent and privacy, they were free to contact me or my supervisor. They were assured that there was no way that the researcher will be able to track information back to the participant.

In addition to this, the use of STATION ensured the desired response rate by allowing study participants to claim continuous professional development (CPD) points. Extensive research was done into the current literature to ensure survey content validity. The results of the study were made available to the participants.

As this study took the form of an online survey which was completed in the participants’ own time, no risks were identified. Chapter Five:

Discussion

In this chapter, the results obtained from the data analysis processes carried out in chapter four are further discussed. Based on the analysis, the following research questions were identified:

1. What is the level of understanding and clinical practice of chiropractors in South Africa regarding concussions?
2. What are the differences in concussion knowledge and clinical practices of chiropractors with additional training compared to those with no additional training?
3. Were there deficits in knowledge within the sample and is there a significant difference between the two groups?

Sample Demographics
The total targeted sample was 830 chiropractors. 140 chiropractors participated, all of whom were registered with AMPCoA and 33% (n=46) of whom were registered with Chiropractic South Africa. Not all chiropractors have a special interest in sport, and generally it is unknown who has this special interest, thus making this sub-group of chiropractors an unknown sample population. We can estimate the number by looking at the number of members registered with the sport interest group Chiropractic South Africa, but it would not be an accurate number of total representation of chiropractors within South Africa. Analysis described the correlation of additional training and being registered with Chiropractic South Africa. A statistical significance was found for participants registered with Chiropractic South Africa, who made up 34% (n=46) of the sample. Chiropractic South Africa members were almost 3 times as likely as those who were not registered to have additional training in sports chiropractic (φ = 21.414, d.f=1, p<.001). Additional training Yes No Total Are you currently registered with Chiropractic Yes Count % within Additional training 23 65.7% 23 22.8% 46 33.8% South Africa? No Count % within Additional training 12 34.3% 77 77.2% 90 66.2% Total Count % within Additional training 35 100.0% 101 100.0% 136 100.0%

124
Sports Concussion Knowledge and Clinical Practices

and 52% male (n=73). Cross-tabulations revealed that although there was only a slightly higher predominance of males in the sample group, when we looked at those who had additional training; there was a greater disparity between the genders. Only 17% of females (n=14) had additional training compared to 33% of males (n=34). See Table 3. The disparity may point towards historical hypomnesis pathologies that persist within sports governance as well as sexism which contributes towards a rough entry into the sports arena for women (Serrie, 2016). A compounding barrier to entry may lie in family planning and parental roles. Laws which favour maternal leave of absence and men being seen as breadwinners lead women towards higher levels of parental duties over their male counterparts, often at the cost of career advancements (Levs, 2015). Q12 Q4 Gender Female Male Total Additional training Yes Count % within Q12 Q4 Gender 11 17.2% 24 33.3% 35 25.5% No Count % within Q12 Q4 Gender 53 62.8% 49 66.7% 102 74.5% Total Count % within Q12 Q4 Gender 84 100.0% 73 100.0% 157 100.0% *not all participants answered this question Table 3: Gender distribution 5.2.2 Years of experience 7 <5 years, o Percent in sample: 36% (n=52) o Percent in group with training: 18% (n=10) >5 years o Percent in sample: 62% (n=85) o Percent in group with training: 28% (n=25) This result lacks statistical significance and the slight discrepancy may be attributed to practitioners with more years' experience being those just starting out. Another factor may include that ICCSEP is not rolled out on an annual basis and practitioners who have been in practice for fewer years may have missed a training cycle. 5.3 Overall Concussion Knowledge of the Sample Group It should be noted that in order to achieve valid statistical analysis, questions that displayed low level correctness were omitted. For these questions, both groups scored poorly and indicate a gap in knowledge despite 26% (n=37) of the sample having additional training. See Table 4. Questions which showed low level correctness included knowledge on: 1. Post concussive symptoms 2. Mid concussion resulting in long term sequelae 3. Signs and symptoms of concussion 4. Number of symptoms required to diagnose concussion 5. Appropriate management of concussion 6. Identification of red flags that predict the potential for prolonged recovery 7. Correct implementation of graduated return to play. Based on these questions, it may suggest that the general practitioner's poor knowledge include the identification of signs, symptoms, and red flags for concussion, and more significantly, the identification, management and understanding of post-concussive syndrome and its consequences. Number of questions correct (max could be 20 correct responses) Percent questions correct for 20 knowledge questions Number of questions correct; removing questions with low correctness (max could be 13 correct responses) Percent questions correct for 13 knowledge questions (seven questions with low correctness omitted

