Prevalence and Severity of Whiplash Associated Disorders in Mixed Martial Arts Athletes

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DECLARATION

I, Danielle Hauman, declare that this thesis is my own, unaided work. It has been submitted for the Degree of Masters in Clinical Sport Physiotherapy at the University of the Free State, Bloemfontein. It has not been submitted before for any degree or examination at any other University.

30th day of June 2018 in Bloemfontein

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"The angel of the LORD appeared to him and said to him, 'The LORD is with you, mighty warrior'." Judges 6:12.

To treat the athlete: “know the sport, review the literature”
(Dhillon et al., 2017:531).

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LIST OF ABBREVIATIONS AND ACRONYMS

ADL	Activities of daily living
CTE	Chronic traumatic encephalopathy
CT	Computed tomography
CROM	Cervical range of motion
EFC	Extreme fighting championship
FS	Free State
HSREC	Health Sciences Research Ethics Committee
KO	Knock-out
MMA	Mixed Martial Arts
NDI	Neck Disability Index
QTFC	Quebec Task Force Classification
RPQ	Rivermead Post Concussion Symptoms Questionnaire
S-LANSS	Leeds Assessment of Neuropathic Symptoms and Signs pain scale
TKO	Technical knock-out
UFC	Ultimate Fight Championship
UFS	University of the Free State
VAS	Visual Analogue Scale
WAD	Whiplash Associated Disorders
WC	Western Cape

DEFINITION OF TERMS

Central Sensitisation	Amplification of sensory input by the central nervous system. This causes sensations of pain even from non-painful stimuli, or a pain response that is greater than expected considering the stimuli (Fleming *et al.,* 2015).
Cervical Strain	The resulting trauma to soft tissue structures of the cervical spine, including the muscles, ligaments and joint capsules, due to whiplash (Siegmund *et al.,* 2009)
Concussion	A pathological process affecting the brain in response to direct impact to the head, or indirect forces transmitted to the brain. Loss of consciousness may, but does not necessarily occur (McCrory *et al.,* 2013).
Disability	The term describing impairments in activities and participation due to physical or mental conditions (Oxford dictionary, 2018).
Grappling	Grappling is a technique used in Freestyle and Greco-Roman wrestling, is used to force the opponent to the ground and into a painful, submissive position by means of choke-holds, neck locks, and peripheral joint locks. (Rezasoltani *et al.,* 2005).

Knock-Out	A boxing term used to describe the act of directly striking an opponent, causing them to lose consciousness, or results in an altered state of consciousness (Buse, 2006). A KO is typically in response to a direct strike to the head and/or face (Hutchinson *et al.,* 2014).
Mixed Martial Arts	A form of combat sport that allows competitors to fight against their opponent using a combination of various styles of martial arts such as boxing, wrestling, Brazilian jiu-jitsu, kickboxing, muay thai and taekwondo (Alm *et al.,* 2013).
Neuropathic pain	Chronic pain due to an injury, inflammation or dysfunction of nervous tissue (Basson, *et al.,* 2014).
Striking	A technique that refers to punching with the fists, kicking, and hitting an opponent with the knees and/or elbows (Lenetsky *et al.,* 2012).
Take down	A manoeuvre used in wrestling and other forms of fighting by which an opponent is hoisted above the ground and forcefully thrown to the floor from a standing position (Lenetsky *et al.,* 2012).
Technical knock-out	When a fight is stopped by the referee due to a combatant receiving repetitive blows and is deemed unable to further defend himself against attack and injury (Buse. 2006).

Whiplash	An injury to the soft tissue and/or joints of the cervical spine (neck) due to a severe acceleration-deceleration of the head (Spitzer, Skovron, Salmi, Cassidy, Duranceau, Suiss and Zeiss, 1995).
Whiplash associated disorders (WAD)	The term used to describe a collection of symptoms experienced after sustaining a whiplash injury. (Rosenfeld, Seferiadis, Carlsson, and Gunnarsson, 2003; Sterling, 2014).

ABSTRACT

Mixed martial arts (MMA) is a full-contact combat sport that has become increasingly popular, even though having been described as violent. There is a growing concern about the risk of head trauma and acceleration injuries in this contact sport. Second to general neck and head injuries, concussion has been noted to be a prevalent injury in martial arts.

The symptoms of concussion and whiplash can often not be distinguished from each other. The biomechanics of whiplash and concussion injuries are similar and both incidents occur concomitantly. The prevalence of whiplash associated disorders (WAD) has not been established in MMA and finding of WAD in other forms of sport is scant. However, due to the nature of MMA, athletes' head and neck are susceptible to translational forces during training and competition. Therefore, it can be postulated that MMA athletes are at risk of recurrent whiplash.

WAD describe a collection of cognitive and cervical symptoms often persisting for longer than three months after a whiplash incident. Predicting the course of recovery from WAD is challenging and improvement of symptoms may be seen during the acute phase but prove more resistant to treatment as symptoms become chronic. The prevalence and severity of WAD in MMA athletes is unknown.

A quantitative, observational descriptive design was used in this study, with the aim of determining the prevalence and severity of WAD in amateur MMA athletes in Cape Town and Bloemfontein, South Africa. Athletes were conveniently sampled and data were recorded by means of one self-developed questionnaire, three standardised questionnaires, and a clinical assessment. The presence of cervical and cognitive symptoms, related to whiplash and concussion, were reported according to the Rivermead Post Concussion Questionnaire (RPQ). The Neck Disability Index (NDI) was used to establish disability due to cervical symptoms. The nature of pain experienced by athletes was assessed and classified according to Leeds Assessment of Neuropathic Symptoms and Signs pain scale (S-LANSS). A clinical assessment established the presence and grade severity of WAD according to the Quebec Task Force Classification (QTFC). The clinical assessment evaluated the intensity of neck

pain, presence of muscle spasms and point tenderness, impaired cervical range of motion, and neurological findings (decreased sensation, decreased muscle strength, and decreased reflexes).

Seventeen (n=17) amateur MMA participants were included in this study, most of which were male (n=15; 88.2%) and young adults with a median age of 25 years. All of the athletes had been participating in MMA training for at least two years. Participants in this study reported suffering knock-out's (KO's) during both training (n= 5; 29.4%) and competition (n=7; 41.2%).

Moderate to severe post-concussion and post-whiplash symptoms, were reported in less than a third (<33%) of participants. Headaches, fatigue, feelings of frustration, and sleep disturbances were, however, frequently reported. According to the NDI, disability due to cervical symptoms was mild in over half of participants (n=11; 64.7%). The presence of neuropathic pain was rated as low and only reported in four participants (n=4; 23.5%).

This study found that 58.8% of athletes presented with neck pain mostly rated as mild. Muscle spasm and point tenderness was prevalent in the majority (n=16; 94.1%) of athletes. All of the participants (n=17; 100%) showed some decrease in their cervical range of motion, however, in most cases, cervical ROM was in the average to good range in all planes of movement. Decreased sensation in dermatomes was reported in three participants (n=3; 17.7%) and decreased muscle strength in myotomes was recorded in four participants (n=4; 23.4%).

In accordance with the classification criteria of the QTFC, WAD was found to be present in ten participants (n=10; 58.8%). Four participants (n=4; 23.5%) presented with WAD II and six participants (n=6; 35.3%) with WAD III.

This study was limited by a small sample size and the findings can likely not be generalised to the MMA athletes in South Africa or the larger population of MMA athletes The findings of this study do support the need for further studies in larger populations of MMA athletes to explore the risk and consequences of the repetitive head trauma in MMA.

Amateur MMA athletes in South Africa are at risk of repetitive head trauma causing concussion and whiplash, and thereby WAD The findings suggest that recurrent head trauma, including concussive and whiplash injuries, may occur during bouts and possibly go unreported or un-noticed. More than half of the participants in this study were classified as having WAD and this should be a point of concern for clinicians.

CHAPTER 1 INTRODUCTION

1.1 Introduction

In 1993 the Ultimate Fighting Championship (UFC) organisation introduced the first sanctioned ‘no holds barred’ competitive fight (Buse, 2006). Today this form of fighting is known as Mixed Martial Arts (MMA) (Alm *et al.,* 2013; Bledsoe, 2006). MMA is a full contact combat sport that allows fighters to incorporate techniques from various martial arts disciplines in order to subdue and defeat an opponent (Bledsoe, 2006). Punches from boxing, strikes and kicks from kickboxing, grappling from Brazilian jiu-jitsu and wrestling, and clinching from muay thai are the most common techniques used by MMA athletes (Alm *et al.*, 2013; Lenetsky *et al.*, 2012). This allows the MMA athlete to overpower an opponent from any position.

Martial arts governing bodies have implemented strict rules to prevent dangerous situations in which athletes inflict and/or sustain serious bodily harm (McClain *et al.,* 2014; Buse, 2006). Nevertheless, aiming for the opponent’s head is still the primary objective, resulting in head and neck impact (Hutchison *et al.,* 2014; Jensen *et al.,* 2017; Bledsoe, 2006). Up to 78% of injuries sustained in MMA athletes are to the head, neck and face, and primarily include soft tissue lacerations, followed by concussion (Venter *et al.,* 2018; Jensen *et al.,* 2017; MinJoon, 2016; Lystad *et al.,* 2014; Oke *et al.,* 2012).

Although more commonly seen in motor vehicle accidents, whiplash is also known to occur in sport (Hynes *et al.,* 2006; McClune *et al.,* 2002). Athletes who participate in contact sport, including MMA, are also at risk of concussion (Venter *et al.,* 2017; Jensen *et al.,* 2017; MinJoon, 2016; Forbes *et al.,* 2012; Hynes *et al.,* 2006). The mechanisms of injury and the symptomology of whiplash and concussion are similar, and it has become evident that the injuries occur simultaneously (Morin *et al.,* 2016; Elkin *et al.,* 2016; Leslie *et al.,* 2013). MMA athletes are therefore also at risk of whiplash.

The collection of cervical and cognitive symptoms experienced after whiplash has been termed as whiplash associated disorders (WAD) (Sterling, 2014; Van Suijlekom *et al.,* 2010; Spitzer *et al.*, 1995). Primary cervical symptoms include neck pain, decreased cervical range of motion, headaches, dizziness, and referred pain to the upper limbs (Sterling, 2014; Spitzer *et al.,* 1995). Up to 50% of people can present with WAD for months to years after the initial whiplash injury (Sterling *et al.,* 2014; Treleaven *et al.,* 2011, Merricke *et al.*, 2010; Van Suijlekom *et al.,* 2010; Bannister *et al.,* 2009).

In addition to the physical symptoms, cognitive deficits and psychological morbidities such as fatigue, depression, irritability, sleep disturbances, poor concentration and anxiety have also been reported (Borenstein *et al.*, 2010; Spitzer *et al.,* 1995). These symptoms can persist for up to three years post-injury (Borenstein *et al.*, 2010). WAD can negatively impact individuals' sport participation and performance, work performance, and activities of daily living (ADL) (Sterling *et al.*, 2009; Panzer *et al.*, 2011; Merrick *et al.,* 2010; Leslie *et al.*, 2013).