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| 12.41| 62.43| 8.84| 68.74| Median 13.00| 60.00| 9.00| 69.23| Mode 15.00| 75.00| 12.00| 92.31| Standard Deviation 3.36| 16.80| 2.46| 19.00| Table 4: Overall theoretical concussion knowledge 5.4 Comparative Analysis of Groups in Sample Population 5.4.1 Differences in concusion knowledge and clinical practices between population groups Despite the overall low correctness score for questions for both populations of the sample, evaluation of table 1 compared to table 2 shows that participants from the group who had additional training scored higher overall and had a lower standard deviation than those who had no further training. See Table 5. Additional training N Mean Std. Deviation questions Number of Yes 35 13.6000 2.99854 correct (max could be 28 correct responses) N103 12.8980 3.37889 Percent Yes 35 69.0000 14.99619 questions correct for 20 knowledge questions N103 69.3596 1.69446 Number of questions Yes 35 9.8657 2.02558 correct, removing questions with low correctness N103 8.4468 2.54317 (max could be 13 correct responses) Percent Yes 35 79.0440 15.58571 correct for 13 knowledge questions (seven questions with low correctness omitted) N103 69.4675 1.96289 *not all participants answered all these questions Table 5: Differences in concussion knowledge between groups 5.4.2 Differences in concussion diagnosis and management between population groups The sample reported very low frequencies of cases of concussion seen in practice. Not one participant from the group with additional training reported seeing one case per week; 1 person from the group without additional training reported seeing one case per week. The frequency of concussion cases seen by both groups was fewer than 12 per year. 43% (n=59), a large portion of the sample (both groups) reported never having seen a concussion case. Both groups in the sample population scored high in asking the patient pertinent history questions regarding cognitive symptoms. However, when asked to report if the same questions were directed toward the family and friends of the patient both groups scored 26% lower. It raises an interesting point of discussion as patients are not
always aware of the cognitive symptoms related to concussion or post-concussion syndrome. It is therefore important to direct these questions to family and friends who could possibly give a more accurate description of cognitive symptoms. Although further analysis and study would have to be conducted to conclude reasons for this, it may be that patients often their appointment with a chiropractor unaccompanied and it is therefore challenging to have family and friends available for inquiry. It is worth noting that the group with training reported higher frequencies (5%, n=5) in inquiring about cognitive symptoms when evaluating MVA symptom history versus impact injuries. Additionally, this frequency was 6% (n=16) higher in the group without training for the same question. This could suggest that the group without training perceives impact injuries as less severe. Research into the overall incidence and prevalence of concussion within South Africa has largely been described within the sports environment, and particularly within rugby due the contact nature of the sport. Research into incidence and prevalence as well as other factors

| 30 of concussion has been impaired by differences in definition along with ethical considerations in evaluating and

managing concussion. For these reasons, describing trends in incidence and management is largely broad and subjective. The consequences of less inquiry into impact injuries proves logical as concussion and mTBI is a danger in non-sport MOIs. Having said this, the incidence of concussion within rugby in South Africa has ranged from 22% to 50% in High school rugby alone (Patrick, al., 2019). This significant statistic suggests that inquiry into impact injury should at the very least equal to that of MVA injuries especially when we consider vulnerability within this age group alone (Adolescents) (Clay, et al., 2013). Comfort levels in diagnosing concussive were reported equally in both groups of the sample. MVA concussion was reported as most comfortably diagnosed by those without additional training, 36% (n=17), while those with additional training reported that they were most comfortable diagnosing severe concussion. Together with the reported low levels of comfort, these results could suggest that the group without training reported mild concussion as most comfortable to diagnose as the severity and risk involved for both the patient and doctor is less. Conversely, the group with additional training may have reported severe concussion as their most comfortable 65% (n=15) to diagnose as the presentation may be more severe and the absence of risk to recognize. Given the aforementioned poor knowledge of red flags and post-concussion symptoms, this was a concerning finding in this data. It may suggest that participants are overestimating some of their knowledge which could lead to practitioners negligence. The sample also reported low levels of comfort in treating concussion. Not one participant from the group with additional training reported being very comfortable in treating concussion. The rest of the sample was evenly distributed between being comfortable and not at all comfortable in treating concussion. In general, those with additional training were on average more comfortable in varying degrees in treating concussive. Less of the additional training group reported being not at all comfortable compared to those with no additional training. 5.4.3 Differences in concussion tool knowledge between population groups: Although the group with additional training scored twice as high as the group with no additional training, overall knowledge of concussion assessment assessment tools was low in both groups; the group with additional training scored a mean of 19% (n=261) for familiarity of moderate to very familiar within the concussion assessment tools. The group without additional training scored a mean of 7% (n=19). The group with additional training was most familiar with recently published concussive assessment tools (SCAT 3 and SCAT 5), the group without training was most familiar with the graded symptom checklist. The greatest difference in knowledge was demonstrated in the familiarity of Zurich guidelines where the group with additional training scored 22% (n=16) more than those without additional training. As the vast majority of these books can be found online at no cost, availability of the assessment tools would not appear to be the reason for the lack of familiarity and may rather suggest that knowledge about the available tools and their availability may be the cause. Following on from the overall poor scores in identifying signs and symptoms; it could be that practitioners may be uncertain on when to apply the appropriate use of these assessment tools. Further investigation into reasons for practitioners being unfamiliar with concussion assessment tools would assist in understanding where the disconnect lies. 5.4.4 Differences in post-concussive knowledge and clinical practice: The group with additional training scored statistically higher 83% (n=29) compared to 56% (n=19) of the non-additional training (p=.001, p=.005). Both groups scored similarly low regarding the duration and long-term sequelae of concussion. This indicated a lack of knowledge in this area and the possible consequence of post-concussive patients being inadequately diagnosed and treated. As stated in the introduction, even mild concussion can have detrimental long-term effects, so it is imperative that a PCP have appropriate knowledge. 5.4.5 Differences in behavioural or clinical practice in population groups. The sample population all reported a diverse patient base that was not heavily distributed towards any patient age group. Children (12 years and under) were the least frequently seen by the sample while age groups from 19-56 and older were reported as the most frequently
Sports Concussion Knowledge and Clinical Practices

The following sections present the conclusions pertaining to the findings that were made in Chapter 4 and further discussed in Chapter 5. From this study, it can be concluded that participants who had additional training were more likely to score higher in the distributed survey. Additionally, participants registered with the chiropractic sports interest group, Chiropractic South Africa, were more likely to have undertaken additional training. Male participants were more likely to have had additional training compared to female counterparts. Theoretical questionnaire scores were high amongst both groups within the sample. Questions related to identification and number of symptoms, red flags and appropriate management scored lowest in both groups. Despite this, participants who had had additional training were more likely to answer questions about mechanism of concussion, symptoms, SCI and post-concussion questions correctly. Participants with additional training report higher level of familiarity with SCAT5, SCAT3, SCAT2 and Zurich guidelines and are more likely to have referred to 2012 Zurich consensus statements. This appears to be largely due to further training through RICS.

226.2 Recommendations Based on the findings of the current study, the following recommendations are made:

- About the trends of concussion knowledge and management. Practitioners with sport chiropractic treatment and management certification should be required to complete regular practical sessions, as is the case with first aid courses, to ensure that they are kept up-to-date with resource material. Familiarity and competency in recognizing, diagnosing, and managing concussion is essentially when dealing with field-side management. Practitioners could investigate making a summary of concussion assessment tools, as well as research results, available to their members. Basic concussion assessment should be included as part of student clinical training. Associations which manage sports practitioners could make concussion consensus statements available to members. Practitioners with special interest in sport chiropractic management and treatment should seek additional training, especially in concussion knowledge, to increase diagnostic and management accuracy.
- 6.3 Suggestions for Further Studies. It is suggested that the following studies be conducted based on the research gaps that were identified during this study: More detailed questioning on where participants with additional training obtained most of their information on concussion. Studies into the comparison of impact, non-impact and sports-related concussion. Additionally, the perceived severity of these three different MOI. Studies into the reasons for disparity within sports chiropractic treatment between male and female practitioners. Further studies into the knowledge of concussion consensus statements and their distribution. 6.4 Conclusions. The study made important findings and associations. Among them, knowledge on recognition, appropriate management and post-concussion knowledge is lacking despite additional training. Although concussion consensus statements and assessment tools have been published, most practitioners remain unfamiliar with the tools and with appropriate management protocols. Overall, practitioners with additional training prove more competent than those without. However, practitioners still lack vital knowledge which raises concern on whether patients are receiving adequate management regarding concussions. Participants registered with Chiropractic South Africa were associated with having done additional training and it would therefore appear that these types of interest groups do play a role in encouraging and advancing competent practitioners. Having said this, the disparity between numbers of male and female practitioners with additional training could be improved upon and accrediting bodies may want to investigate where the gap lies and how to ensure increased parity. A disconnect exists. All practitioners that responded to the survey had a special interest in sports chiropractic management and treatment. Surprisingly, only 26% (n=37) had undertaken additional training vs. 74% (n=104) without additional training. 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

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Appendix G: Approval letters from Research Ethics Committee and Higher Degrees

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Instructions:
- Please complete all sections 1.5 below.
- If any option(s) in Section 3 are selected, please ensure that supporting Adverse Event Reporting Forms (REC 9.0) are attached to this form.
- Please ensure that explanations are provided whenever required.