Acute and ongoing symptoms of WAD may result in the athlete decreasing training participation, completely ceasing their training, or abstaining from competition due to fear of pain and/or further injury (Robinson *et al.,* 2013). Early identification of WAD facilitates the appropriate referral for therapy interventions, thus optimising the outcome (Sterling, 2014; Lundmark *et al.*, 2006). A multi-disciplinary and biopsychosocial approach is needed to address physical, cognitive and psychological findings of WAD (Sterling, 2014; Yoganandan *et al.*, 2002). MMA trainers, sports physicians and physiotherapists need to understand the physical demands of MMA, recognise risk factors, and recognise unnoticed or unreported symptoms of WAD in the MMA athlete.

1.2 Problem Statement

The prevalence and severity of WAD in MMA athletes has not been established and is yet to be determined. Research into MMA has focused on defining the general injury profile, analysing fitness and training requirements, analysing injury risk factors, and determining the incidence of head and neck injuries (Venter *et al.,* 2017; Jensen *et al.,* 2016; Minjoon, 2016; McClain *et al.,* 2014; Hutchison *et al.*, 2014; Fife *et al.*, 2013; Lenetsky *et al.*, 2012; Zazryn *et al.*, 2006; Rezasoltani *et al.,* 2005; Kochhar *et al.*, 2005). It has been reported that MMA athletes are at risk of head injury, concussion, and, therefore concomitant whiplash (Venter *et al.,* 2017; Minjoon, 2016; Lystad *et al.,* 2014; Leslie *et al.,* 2013).

The available literature does not report on findings of WAD in MMA athletes and scant research is available on the presence of WAD in other contact sports (Hynes *et al.,* 2006). The prevalence of WAD in MMA due to repeated head impact and neck translation forces need to be explored. Baseline findings may encourage further research into the causality of WAD, risk of WAD, and severity of WAD in MMA.

1.3 Research Question

What proportion of amateur competitive MMA athletes suffer from WAD and how severe is WAD in these athletes?

1.4 Aims

This study aimed to determine the prevalence and the severity of WAD in MMA athletes in Bloemfontein, Free State (FS) and Cape Town, Western Cape (WC).

1.5 Objectives

The primary objectives of this study were:

To determine the prevalence of WAD in MMA athletes in Bloemfontein, FS and Cape Town, WC

To describe the severity of WAD in MMA athletes in Bloemfontein, FS and Cape Town, WC.

A secondary objective of this study was:

To investigate the relationship between neck disability and the severity of WAD in MMA athletes in Bloemfontein, FS and Cape Town, WC.

1.6 Value of the Study

This study provides the first baseline data on the prevalence and severity of WAD in MMA athletes in South Africa. The study findings furthermore add to the limited body of global data on the presentation of WAD in MMA athletes. The findings in the current study will also highlight the importance of screening MMA athletes who sustain forceful blows to the head and neck. Identification of WAD enables referral to the necessary members of the multi-disciplinary team. Physiotherapy assists in the management and alleviation of physical symptoms including headaches, neck pain, referred pain, and dizziness. Occupational therapists and psychologists may assist in the management of cognitive and psychological symptoms.

1.7 Organisation of the Script

This mini script has been organised under the following chapters:

Chapter 1: Introduction
Chapter 2: Literature Review
Chapter 3: Methods
Chapter 4: Results
Chapter 5: Discussion
Chapter 6: Conclusion

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter will provide an overview of the relevant literature on whiplash and WAD in the context of MMA. The scope of the review will extend to identify the risk of whiplash in MMA athletes, describe the mechanism of whiplash, and clarify the relationship between whiplash and WAD. The symptoms, prognosis, and intervention for WAD in the context of current published findings will be discussed.

Articles for the literature review were sourced using the EBSCO host platform. The following databases and search engines were used: CINAHL Full Text, Google Scholar, PEDro, Africa-wide Information, BMJ Journals online, Academic Search Complete, African Journals online, PubMed, Medline Plus, Science Direct, and SPORT Discuss with Full Text. The following search terms were used: boxing; martial arts, mixed martial arts, contact sport injuries; combat sport injuries; trauma; South Africa; knock-out; head trauma; neck trauma; concussion; whiplash; whiplash associated disorders, acceleration injuries; acceleration-deceleration injuries; cervical spine; cervical strain; physiotherapy; rehabilitation. Publication restrictions placed on the search resulted in articles published between January, 2000 and March, 2018 being eligible for inclusion.

2.2 History of Mixed Martial Arts

The waging of combat to overpower, subdue, and defeat an opponent is, and has been, the corner stone of martial arts since ancient Greek times (Buse, 2006). Even at that historical time in 648 BC, hand-to-hand combat was considered a sport and the athletes strove to be the ultimate fighter (Rainey, 2009; Buse, 2006). Fighters condition their minds and bodies so that they can tactically and physically defeat an opponent (La Bounty *et al.,* 2011)

Today, being a derivative of ancient combat sports, MMA combines fighting skills from all disciplines of martial arts (Rainey, 2009; Bledsoe, 2006). Athletes are allowed to use as many various techniques as they wish against their opponent, whilst fighting in an enclosed cage (Alm *et al.,* 2013; Lenetsky *et al.,* 2012). In the modern sporting arena, MMA has shifted from a ‘no holds barred’ nature and is regulated for safety by combat sport governing bodies, including The International Mixed Martial Arts Federation (Venter *et al.,* 2017; McClain *et al.,* 2014; Buse, 2006;). MMA is also practiced by many for its health benefits as a form of intensive physical exercise (Rainey, 2009).

2.3 Rules of Mixed Martial Arts

2.3.1 Fighting techniques

MMA athletes need to be trained in a variety of fighting techniques across the various fighting disciplines, and the main techniques used are striking, grappling, clinching and take-downs (Alm *et al*., 2013; Lenetsky *et al*., 2012; LaBounty *et al.,* 2011).

Striking techniques are used in boxing, jiu-jitsu, kickboxing, and taekwondo (La Bounty *et al.,* 2011). The term ‘striking’ refers to punching with the fists, kicking, and hitting an opponent with the knees and/or elbows (Lenetsky *et al.,* 2012). ‘Grappling’, a technique used in Freestyle and Greco-Roman wrestling, is used to force the opponent to the ground and into a painful, submissive position by means of choke-holds, neck locks, and peripheral joint locks. This makes it impossible for an opponent to manoeuvre or regain a position of advantage (Rezasoltani *et al.,* 2005). ‘Clinching’ is a technique that allows the combatant to get close to the opponent in a standing grappling position (Zerling, 2016:26). From this position short, repeated strikes to the head and trunk are inflicted to injure and wear out the opponent. Clinching provides the perfect opportunity to take the fight to the ground and force the opponent into submission (Zerling, 2016:30). ‘Takedown’ techniques such as throws and trips, are also used to force the opponent from a standing position to the ground. During a takedown the opponent is hoisted into the air and thrown to the ground with force, whereas trips involve forcing the opponent to lose his footing and fall (Lenetsky *et al.,* 2012).

2.3.2 Victor of a bout

Victory in a MMA bout is achieved if the opponent is rendered unconscious, presents with an altered state of consciousness, is injured to such an extent that he/she cannot defend against further attack, or if subdued in a submissive position (The International Mixed Martial Arts Federation, 2017; Buse, 2006). In the case that neither combatant was subdued the winner is the combatant who scored the most points according to the judges (The International Mixed Martial Arts Federation, 2017; Rainey, 2009).

A win by knock-out (KO) is achieved through a direct strike, usually to the head or face, that renders the contender unconscious or unable to continue fighting, resulting in an immediate victory. (Buse, 2006; Leslie *et al.*, 2013). The primary points of impact for a KO are the mandibular and maxillary regions of the face (Bingul *et al.,* 2018; Hutchison *et al.,* 2014). MMA athletes are allowed strike the head of the opponent by means of a rotational hook punch, linear jaw punch, an elbow strike, a knee strike, or a kick.

A win by technical knock-out (TKO) occurs when a bout is stopped by a referee when of the opinion that the athlete is being subject to excessive blows and unable to further defend him/herself (Hutchison, 2014; Buse, 2006.). Athletes can also indicate submission using either a verbal or physical indication, namely tapping of the ground, tapping the opponent, or tapping on themselves. In such a case the victor wins by submission (Rainy, 2009; Buse, 2006).

The victor of a bout is the athlete who inflicts the most deliberate physical damage to the opponent (Lenetsky *et al.*, 2012; Oke, *et al.*, 2012). Even though both athletes are at high risk of physical injury, published data has shown that the defeated combatant was 2.4 to 2.5 times more likely to be injured compared to the victor (Ngai *et al.,* 2008).

2.4 The Risk of Head and Neck Injuries in Mixed Martial Arts Athletes

2.4.1 Mechanisms of head and neck injuries

Repeatedly striking for the opponent's head is a key offensive strategy employed by athletes during a bout (Hutchinson *et al.,* 2014). This strategy poses a considerable risk for athletes of both inflicting and receiving direct trauma to the head and neck (Jensen *et al.,* 2017; Hutchinson *et al.,* 2014; Bledsoe, 2006). The linear head acceleration from hook, jaw, forehead and uppercut strikes is likely to result in an acceleration force that is much higher than the minimal force required to cause cervical strain (Fife *et al.,* 2013; Forbes *et al.,* 2012; Panzer *et al.,* 2011). In addition, the repeated application of techniques such as grappling, neck locks and take-downs increase the risk of linear and rotational displacement forces being applied to the head and neck (Hutchison, *et al.,* 2014; McClain *et al.*, 2014; Kochhar *et al*., 2005).

Grappling, although to a lesser extent than striking, places strain on cervical structures that have to resist flexion, side flexion and extension displacement forces (Jensen, 2017; Rezasoltani *et al.,* 2005). Muscles need to contract isometrically to maintain the position of the neck, and eccentrically to counter the opponent's forced displacement of the head or body (Rezasoltani *et al.,* 2005). Kochhar et al. (2005) investigated the risk of sustaining cervical spine and soft tissue injuries during four take-down/throwing manoeuvres in MMA athletes. They found that the kinematics involved with these takedowns places considerable strain on the cervical spine. They also found the kinematics to be equivalent to those in the event of rear-end motor vehicle impact.

In addition to the risk of head and neck injuries from direct strikes, grappling and take-downs, athletes are also at risk of sustaining head and neck impact from the surrounding environment (Hutchison *et al.,* 2014). Hutchison et al. (2014) found that 63.1% of athletes in their study who lost a bout by a fight-ending KO also sustained secondary head impact with the ground or the cage. The impact of the head with either the floor and/ or cage can cause whiplash and/or concussion (Marshall *et al.,* 2015; Hutchison *et al.,* 2014).

2.4.2 Prevalence of head and neck injuries in mixed martial arts athletes

Studies by Jensen *et al.* (2017), Minjoon (2016) and Lystad et al. (2014), describing the injury profile of MMA athletes, highlighted the frequent occurrence of head and neck injuries, with injury rates ranging between 38 and 78%. These findings also concur with the earlier findings of Bledsoe et al. (2006), Zazryn et al. (2006), Rainey (2009) and Oke et al. (2012) in that injuries sustained by MMA athletes were primarily to the head, neck and face.

Hutchinson et al. (2014) found that the head was the body part struck with a 100% consistency during every bout. Forty-six percent (46%) of the participants in their study suffered a KO, whilst 54% suffered a TKO resulting from repetitive strikes to the head. These findings are consistent with earlier published findings where 28 to 33% of bouts were reportedly stopped due to head impact from TKOs and KOs (Ngai *et al.,* 2008; Bledsoe *et al.,* 2006; Buse, 2006). McClain *et al.* (2014) went on to report the KO's and TKO's were the key reasons for stopping bouts. Following the fight-ending KO or TKO, numerous athletes (21.5%) who sustained head impact presented with an altered mental state. This supports the earlier findings of Buse's (2006) impaired level of consciousness and gait unsteadiness in athletes who were knocked out. Gait unsteadiness and dizziness has been distinctly associated with a whiplash injury (Treleaven, *et al.,* 2003).

Considering the literature presented on both the mechanisms and prevalence of head and neck injuries in MMA it is apparent that MMA athletes are subjected to repetitive head impact and cervical strain. It is therefore postulated that MMA athletes are considered to be at risk of sustaining whiplash and/or concussion.

2.5 Whiplash

Whiplash describes an injury caused by the transfer of overt or excessive energy to the soft tissue structures around the cervical spine (Michaleff, *et al.,* 2012). This energy transfer occurs in response to the sudden acceleration and deceleration of the cervical spine, which is caused by external forces applied to the head or other parts of the body (Tameem *et al.,* 2014; Nijs *et al.,* 2009). The resulting trauma to soft tissue structures of the cervical spine, including the muscles, ligaments and joint capsules is referred to as “cervical strain” (Siegmund *et al.,* 2009).

2.5.1 Mechanisms of a whiplash

During whiplash, a stationary cervical spine is displaced by large frontal, rear, or rotational acceleration forces applied to the head and neck. These forces may be the result of direct or indirect mechanisms of impact (Alexander, 2003; Nijs *et al.,* 2009). Indirect impact is a force applied outside of the body that results in the acceleration of the head and neck, as is seen in rear-end motor vehicle collisions (Tameem *et al.,* 2014). Direct impact forces on the other hand are applied by a direct blow to the head or neck, resulting in acceleration of the head and neck (Alexander, 2003). In both of the aforementioned instances, the head and cervical spine are accelerated then decelerated by cervical muscles or when contact is made with an external object such as a steering wheel, arm, leg, or by impact with a floor or wall (Tameem *et al.,* 2014). Cervical muscles and other soft tissue structures are placed under considerable strain at end ranges of flexion, extension and rotation. Anatomical structures including ligaments, discs and facet joints serve to limit extreme ranges, and cervical muscles respond by contracting in order to return the head to its starting position (Siegmund *et al.,* 2009; Yonganandan *et al.,* 2002).

2.5.1.1 *Indirect mechanisms*

Motor vehicle accidents are the primary cause of whiplash injuries and accurately depicts an indirect mechanism of whiplash (Tameem *et al.,* 2014; Chen, *et al,* 2009). An outside rear force results in an indirect translation of force to the head causing an initial reverse curvature of the cervical spine (Tameem *et al.,* 2014; Yonganandan *et al.,* 2002). The upper cervical spine is displaced into flexion, the head lags behind and the lower cervical spine extends (Yonganandan *et al.,* 2002). As the loading to the cervical spine reaches its end phase the head moves out of its state of inertia and, along with the upper cervical spine, follows with the lower cervical spine into extension so that the entire cervical complex is in a lordotic curve (Yonganandan *et al.,* 2002; Jason *et al*., 2001). Anterior cervical muscles are placed on full stretch and contract eccentrically to produce a rebound into flexion (Hai-bin, *et al,* 2009). In return, posterior cervical muscles are now eccentrically loaded and contract to return the head to neutral (Chen, *et al,* 2009) (Figure 2.1). In the case of an indirect frontal and rotational acceleration force being applied to the head, the head and cervical spine are also placed under extension-flexion displacement and soft tissue structures are placed under considerable strain (Panzer, *et al.,* 2011).

2.5.1.2 Direct mechanisms

A direct impact, or strike to the head, causes acceleration and displacement of the head and neck into flexion, extension or rotation, depending on the force that is applied (Montenigro *et al.,* 2015). If the accelerating head is not stopped by a physical object, translation will continue until soft tissue structures reach their limit of strain, contract eccentrically to decelerate the head, resulting in a rebound of the head to its starting position (Chen, *et al,* 2009; Siegmund *et al.*, 2009). The cervical ligaments and facet joints are primarily responsible for preventing excessive directional translation of vertebrae. Rotational acceleration forces due to direct impact to the side of the head results in considerable shearing forces transmitted to the head and neck (Jayarao *et al.,* 2010).

Symptoms and clinical findings of whiplash will be discussed in Section 2.9.

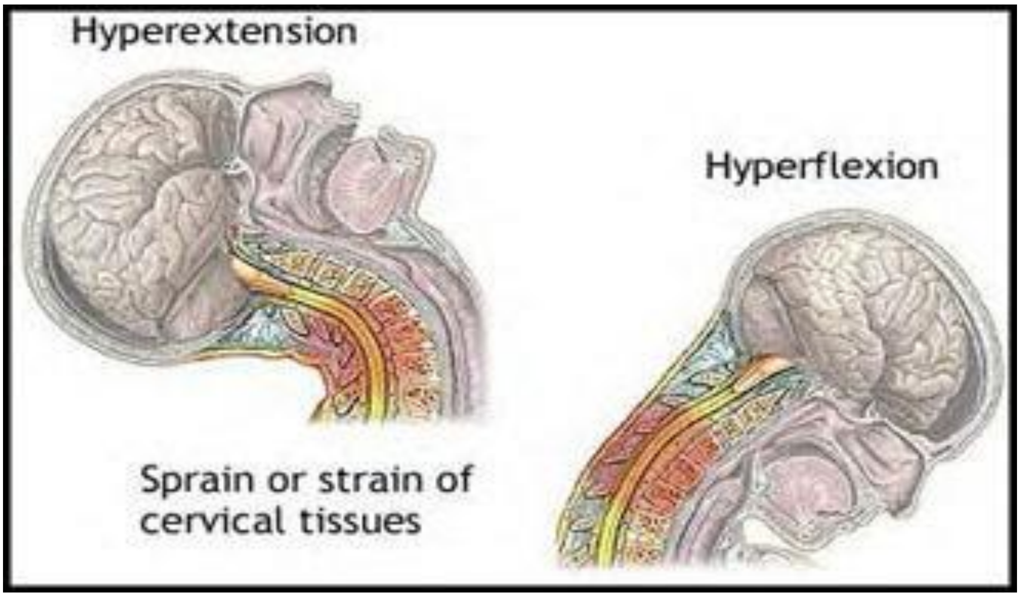

Figure 2. 1 Stretch and strain of cervical soft tissue during whiplash. **Abu Naser *et al.,* 2016:14**.

2.6 Concussion

Concussion is caused by direct impact to the head or indirect impact to a part of the body, resulting in the transmitted displacement of the head (McCrory *et al.,* 2013). Acceleration of the head and neck during direct impact or indirect external forces results in two occurrences: linear and rotational acceleration of the brain, and transferring of mechanical energy to cerebral tissue on a cellular level (Meaney *et al.,* 2011) The result is that the brain is 'shaken' in the enclosed skull causing damage and shearing of cerebral tissue and vasculature (King *et al.,* 2014; McCrory *et al.* 2013; Meaney *et al.,* 2011). Concussion may be caused by both high and low velocity forces and may, but does not always, result in a loss of consciousness (Marshall *et al.,* 2015; King *et al.,* 2014; Neidecker *et al.,* 2017; McCrory *et al.* 2013, Collins *et al.,* 2006).

Making the clinical diagnosis of a concussion is often a challenge due to the following factors: symptoms of concussion are mostly self-reported, each athlete presents differently, athletes may not recognise concussion symptoms, the occurrence of head impact must be observed, and athletes may not present with noticeable manifestations of loss of consciousness or gait unsteadiness (King et al, 2014; McCrory *et al.* 2013). This results in concussions often going unnoticed or unreported in the sporting arena (King *et al.,* 2014).

Concussion disorders may be acute with clinical symptoms including confusion, dizziness, nausea, headaches or a loss of consciousness (Neidecker *et al.,* 2017; McCrory *et al.* 2013). Acute concussion disorders mostly present without visible structural brain injury on neuroimaging studies (McCrory *et al.* 2013). Chronic, or prolonged post-concussion symptoms include continuation of acute symptoms for longer than four weeks (Marshall *et al.,* 2015).

A single incidence of concussion places the athlete at high risk of sustaining a second concussion, or other subsequent injuries (Montenigro *et al.,* 2015; King et al, 2014). In turn, repeated concussions may result in cumulative symptoms or more severe brain injury, brain degeneration and possibly chronic traumatic encephalopathy (CTE) (King et al, 2014, McCrory *et al.* 2013; Tator, 2013). Research into the risk of athletes in contact sports such as American football, wrestling, hockey and boxing sustaining CTE has gained momentum over the past decade (Maroon *et al.,* 2015; Tator, 2013). A late, neurodegenerative disease, CTE can only be established post-mortem, but has been described in boxing and football athletes (Montenigro *et al.,* 2015). Neuropathological changes in the brain in contact sport athletes have been postulated to be the result of repetitive concussion injuries (Maroon *et al.,* 2015; Tator, 2013). However, research cannot absolutely link these changes to repetitive concussions or head impact (Maroon *et al.,* 2015; Gardner *et al.,* 2014; Tator, 2013).

2.7 Distinguishing Concussion from Whiplash

Concussion and whiplash is hard to differentiate, as they often occur simultaneously in the case of acceleration-deceleration injuries to the head and neck (Elkin *et al.,*2016; Morin *et al.* 2016; Marshall *et al.,* 2015; Leslie *et al.*, 2013; Haynes *et al.,* 2006). Early symptoms of concussion and whiplash are similar and include neck pain, headaches, dizziness, double vision, confusion and nausea (Elkin, 2016; Marshall *et al.,* 2015).