1. Stage of Ongoing Research

| 1.1. Data Collection Ongoing | x | 1.2. Data Collection Complete |
| 1.3. Data Analysis Ongoing | | 1.4. Data Analysis Complete |
| 1.5. Thesis/Dissertation/Report Writing | | 1.6. Research is Complete |

2. Research Progress: (Please give an overall summary of the research progress to date, from the last renewal if applicable)

Click here to enter your progress report.
3. Reportable Events/Deviation etc.

Have any of the following occurred during the period covered by this report? Please attach all associated supporting Adverse Events Reporting Forms (REC-9.0) to this form.

3.1. Serious Adverse Event(s) (AEs) ☐
3.2. Non-serious Adverse Event(s) ☐
3.3. Related AE(s) ☐
3.4. Unrelated AE(s) ☐
3.5. Anticipated AE(s) ☐
3.6. Unanticipated AE(s) ☐
3.7. Proposed Deviation ☐
3.8. Proposal Non-compliance ☐

Note: Serious and related AEs are reportable within 24 hours of their discovery. The above is a summary covering the reporting period of this report and is not the first time serious and related AEs should be reported.

Note: Non-serious and related AEs and all proposed deviations and non-compliance are reportable within 5 working days of their discovery. The above is a summary covering the reporting period of this report and is not the first time non-serious and related AEs and proposed deviations and non-compliance should be reported.

4. Risk: Benefit Ratio

Has the risk: benefit ratio changed in the period covered by this report?

4.1. Yes ☐
4.2. No ☑

Is yes, please explain below and explain any steps you have taken in relation to this:

Click here to enter your explanation.

5. Conflicts of Interest

Have there been any possible conflicts of interest in the period covered by this report?

5.1. Yes ☐
5.2. No ☑

Is yes, please explain below, and explain how these were resolved:

Click here to enter your explanation.

<table>
<thead>
<tr>
<th>Supervisor/Researcher Signature</th>
<th>Student Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (dd/mm/yy)</td>
<td>Date (dd/mm/yy)</td>
</tr>
<tr>
<td>10/06/2019</td>
<td>10/06/2019</td>
</tr>
</tbody>
</table>
# Sports Concussion Knowledge and Clinical Practices

## RESEARCH PROPOSAL AMENDMENT

**Application Form (REC 8.0)**

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Posthumus K</th>
<th>Student Number</th>
<th>201300130</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor Name</td>
<td>Dr DM Landman</td>
<td>Co-Supervisor Name</td>
<td>Dr G Paton</td>
</tr>
<tr>
<td>Department</td>
<td>Chiropractic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Title</td>
<td>Sports concussion Knowledge and Clinical Practices: A survey of South African Chiropractors with a special interest in sports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearance No</td>
<td>REC-01-159-2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearance Date</td>
<td>30/10/2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Instructions:**

- Please complete this form if you are contemplating any changes to research that has already received ethical clearance.
- Respond to the questions below, based on the envisaged amendments.
- Send this completed form with the original research proposal (i.e., the version of the research proposal with ethical clearance), the amended research proposal with envisaged amendments clearly highlighted, and a copy of the ethical clearance letter back to the REC Secretariat. Please also send information letters, consent forms and any other attachments as required.

<table>
<thead>
<tr>
<th>Envisaged Amendment Effects</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The envisaged amendments will, or are likely to, affect the sampling strategy, sample size, data collection methods or data analysis.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The envisaged amendments will, or are likely to, affect the informed consent process as described in the original research proposal.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The envisaged amendments will, or are likely to, negatively affect the risk/benefit ratio as described in the original research proposal.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The envisaged amendments will, or are likely to, impact negatively on any or all participant's right to privacy or the researcher's duty to maintain confidentiality of data, as described in the original research proposal.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Implementation of envisaged research proposal amendments may only proceed after a new ethical clearance letter is issued by the REC.

**Supervisor/Researcher Signature**

Date (dd/mm/yy): 10/06/2019

**Student Signature**

Date (dd/mm/yy): 10/06/2019

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* Avoid showing the amendments in Word Track Changes. Rather highlight them with a different (and clearly visible) font colour, or underlining.

Version 3.1: Approved 26 July 2018

Author: Prof. C. Smit