Chronic symptoms of both whiplash and concussion include the continuation of acute symptoms, as well as psychological findings such as depression, mood changes, fatigue and insomnia (Neidecker *et al.,* 2017; Leslie and Craton, 2013). Acute and chronic symptoms may originate from the cervical spine, in response to a traumatic brain injury, due to alterations in pain processing systems, or due to psychological factors (Persson *et al.,* 2016; Steilen *et al.,* 2014; Leslie *et al.*, 2013; Bismil *et al*., 2012; Van Suijlekom *et al.,* 2010).

A specific diagnosis of either whiplash or concussion is further complicated by the fact that structural and brain tissue abnormalities are unidentifiable on conventional X-rays (McCrory *et al.* 2013; Herring *et al.,* 2011). Advanced neuroimaging studies including MRI and computed tomography (CT) can be used to diagnose the presence of more serious brain injuries such as cerebral oedema, intracranial bleeds; or bony abnormalities such as skull and cervical fractures (Herring *et al.,* 2011; Bannister *et al.,* 2009). Neuro imaging alone is inadequate in determining the presence and prognosis of concussion and whiplash. Clinical neurological, musculoskeletal and psychological examination is required (Neidecker, *et al.,* 2017; Dufton *et al.,* 2012; Herring *et al.,* 2011.

2.8 Occurrence of Whiplash and Concussion in Mixed Martial Arts Athletes

Previous research has been published on the prevalence of concussion, and head and neck injuries in MMA athletes (Venter *et al.,* 2018; Jensen *et al.,* 2017; MinJoon, 2016; Lystad *et al.,* 2014), however, no data is available on the prevalence of whiplash in MMA. Concussion, although less prevalent than laceration and contusion injuries to the head and neck, has been reported as prevalent in MMA athletes (Venter *et al.,* 2018; Jensen *et al.,* 2017; MinJoon, 2016). It is reasonable to anticipate that MMA athletes are at risk of sustaining whiplash injuries by virtue of the high-velocity contact between the athletes, and concomitantly with concussion injuries (Leslie *et al.,* 2013; Michaleff *et al.*, 2012; Haynes *et al.,*2006).

The probability of MMA athletes sustaining a concussion and whiplash can be linked to the fact that a KO meets the defining criteria for a concussion (Hutchison *et al.,* 2014; McCrory *et al.* 2013). A KO is primarily aimed at the head and face resulting in the athlete sustaining direct impact which causes an altered state of consciousness (Hutchison *et al.,* 2014; McCrory *et al.* 2013). The probability of sustaining a concussion and whiplash is further evident when considering the gravity force (G-force) required to produce head and cervical trauma (Forbes *et al.,* 2012; Panzer *et al.,* 2011) (Figure 2.2).

2.8.1 Physics of martial arts

Gravity force (G-force) describes the forces acting on the body during acceleration and deceleration (Voshell, 2014). An increase in speed or a sudden change of direction results in increased G-forces acting on the body and, therefore, increased energy transfer (Voshell, 2014).

Drawing parallels from fighting and American football the following G-forces are also likely to apply to MMA athletes. A NFL player hitting an icy grass deck is estimated to impart around 150g to the body (Higgins, 2009). A NFL tackle is estimated to impart between 30 to 60 g's. Comparable findings in combat sport report that during boxing a direct blow to the head imparts a G-force of 53g to the head (Walilko, *et al.,* 2005). Similarly, Fife *et al.* (2013) found that hook and jaw punches produce G-forces of 71g and 51g respectively. In the NFL and combat sport these impact forces are applied repeatedly to the body during a bout, further heightening the risk of concussion and whiplash (Figure 2.2).

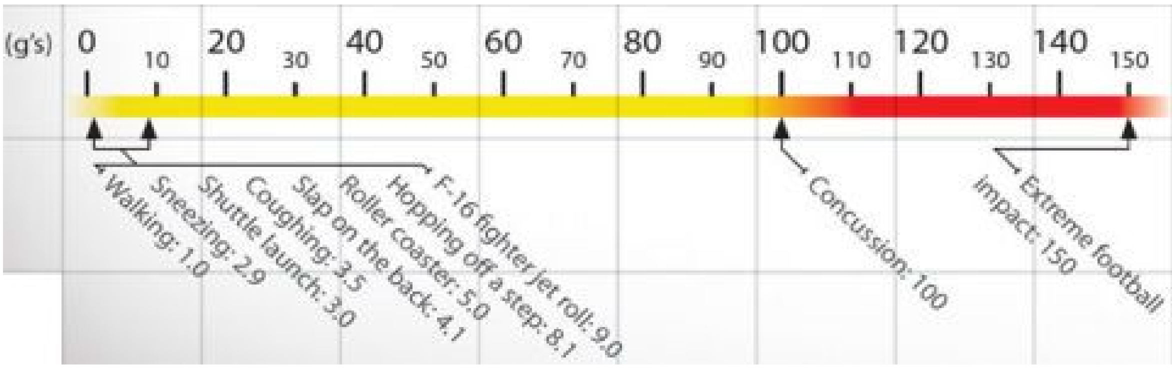

Figure 2. 2 G-force imparted during NFL for a concussion (Higgins, 2009).

Concussions occur at G-forces from approximately 90g and cervical strain can occur from as low as 4.5g (Marshall *et al.,* 2015; Forbes *et al.,* 2012). Panzer *et al.* (2011) went on to report that soft tissue injury occurs at G-forces between 15g and 22g of frontal linear impact. Therefore, G-forces acting in on the head and neck during a direct or indirect blow are sufficient and exceed the forces required to cause both concussion and whiplash (Marshall *et al.,* 2015; Fife *et al.,* 2013) (Figure 2.2).

2.9 Whiplash Associated Disorders

Whiplash associated disorders (WAD) describe the collection of clinical manifestations and cervical symptoms following a whiplash injury (Sterling, 2014; Van Suijlekom *et al.,* 2010; Spitzer *et al.*, 1995). The classification of WAD as being acute or chronic is based on the timeframe symptoms persist post-injury, acute being 0-12 weeks and chronic 12 weeks or longer. (Sterling, 2014).

2.9.1 Acute whiplash associated disorders

Acute symptoms of WAD include both physical and cognitive manifestations. Physical symptoms include neck pain and stiffness, dizziness, headaches and paraesthesia in the upper limbs (Spitzer *et al.,* 1995; Rosenfeld *et al.,* 2003; Treleaven *et al.,* 2011; Sterling, 2014). Patients may also present with physical signs of soft tissue point tenderness, gait unsteadiness, decreased cervical range of motion, swelling, altered sensation, and decreased muscle power within the upper limbs, and altered reflexes (Sterling, 2014; Elliot *et al.,* 2009).

Cognitive manifestations include symptoms of fatigue, signs of poor concentration, feelings of depression, sleep disturbances and anxiety (Merrick *et al.*, 2010; Borenstein *et al.,* 2010). Initial signs and symptoms may settle within the first few days, but can take up to three months (Sterling, 2014; Bannister *et al.,* 2009).

2.9.2 Chronic whiplash associated disorders

It has been reported that 40-50% people who suffered whiplash present with prolonged symptoms (Sterling, 2014; Bannister *et al.,* 2009). Chronic WAD describes all somatic, cognitive and psychological manifestations that persist for longer than three months and it has been reported that these symptoms can persist for up to five years after the injury (Merrick *et al.*, 2010; Van Suijlekom *et al.,* 2010; Athertone *et al.,* 2006). Somatic manifestations include chronic neck pain, loss of cervical range of motion, altered cervical recruitment patterns, decreased postural control, decreased balance, cervical joint positioning error and altered gaze stability (Treleaven *et al.,* 2011; Elliot *et al.,* 2009; Treleaven *et al.,* 2003). Psychological aspects include depression, fear avoidance, anxiety and post-traumatic stress, and cognitive symptoms (2.9.1) can persist for up to six months post injury (Beeckmans *et al.,* 2017Tameem *et al.,* 2013; Elliott *et al.,* 2009).

2.9.3 Physiology of Pain in Acute and Chronic Whiplash Associated Disorders

The primary source for initial symptoms following whiplash is unclear, but damage to anatomical structures are considered to be the most probable causes (Siegmund *et* *al.,* 2009; Binder *et al.,* 2007). Soft tissue damage and lesions to structures such as cervical zygapophysial joints, joint capsules, ligaments, cervical discs, surrounding muscles, peripheral nerves, cervical nerve roots and branches of dorsal rami; and the vertebral artery following whiplash (Steilen *et al.,* 2014).

Cervical zygapophyseal joints, ligaments and the joint capsules are very susceptible to injury under strain (Persson *et al.,* 2016; Steilen *et al.,* 2014; Van Suijlekom *et al.,* 2010). It has been widely hypothesised by investigators and physicians that cervical zygapophyseal joints and joint capsules are the primary site of anatomical damage after whiplash (Steilen *et al.,* 2014). The cervical zygapophyseal joints provide a very small surface area from which to disperse the forces imparted during impact to the head and neck, making them more prone to strain (Steilen *et al.,* 2014). Furthermore, the zygapophyseal joints and the surrounding synovial fluid-containing capsules are innervated by medial branches of cervical dorsal rami, which provide rich nociceptive input (Persson *et al.,* 2016; Steilen *et al.,* 2014; Bismil *et al.*, 2012; Van Suijlekom *et al.,* 2010). Upper cervical ligaments (alar and apical ligaments) have large potential for injury during whiplash as they undergo large amounts of strain and have a lower failure threshold (Fice *et al.,* 2012).

Sudden acceleration-deceleration of the neck can also cause excessive strain and injury to anterior, posterior, and lateral surrounding muscles (Steilen *et al.,* 2014; Chen, *et al,* 2009; Siegmund *et al.,* 2009). Cruz *et al.* (2004) noted that all participants who had suffered whiplash 36 hours prior to examination presented with posterior cervical muscle spasm. The majority of the participants presented with lateral and anterior cervical muscle spasm. On comparing myofascial pain patterns of patients with WAD I to II (Section 2.9.5 and Table 2.1) with patients suffering mechanical, non-traumatic neck pain, Castaldo et al. (2014) found that the patients with WAD had more active, pain-producing myofascial trigger points.

The presence of anatomical damage has not been established as an isolated cause nor prognostic indicator for WAD (Dufton *et al.,* 2012). Even though acceleration forces can result in strain to cervical structures, there is often poor evidence of considerable tissue damage or joint dysfunctions to be the only predicting factor for the severity and chronicity of WAD (Sterling, 2014; Herring *et al.,* 2011; Bannister *et al.,* 2009). WAD can present and persist without clinical findings of anatomical tissue damage and, even in the presence of minor tissue lesions, symptoms may be exaggerated in relation to the level of damage (Steilen *et al.,* 2014). Nociceptive processing systems and psychological factors such as fear of movement and depression have however been found to be strong predictors in the course and prognostic outcome of WAD (Lim *et al.,* 2011; Carroll *et al.,* 2009; Yoganandan, *et al.,* 2002).

Research indicates that perceived WAD severity and chronicity can be attributed to altered pain processing mechanisms and hypersensitivity within the central nervous system (Van Oosterwijck, *et al.,* 2012; Lim, *et al.*, 2011; Woolf, 2011; Sterling *et al.,* 2009; Banic, *et al.,* 2004; Sterling *et al.,* 2003). Central hyper-excitability can be caused by damage to dorsal root ganglia, cervical nerve roots, or peripheral nerves by means of impact or excessive loading during whiplash (Smith *et al.,* 2014; Davis, 2013; Siegmund *et al.,* 2009). This results in the continuous conduction of nociceptive signals by excitable spinal neurons, even in the absence of further central or peripheral noxious stimulus (Smith *et al.,* 2014; Davis, 2013; Lim, *et al.*, 2011; Woolf, 2011). When the central nervous system adapts inappropriately to signals from nociceptors and mechanoreceptors, pain is described as being more neuropathic in nature and is often characterised by burning, tingling or numb sensations (Colloca *et al.,* 2017; Davis, 2013). Neuropathic pain is defined as pain in response to direct damage of the nervous system (Nishikawa *et al.,* 2017; Basson *et al.,* 2014). Neuropathic pain and central hypersensitivity contributes to the complex presentation of WAD and is linked to higher pain levels and greater disability due to pain (Davis, 2013; Van Oosterwijck, *et al.,* 2012; Sterling *et al.,* 2009).

2.9.4 Diagnosing Whiplash Associated Disorders

WAD is complex in nature and the diagnosis and prognostic outcome should be based on a holistic, multi-factorial and multidisciplinary approach (Dufton *et al.,* 2012). The diagnosis of WAD is based on self-reported symptoms and clinical findings (Sterling, 2014). X-rays do not provide satisfactory evidence for the diagnosis of WAD, unless a cervical fracture (Grade IV WAD) (Table 2.1) is suspected (Sterling 2014; Herring, 2011). Assessment of WAD should include medical, allied health and psychological support services (Dufton *et al.,* 2012; Yoganandan *et al.,* 2002).

Whiplash symptoms need to be identified in the athlete as soon as possible after head impact or indirect acceleration. Early diagnosis and appropriate therapeutic interventions can relieve acute symptoms, decreasing the risk of progression to chronic WAD (Lundmark *et al.*, 2006). Initial evaluation by an on-site physician or physiotherapist will be beneficial to the athletes in that there will be early referral for further medical evaluation and management of symptoms.

On-site assessment should be done following a witnessed forceful head impact or acceleration, especially where there is suspicion of whiplash or concussion (Herring *et al.,* 2011; McCrory *et al.,* 2013). An observable incident of direct head impact may be the defining reference for distinguishing whiplash from concussion (Herring *et al.,* 2011). If a concussion is suspected an immediate referral to a medical doctor is required to determine this diagnosis. In the case of a concussion it is improbable that the athlete will not have also suffered a whiplash injury, considering the low g-forces required to produce cervical strain (Section 2.8.1). Physical symptoms such as neck pain, headache, dizziness, paraesthesia and vomiting can indicate possible whiplash and concussion (Neidecker *et al.,* 2017; Marshall *et al.,* 2015).

A neuropsychological assessment should be conducted directly after direct impact to the head, after impact to the thorax resulting in indirect whiplash, or when referred to Ssport clinicians, including physiotherapists, for further evaluation. Testing of balance and coordination, as well as cognitive function including dizziness, loss of consciousness, and disorientation, can provide a baseline from which to determine the athlete's condition or prognosis (Neidecker, *et al.,* 2017; Herring *et al.,* 2011). Baseline testing will determine if an athlete is safe to return to play or whether referral for further medical investigations are indicated (Herring *et al.,* 2011). If a cervical fracture is suspected the neck should be immobilised immediately and the athlete transported by ambulance to the nearest medical centre for neuroimaging studies (Herring *et al.,* 2011).

Follow-up evaluation of the injured athlete is essential in the management of WAD. The persistence of WAD symptoms can be established through the administration of self-report post-concussion and neck disability questionnaires by sport physicians and other members of the medical team (Sterling, 2014). A comprehensive patient history in combination with somatosensory, neurological and motor evaluations will enable the clinician to establish the presence, severity, and prognosis of WAD (Neidecker, *et al.,* 2017; Dufton *et al.,* 2012; Yoganandan *et al.,* 2002).

2.9.5 The Quebec task force classification for determining the presence and grade severity of whiplash associated disorders

The Quebec Task Force Classification (QTFC) was developed as a tool to determine the presence and grade/severity of WAD based on the presence of clinical signs and symptoms (Sterling, 2014; Spitzer *et al.,* 1995) (Table 2.1). These clinical signs and symptoms include neck pain and stiffness; point tenderness and muscle spasm in the cervical musculature; decreased cervical range of motion, cervical joint instability and decreased neural conduction (Sterling, 2014; Spitzer *et al.,* 1995). Signs of decreased neural conduction include decreased or absent deep tendon reflexes, muscle weakness and/ or sensory deficits (Petty *et al.,* 2006; Spitzer *et al.,* 1995).

A modified version of the QTFC has been proposed to better account for the complex physical presentation and psychological disturbances associated with WAD (Sterling, 2004). However, the QTFC developed by Spitzer et al. (1995) is the primary classification system for WAD, is widely used in research, has been used to predict prognostic outcomes of WAD, and is used internationally (Sterling, 2014, Carroll *et al.,* 2009, Sterling, 2004; Rosenfeld *et al.,* 2003).

Table 2.1 Quebec Task Force Classification

Grade	***Clinical Presentation***
WAD 0	No complaints of neck pain No physical signs
WAD I	Complaint of neck pain, stiffness, or tenderness only No physical signs
WAD II	Neck complaints Musculoskeletal signs: • Decreased range of motion • Point tenderness in neck and shoulders
WAD III	Neck complaint Musculoskeletal signs Neurological signs • Decreased or absent deep tendon reflexes • Weakness/ poor conduction within myotomes • Sensory deficits within dermatomes
WAD IV	Neck complaint with fracture or dislocation

(Spitzer *et al.,* 1995 cited by Sterling, 2014:7).

2.9.6 Outcome for Whiplash Associated Disorders

The outcome of WAD is determined by multiple complex physical and psychological factors (Sterling, 2014; Carroll *et al.,* 2009). Research has found that higher intensity of neck pain, moderate to severe degree of neck disability, and impaired cervical range of motion are predictors for a poor outcome following whiplash (Nieto *et al.*, 2013; Merrick *et al.,* 2010; Borenstein *et al.,* 2010; Carroll *et al.,* 2009).

2.9.6.1 *Neck pain*

Severe pain initially following whiplash has been shown to be a strong prognostic predictor of chronic pain (Steilen *et al.,* 2014; Nieto *et al.*, 2013). Chronic neck pain is the most common persisting long-term symptom in WAD and is associated with a poor outcome or prognosis (Dufton *et al.,* 2012). Chronic neck pain resulting from central or peripheral hypersensitivity has an even more complex presentation and treatment implementations to prevent poor long-term outcomes is challenging to the clinician (Stelin *et al.,* 2014; Davis, 2013).

2.9.6.2 *Cervical range of motion*

Patients presenting with WAD regularly demonstrate a significant decrease in CROM, especially patients who are classified with grade II and III WAD (Woodhouse *et al.,* 2008; Cruz *et al.,* 2004; Treleaven, *et al.*, 2011). Woodhouse *et al.* (2008) found that participants with WAD showed a decrease in CROM in all planes of movement compared with participants with non-traumatic neck pain and those who were asymptomatic. Restricted CROM has a positive association with higher pain intensity and also an increased risk for chronic symptoms (Borenstein *et al.*, 2010).

2.9.6.3 *Disability due to cervical symptoms*

Disability, impaired activities of daily living, and poor participation due to cervical symptoms is the most reliable prognostic indicator for WAD recovery (Sterling, 2014). Moderate to severe scores of cervical –related disability (Table 3.1) post-injury have been found to predict poor long term outcomes for WAD (Sterling, 2014). It has been found that positive association exists between high levels of neck pain intensity and disability (Merrick *et al.,* 2010).

Severe neck pain has been associated with moderate to severe disability even five years post injury (Merrick *et al.,* 2010). Mild, moderate and severe neck disability after whiplash has been found to be associated with persistent symptoms of neck pain and headaches, as well as cognitive and psychological factors (Howell, 2011; Merrick *et al.*, 2010).

Cognitive and psychological factors are directly associated with neck pain and ongoing perceived disability (Beeckmans *et al.,* 2017; Elliott *et al.,* 2009; Robinson *et al.,* 2007). Psychological disturbances post whiplash include anxiety, depression, and fear avoidance and, once again, are a result of persistent pain and perceived disability (Tameem *et al.,* 2013; Elliott *et al.,* 2009).

Cognitive dysfunctions can present for more than six months after a whiplash injury and include memory dysfunctions, decreased concentration, and decreased speed of performance during divided and sustained attention activities (Beeckmans *et al.,* 2017). These cognitive dysfunctions, if present after whiplash, are mild and directly influenced by the presence of neck pain and psychological factors such as anxiety (Beeckmans *et al.,* 2017; Robinson *et al.,* 2007).

2.10 Impact of Whiplash Association Disorders on Mixed Martial Arts Participation

The severity of WAD, the presence of poor prognostic indicators (Section 2.9.5) and psychological dysfunction are all determinants in the length of time the athletes will be out of their sport, or even if the athletes can return to their sport at all (Sterling, 2014; Carroll *et al.,* 2011).

Athletes who sustain a cervical fracture or dislocation (WAD IV) may require surgical intervention, resulting in prolonged hospitalisation and long-term rehabilitation. In the case of cervical fractures there is a risk of not being permitted to return to training or competition (Cantu *et al.,* 2013). Athletes with musculoskeletal and neurological findings associated with more severe WAD (WAD II and WAD III) are at risk of disability and poor treatment outcomes (Sterling *et al.,* 2014; Davis, 2013; Carroll *et al.,* 2011). This may in turn results in delayed return to training and competition as the risk of re-injury cannot be minimized (Dhillon *et al.,* 2017).

Cognitive and psychological symptoms including disturbed sleep, irritability, and poor concentration lead to limitations in sport participation and activities of daily living. All competitive athletes have an athletic identity and the inability to participate in sport can negatively impact this identity and cause feelings of guilt (Marshall *et al.,* 2012). Athletes with mild to moderate WAD (WAD I to WAD II) may not necessarily stop training or competition, but will still present with restricted CROM, chronic neck pain, and will be at risk for mild to moderate disability due to cervical symptoms (Sterling, 2014).

Regardless of the grade of severity, it could be postulated that WAD may place the MMA athlete at risk for further subsequent head and neck injuries due to symptoms of dizziness, pain, poor concentration and decreased range of motion. Decreased range of motion, decreased concentration and dizziness are common symptoms after whiplash (Treleaven *et al.,* 2011; Sterling, 2014). Decreased CROM has been found to cause dysfunction in gaze stability, head-eye coordination and joint positioning error, leading to dizziness and unsteadiness (Treleaven *et al.,* 2003; Treleaven *et al.,* 2011). Decreased concentration has been linked to neck pain after whiplash (Beeckmans *et al.,* 2017).

It could be postulated that dizziness, unsteadiness, and altered concentration may decrease the athlete's ability to defend himself against offensive strikes from an opponent. Considering that whiplash and concussion often occur simultaneously, athletes with WAD may also have suffered a concussion, placing them at risk for a second concussion, or other injuries (Montenigro *et al.,* 2015; King et al, 2014).

The primary concern for researchers in health care and sport clinicians is that there is emerging evidence that athletes are at risk of repetitive whiplash and concussion, placing them at risk of significant neurological complications over time (Montenigro *et al.,* 2015; Hutchison *et al.,* 2014; Tator, 2013). All MMA athletes are at risk of repetitive head and neck trauma, whether during training or competition. Each traumatic event increases the risk of aggravation of an already present condition and increases the risk of sustaining a more severe physical or neurological condition (King et al, 2014).

2.11 Physiotherapy and Whiplash Associated Disorders

The effects of physiotherapy are most effective if treatment is commenced within the first three months of the WAD inducing injury (Amirfeyz *et al.,* 2009). Physiotherapy intervention needs to be multi-faceted in order to address the physical and neurological dysfunction (Dufton *et al.,* 2012). Physiotherapy can address the aspects of WAD I-III, including pain, decreased cervical range of motion, and nerve root irritation (Sterling, 2014; Amirfeyz *et al.,* 2009). Best-evidenced physiotherapy treatment for acute WAD includes early active mobilisation or movement of the neck, exercises and patient education (Bussières *et al.,* 2016; Sterling, 2014). There is poor evidence on which exercises are best suited for the management of acute WAD, but the return to normal ADL has proven to be the best advice currently (Sterling, 2014; Aireys *et al.,* 2009).

In the case of chronic WAD, physiotherapy treatment should include joint and soft tissue mobilisation, and cervical exercises to address pain and restricted range of motion (Sterling, 2014). Physiotherapy alone is not optimal for the management of WAD. For example, according the QTFC WAD II primarily presents with symptoms of neck pain and musculoskeletal dysfunction (Table 2.1) (Spitzer *et al.,* 1995). However, this definition does not take into account the impact of psychological factors on these findings (Sterling, 2004). Psychological and cognitive symptoms need to be addressed by other members of the mutli-disciplinary team, including occupational therapist and sport psychologists (Sterling, 2014; Dufton, 2012).

2.12 Summary

MMA is a combat sport that allows for the use of a combination of fighting techniques across various fighting disciplines. Techniques used in MMA include striking, grappling, clinching and take-downs. Repeatedly striking for the opponent's head is a key offensive strategy employed by athletes during a MMA bout. This places MMA athletes at high risk of sustaining repetitive head trauma. Current research reports a high occurrence of head and neck injuries in MMA athletes, with injury rates of up to 78%.

WAD describes cervical and cognitive symptoms following a whiplash injury. WAD can be acute or chronic based on the timeframe symptoms persist post-injury. The presence and severity of WAD is determined by the presence of physical, neurological and psychological dysfunction. Physical and neurological symptoms include neck pain and stiffness; point tenderness and muscle spasm in the cervical musculature; decreased cervical range of motion, cervical joint instability and decreased neural conduction. WAD severity, presence of poor prognostic indicators and psychological dysfunction influence the length of time an athlete will be out of the sport, or even if the athlete can return to the sport.

The assessment and management of WAD should include medical, allied health and psychological support services. Concussion and whiplash symptoms need to be identified in the athlete as soon as possible after head impact. Early diagnosis facilitates referral to appropriate therapeutic interventions, including physiotherapy. Physiotherapy treatment provides symptom relief, decreasing the risk of progression to chronic WAD and disability.

The available literature reports that MMA athletes are at high risk of repeated head impact and cervical strain. Research has found that the g-forces resulting from direct blows to the head or indirect impact with the environment often far exceed the forces required to cause concussion, and simultaneously whiplash in these athletes. Although this data is available the prevalence of or risk for WAD in this population has not been determined. There are no known published findings on the prevalence and severity of WAD in MMA athletes.

The study method will be presented in Chapter three.

CHAPTER 3 METHODS

3.1 Introduction

This chapter will describe the methodology used to meet the objectives of the study. The study design, study population and participant recruitment will be described. The measurement tools used to gather data and the study procedure will also be outlined.

3.2 Study Site

The study was conducted in two cities in South Africa, namely Bloemfontein, FS and Cape Town, WC. Cape Town was found to have 23 listed MMA gyms. Bloemfontein, however, only has one listed MMA gym, with approximately 45 athletes renewing their contracts annually. Many athletes participate in MMA for the fitness and health benefits, rather than to compete on amateur or professional levels (Rainey, 2009). A very small proportion of athletes who participate in MMA are competitive on an amateur or professional level. Information gathered from gym owners, MMA trainers, MMA event organisers and MMA representatives described a small population of approximately 70 and 10 athletes who are competitive on an amateur level can be found in Cape Town and Bloemfontein respectively.

3.3 Study Design

A quantitative, descriptive, observational study design was used in the study.

3.4 Participants

The study population consisted of amateur competitive MMA athletes from Bloemfontein, FS and Cape Town, WC. All athletes who met the inclusion criteria and provided written informed consent were included in the study sample.

Athletes were included if they were eighteen years or older, English literate and were registered at MMA gyms in either Cape Town, WC, or Bloemfontein, FS. Athletes had to have competed in amateur competitions in South Africa between January 2015 and December, 2017. Athletes were excluded if diagnosed with concussion or whiplash injuries unrelated to MMA training or competitive fights over the previous two years; or if they were diagnosed with a traumatic brain or cervical spine injury.

As the population of amateur competitive MMA athletes were small, a sample of convenience was used. All available athletes meeting the inclusion criteria were included. Seventeen MMA athletes were included in the study, with nine from Cape Town and eight participants from Bloemfontein.

3.5 Ethical Considerations

Permission to conduct the study was obtained from the Health Sciences Research Ethics Committee (HSREC) (clearance certificate number HSREC 64/2016) prior to commencement of the study (Appendix A). Anna Swanepoel and Celia Smith Physiotherapists granted permission for the use of their practice rooms as a venue for the assessments (Appendix B and C).

Participants were informed of the purpose of the study by means of an English information letter (Appendix D) and the researcher provided further verbal explanation where necessary. Participants were provided adequate time to consider their voluntary participation. Participants had the right to decline participation or withdraw from the study without reason, risk, penalty or discrimination. A contribution was made towards the transportation costs incurred by participants to get to assessment sites. Written informed consent was obtained from all participants included in the study (Appendix D). All participant information was kept confidential.

The study was conducted in line with the approved protocol. Participants who presented with WAD symptoms were referred to a physiotherapist for further treatment.

3.6 Materials and Measures

In order to determine the presence and severity of WAD, related variables were assessed. Variables assessed included the presence of cervical and cognitive symptoms, the presence of cervical–related disability, and the presence of neuropathic pain. Outcome measures were chosen accordingly. The severity of WAD was assessed using the criteria stipulated by the QTFC (Table 2.1), namely, assessing the presence of pain, musculoskeletal dysfunction, and neurological dysfunction.

Data were collected by means of a four-part data form. The data form (Appendix E) included a self-developed demographic and sport participation-related questionnaire, and three standardised questionnaires. The standardised questionnaires included the Rivermead Post Concussion Questionnaire (RPQ), Neck Disability Index (NDI) and the Leeds Assessment of Neuropathic Symptoms and Signs pain scale (S-LANSS). All questionnaires and participant information documents were available in English. All data collected from the clinical assessment were recorded on a self-developed record form (Appendix F)

The objective measurement tools used in the study will now be described.

3.6.1 Objective measurement tools

3.6.1.1 The Rivermead Post-Concussion Symptoms Questionnaire

The RPQ (Appendix G) is a standardised self-administered questionnaire developed by King et al. (1995) to establish the presence and severity of frequently reported post-concussion and post -whiplash cervical and cognitive symptoms (Herrmann, *et al.,* 2009; King *et al.,* 1995). The RPQ contains 16 items consisting of the most frequently noted post-concussion and late whiplash syndrome symptoms (King *et al.,* 1995). Each item is allocated a score from 0 to 4. A score of 0 indicates no symptoms are experienced, a score of 1 indicates no associated problems are experienced due to the symptom, a score of 2 that the symptom is a mild problem, a score of 3 that the symptom is a moderate problem and a score of 4 that the symptom is a severe problem (King *et al.,* 1995). Each item is scored individually to determine the presence and severity of the symptom. The scores on the RPQ can be tallied to calculate a total score.

Eyres *et al.,* (2005) found the RPQ to be reliable with the test-retest procedure. The RPQ has been used successfully in identifying symptom presence and severity in populations after concussion, whiplash, traumatic brain injuries, and after physical injuries without brain injury (Stålnacke, 2012; Merrick *et al.,* 2010; Potter *et al.,* 2006). The RPQ is considered an appropriate measure for use in both the acute and chronic phases of whiplash (Merrick *et al.,* 2010).

The RPQ is available online free of charge (King *et al.,* 1995) (Appendix G).

3.6.1.2. Neck Disability Index

The Neck Disability Index (NDI) is a standardised self-administered questionnaire used to identify disability associated with cervical symptoms (Vernon *et al.,* 1991) (Appendix H). The NDI contains ten items. Each item or activity is scored on a scale ranging from 0 to 5, with a lower score indicating lower disability and a higher score a greater level of disability (Vernon, 2008; Vernon *et al.,* 1991). Scores for individual items are tallied to give a total score out of 50. Total scores are used to classify the presence and extent of the disability (Table 3.1). The total score can also be doubled to determine the percentage disability (Table 3.1).

Table 3.1 Descriptive Classifications of the NDI

Raw Score	Extent of Disability	Percentage of Disability
0-4	No disability	0-8%
5-14	Mild disability	10-28%
15-24	Moderate disability	30-48%
25-34	Severe disability	50-68%
35-50	Complete disability	70-100%

Vernon, 2008:493.

The NDI is the most frequently administered and of the most effective outcome measure in assessing cervical-related disability (Sterling, 2014; Howell, 2011; Vernon, 2008). The NDI total scores can be utilised to determine the presence and extent of self-rated disability related to neck pain post-whiplash (Merrick *et al.* 2010). Vernon (2008) found that 41 studies with WAD populations used the NDI. To the researcher's knowledge, the NDI has only been used in a case report on concussions in MMA athletes, but the report was based on a fictitious character (Burns, 2015).

Permission was granted by the Mapi Research Trust to use the NDI (Appendix F).

3.6.1.3. S Leeds Assessment of Neuropathic Symptoms and Signs pain scale

The Leeds Assessment of Neuropathic Symptoms and Signs pain scale (S-LANSS) is a standardised self-administered questionnaire used to identify persons suffering from cervical-related neuropathic pain (Bennett *et al.,* 2005; Sterling *et al.*, 2009) (Appendix J). The questionnaire contains seven items. The respondent has to indicate an answer of "yes" or "no" to seven questions related to neurological aspects of their pain. The answer to each question had a different value/score allocated to it. All values are added together at the end of the questionnaire to give a total score. The total scoring value could range between 0 and 24. A total score ranging between 13 and 24 was indicative of the pain having a strong neuropathic component. A total score of 0 to 12 is suggestive of pain being primarily non-neuropathic in origin. Permission to use the S-LANSS for research purposes was received from the author, Mr. M.I. Bennett (Appendix K). This questionnaire was self-administered.

The S-LANSS has been found to be a useful tool in investigating the presence of neuropathic pain as a component in whiplash (Sterling *et al.*, 2009). It has been shown to have a good level of consistency and distributing the questionnaire to participants for self-completion did not change its reliability in the clinical setting (Bennett *et al.*, 2005). The S-LANSS is sensitive and specific (up to 82% and 80% respectively) to measuring neuropathic pain, even in participants with a mixed pain picture (Jones *et* *al.,* 2013; Bennett *et al.*, 2005). The S-LANSS has been used in studies with the NDI as self-reported measures in chronic whiplash populations (Smith *et al.,* 2013).

3.6.1. 4 The Quebec Task Force Classification

The Quebec Task Force Classification (QTFC) (Spitzer *et al.,* 1995) was developed to determine the severity of WAD by classifying WAD symptoms into grades. The QTFC has also been used to predict prognosis outcomes of WAD (Carroll *et al.,* 2009). Clinical findings, namely neck pain, point tenderness, cervical range of motion, neurological finding of decreased sensation or muscle strength, and fractures or instability is assessed. Clinical findings of the assessment are used to classify WAD in accordance with set criteria (Table 2.1) (Spitzer *et al.,* 1995). This enables the clinician to make the diagnosis of WAD on the basis of a clinical assessment, rather than on self-reported symptoms from the patient alone (Sterling, 2014). The QTFC is also used as a guideline for the management and prognosis of WAD (Sterling, 2004). The QTFC is still the primary classification system for WAD and is used internationally (Sterling, 2014).

3.6.2 Measurements

3.6.2.1 Demographic information and sport specific information

Demographic data relating to age and gender, and sport specific information were collected from participants by means of a self-administered questionnaire (Appendix E). Sport specific information included the number of years training and competing in MMA, the number of competitive fights, the time spent per week training (hours), specific training regimes, the number of knock-outs sustained during training periods and competitive bouts respectively, and the prevalence of whiplash and concussion diagnoses.

3.6.2.2 Presence and severity of post-concussion and post-whiplash symptoms

Participants completed the RPQ to determine the presence and severity of cervical and cognitive symptoms associated with concussion and whiplash (Appendix G)

3.6.2.3 Disability associated with cervical symptoms

Participants completed the NDI to determine the presence and extent of disability due to cervical symptoms (Appendix H)

3.6.2.4 Presence of neuropathic pain

Participants completed the S-LANSS to determine the presence of neuropathic pain (Appendix J)

3.6.2.5 Severity and grade classification of whiplash associated disorders

A clinical assessment evaluating the presence of neck pain, point tenderness and muscle spasm in the cervical musculature, decreased cervical range of motion, neurological dysfunction and neck instability were used to determine the presence and grade the severity of WAD according to the QTFC (Table 2.1).

3.6.2.5.1 Pain

Participants were presented with a hard copy of the visual analogue scale (VAS) and asked to rate the intensity of their neck pain at the time of the assessment on a scale of 0 to 10 using (Appendix F). A higher score described a greater intensity of pain. Pain was rated as absent (0 out of 10), mild (1 to 4 out of 10), moderate (5 to 7 out of 10), or severe (8 to 10 out of 10) (Hawker *et al.,* 2011).

The VAS has been found to be reliable in various populations and is considered the gold standard for measuring pain (Bendinger *et al.,* 2016; Hawker *et al.,* 2011). The test-retest reliability of the VAS is good, participants respond well to the measurement scale, and researchers require very little training when using this scale (Hawker *et al.,* 2011; Bijur *et al.,* 2001). There are no normative values for the VAS and so the validity of the scale is uncertain (Hawker *et al.,* 2011).

3.6.2.5.2 Point tenderness and muscle spasm of the cervical muscles.

The participant was positioned in prone or supine on a plinth. The researcher palpated the cervical muscles bilaterally for point tenderness and muscle spasm by applying point or pincher pressure. The muscles examined included the cervical spine extensors (splenius capitus m. and cervicis m., semispinalis capitus m., and multifidus m.), suboccipitals, scalene group, and upper trapezius m. Participants were instructed to indicate any tenderness or pain experienced upon the application of pressure. The scalene and sternocleidomastoideus muscles were palpated in supine with the participants' head positioned in neutral alignment on a pillow.

Manual palpation is the primary method used by physiotherapists to assess for myofascial dysfunction (Sanz *et al.,* 2016; Myburgh *et al.,* 2008) Tenderness, pain with palpation, and increased muscle tone are common indicators of muscle spasm and myofascial trigger points (Mense 2008). The reliability and accuracy of manual palpation has been found to be dependent on the experience of the examiner (Sanz *et al.,* 2016; Mora-Relucio, 2016; Quinter *et al.,* 2015; Myburgh *et al.,* 2008). The location of the muscle, the depth of the muscle and the depth of pressure also determines the reliability of manual testing (Sanz *et al.,* 2016). Inter-examiner reliability has been found to be poor during manual palpation of trigger points, but assessments from an individual examiner may be more consistent (Sanz *et al.,* 2016; Quinter *et al.,* 2015).

Assessing for muscle spasm and point tenderness was done solely by the researcher to ensure quality control, consistent objectivity and reliability during the assessment. The risk of potential bias due to a single examiner was addressed. The researcher had adequate training and experience to accurately assess for muscle spasms, and the assessment was conducted in line with the set out protocol.

Electromyography can be used to evaluate the activity of muscles and confirm muscle spasm (Cruz *et al.,* 2004), however this measurement tool is not always available in clinical practice and was outside of the scope of this study.

3.6.2.5.3 Cervical range of motion

iPhone applications have moderate to good validity when used to measure cervical range of motion (Tousignant-Laflamme *et al.*, 2013). Flexion, extension, lateral flexion and rotation range of motion of the cervical spine were measured using the clinometer iPhone application (Peter Bretling, Version 3.3). Participants were seated on a plinth with their feet supported. When measuring flexion and extension the Clinometer iPhone application was aligned with the ear's point of attachment to the head. For lateral flexion the iPhone was placed in line with the corner of the eye in a coronal plane. The integrated Compass iPhone software application was used to measure rotation (Tousignant-Laflamme *et al.*, 2013). The iPhone was placed on top of the participants' head in line with the front of the nose.

Measuring cervical range of motion using the *Compass* and *Inclinometer* has been researched to show high intra-reliability in all planes of movement except rotation and moderate inter-reliability (Tousignant-Laflamme *et al.,* 2013). Measuring cervical range of motion using the iPhone applications presents comparable results and has a moderate to good level of validity (Tousignant-Laflamme *et al.,* 2013). The study was done on healthy participants and there is a lack of studies on measuring cervical range of motion using iPhone applications in patients with cervical problems.

Range of motion was tested bilaterally. Three measurements (readings) were taken for each of aforementioned cervical ranges of motion. Readings were noted in degrees. An average of the three readings was calculated (Appendix L).

Normal neck range of motion was considered 90° flexion, 70° extension, 45° lateral flexion and 90° rotation (Swartz *et al.,* 2005). Range of motion was classified as good (100-75% of normal range), average (50-75% of normal range) or poor (<50% of normal range) (Cruz *et al.,* 2004) (Table 3.2).

Table 3.2 Classifications of cervical range of motion

Plane of Movement	Good	Average	Poor
Flexion	90°	40-70°	<40°
Extension	70°	35-55°	<35°
Lateral Flexion	45°	22-35°	<22°
Rotation	80-90°	40-70°	<40°

(Swartz *et al.*, 2005: 156)

3.6.2.5.4 *Neurological examination*

The neurological examination was done to assess the presence of a neural disorder. The integrity of the nervous system was evaluated by testing sensation, muscle strength, and deep tendon reflexes. The neurological tests were done in accordance with the methods described by Petty et al. (2006) (Table 3.3).

Sensation was tested in the dermatomes of the nerve roots of C1 to T1 (Table 3.3). Sensation was tested with participants in supine on a plinth, their heads comfortably positioned on a pillow and their eyes closed. Light touch was tested by lightly touching the distal dermatome with a cotton wool ball. The left and right sides were immediately compared. The participant had to verbally indicate whether the sensation felt was the same on both sides. If light touch sensation was not the same on both sides, pain was tested using the flag-pin/ pinprick test (Petty *et al.*, 2006). The sharp point of a reflex hammer was used to apply pressure in the distal part of the dermatome. If tests for light touch and pain indicated decreased or altered sensation in a dermatome it was considered to be a neurological deficit.

The presence of muscle weakness caused by decreased neural conduction in the myotomes specific to the nerve roots of C1 to T1 was determined using the break test. Break tests were conducted with participants in a comfortable sitting position, with their feet supported. Participants were asked to hold an isometric muscle contraction specific to the myotome (Table 3.3). The specific muscle being tested was placed in mid-position and then resistance applied. The isometric contraction was held for six seconds (Petty *et al.,* 2006). Break tests were done bilaterally in order to establish discrepancies in strength between the left and right upper limb. Observable weakness was an indication of decreased neural conduction and considered a neurological deficit.

The Biceps (C5/6) and Triceps (C7) reflexes were tested with participants in supine on a plinth. The limb was placed in mid-position and tested with a reflex hammer to elicit a strong jerk (Petty and Moore, 2006). Deep tendon reflexes were noted as being normal, decreased, or absent.

The validity and reliability of neurological examination (testing sensation, testing muscle strength, testing deep tendon reflexes, and cervical instability tests) has not always been reported as strong (Lemeunier *et al.,* 2017). Conducting a full neurological examination is however still a main recommendation when evaluating the patient with neck pain (Monticone *et al.,* 2013). These need to be done in conjunction with a thorough history, disability questionnaires and red flags require deeper investigation (Monticone, *et al.,* 2013).

Other studies have found that manual testing of muscle strength, or the break test, and deep tendon reflex testing have good inter-examiner reliability, good test-retest reliability and good clinical agreement (Cook, 2009; Cuthbert *et al.,* 2007). Factors to improve the accuracy of testing included training and experience of the researchers, consistency with regards to following protocol, consistency when application of pressure or touch (Sanz *et al.,* 2016; Quinter *et al.,* 2015; Myburgh *et al.,* 2008; Cuthbert *et al.,* 2007).

Table 3.3 Nerve Root Dermatomes and Myotomes

Dermatomes Sensory Testing		***Myotome Muscle Strength Testing***	
C1-C2	Front of face	**C1-C2**	Upper cervical flexion and extension respectively
C3	Lateral neck	**C3**	Cervical lateral flexion
C4	Supraclavicular	**C4**	Shoulder girdle elevation
C5	Lateral shoulder	**C5**	Shoulder abduction
C6	Thumb and index finger	**C6**	Elbow flexion
C7	Palmar aspect 3 middle fingers	**C7**	Elbow extension
C8	Medial lower arm and hand	**C8**	Thumb extension
T1	Medial elbow	**T1**	Finger abduction/adduction

(Petty and Moore, 2006: 69, 72)

3.6.2.5.5 Cervical stability

Stability of the upper cervical spine was tested in sagittal and coronal planes according to Petty et al. (2006). Anterior and posterior stability tests were done for the atlanto-occipital joint in the sagittal plane. With the participant in supine on a plinth, a bilateral anterior force to the atlanto-occipital joint was applied by the researcher to test for posterior instability, and a bilateral posterior force to test for anterior instability.

Stability of the atlanto-axial joint in the coronal plane was tested using a lateral stability stress test. With the participant in supine the researcher attempted to produce a lateral movement of the atlas and occiput on top of the axis (Petty *et al.*, 2006).

Instability tests were considered positive if any of the participant's neck pain symptoms or other symptoms such as nystagmus, limb paraesthesia, and unilateral pain along the length of the tongue or facial lip paralysis were reproduced (Petty and Moore, 2006).

Sensitivity of detecting upper cervical spine instability with manual tests alone is low (Lemeunier *et al.,* 2017; Hutting *et al*., 2013; Olsen *et al.,* 2001). Possible signs of cervical instability need to be assessed within the scope of patient history, trauma, disability questionnaires, findings of other neurological examinations, and patients should be referred for deeper investigation (Lemeunier *et al.,* 2017; Olsen *et al.,* 2001).

3.7 Study Procedures

A list of MMA gyms was sourced and compiled. Trainers at MMA gyms and MMA event organisers in Bloemfontein, FS and Cape Town, WC were contacted by the researcher telephonically or via email. The aims and objectives of the study were explained and they were asked for assistance in the recruitment of participants. They were asked to ask their athletes if they were willing to be contacted by the researcher to be invited to participate in the study. Contact details for athletes who were willing to be approached were given to the researcher.

The athletes were contacted telephonically by the researcher and invited to participate in the study. The aims, objectives and procedure of the study were explained. If willing to participate an in person appointment was made for their participation.

In person appointments with participants took place at a designated private physiotherapy practice in Bloemfontein, FS and Cape Town, WC. On meeting the athletes at their appointment they were given an information letter in English. Participants were provided the opportunity to read through the document and to ask any questions they had. Once written informed consent had been obtained, participants were included in the study (Figure 3.1).

Participants first completed the sociodemographic data form and the three standardised questionnaires (the RPQ, NDI and S-LANSS) in a private room in the practice. The researcher was on hand to answer any questions participants had during the completion of the questionnaires. On completion the researcher scanned the documents for missing data. In cases of missing data participants were asked to complete all questions and the documents were returned to them to complete. Completed documents were collected by the researcher.

After completion of the documentation participants underwent a clinical assessment in the same room. The room was set up with a plinth for the participant to sit and lie on, an iPhone with the necessary applications, a reflex hammer with a sharp point, and cotton wool. Participants were asked to wear a shirt that would expose their neck, shoulders and upper arms.

The intensity of the participant's neck pain was assessed first using the VAS (section 3.5.2.5.1). The participant was then positioned in prone or supine on the plinth and the researcher palpated the cervical muscles (mm cervical extensors, sub-occipitals, upper trapezius, scalene, sternocleidomastoideus). This was followed by the measurement of cervical range of motion in sitting for cervical flexion, extension, lateral flexion and rotation using an iPhone clinometers and compass (section 3.6.2.5.3).

After the range of motion testing, a neurological examination was conducted to establish the integrity of neural conduction. This included the testing of sensation according to dermatomes (light touch and pin prick where indicated), muscle strength using resisted movements according to myotome function, and deep tendon reflexes (Biceps and Triceps) were tested once with a reflex hammer (section 3.5.2.5.4).

Lastly, anterior and posterior stability of the atlanto-occipital joint and lateral stability of the atlanto-axial joint was tested in supine.

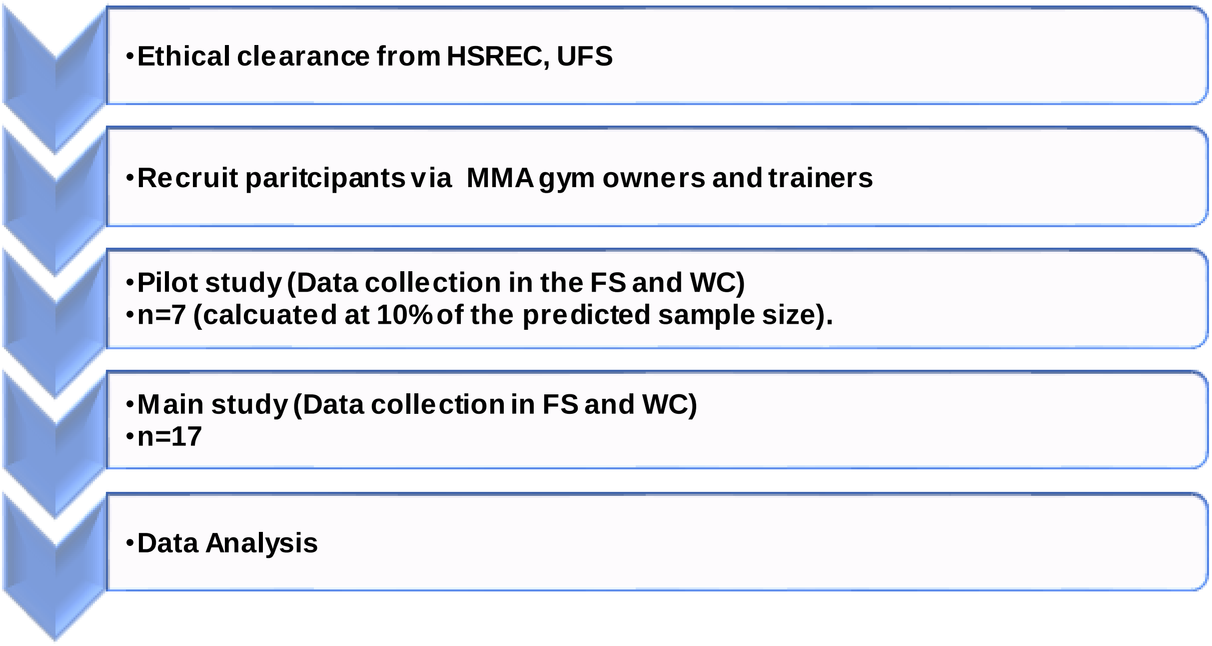

Figure 3 1 Flow diagram of study procedure

3.8 Pilot Study

After ethical clearance was obtained a pilot study was conducted in line with the approved protocol. Seven MMA athletes meeting the inclusion criteria were included in the pilot study. This included three athletes from Bloemfontein, FS and four from Cape Town, WC. The pilot study served multiple purposes.

It was used to assess the feasibility of the study procedure and suitability of the chosen outcome measures in the population. The researcher had practiced performing the clinical assessment on non-study participants to ensure that they were done correctly and proficiently The proficiency of the researcher in both administering the questionnaires and conducting the clinical assessment was found to be adequate. The feasibility of the iPhone Compass and Clinometer applications for measuring cervical ROM was also considered. Range of motion was first tested in pilot study participants using a universal goniometer and then re-tested using the Compass and Clinometer. The measurements taken using the iPhone Compass and Clinometer applications were comparable to those taken using the universal goniometer, showing the iPhone applications to be an appropriate measure. Only the iPhone applications were used to measure cervical ROM in the main study. It was decided that participants had to be advised to wear a shirt exposing the neck and shoulder area during testing. In addition, the understanding of the questionnaires by participants was tested and found to acceptable.

The pilot study also evaluated logistical aspects relating to the study procedure including the time required for participants to complete the questionnaire and the researcher to perform the clinical assessment. It was estimated that an hour would be needed. The data form for the objective test findings did not distinguish between the left and right side. This was corrected and the final data form resubmitted to the HSREC.

No major changes were made to the study methods following the pilot study, and the data from all pilot study participants were included in the main study.

3.9 Data Analysis

Data were coded, entered into an EXCEL spreadsheet and checked by the researcher. The data were then analysed by the Department of Biostatistics, University of the Free State. Data were subjected to a test of normality and was found to be skewed.

Sample characteristics are presented using median with ranges for continuous data and frequencies with percentages for categorical data. In addition to being treated as a numerical score, total scores for RPQ, NDI, and S-LANSS were classified in accordance with each measure-specific classification system (Section 3.6.1). Classification data is reported using frequencies with percentages. The prevalence of WAD was calculated using a 95% confidence interval. The association between neck disability and WAD severity was established using the Fisher's Exact Test.

The results of the study will be presented in Chapter four.

CHAPTER 4 RESULTS

4.1 Introduction

The results of this study will be presented in this chapter and briefly commented on. Loss to inclusion will be outlined, and the reasons for loss to inclusion will be highlighted.

Sample characteristics will be summarised. Cervical and cognitive whiplash symptoms will be described as collected using the RPQ; and the extent of neck disability and the presence of neuropathic pain as collected by the NDI and S-LANSS respectively will be presented. Lastly, the prevalence and severity of WAD according to the QTFC will be reported. Further implications of the findings, limitations of the study, and future recommendations will be discussed in Chapter five.

4.2 Athlete Recruitment

Seventeen athletes participated and were included in this study over an 18-month period, with eight participants included from Bloemfontein and nine from Cape Town. Twenty-four MMA gyms in Bloemfontein and Cape Town were identified from online listings. Seventeen of these gyms were excluded from recruitment (n=17). Six (n=6) gyms did not have any amateur competitive MMA athletes. Trainers and owners from two gyms (n=2) responded, but none of their athletes were willing to be contacted by the researcher. Nine gyms (n=9) could not be contacted by the researcher or did not respond to repeated phone calls, voice mail messages or emails.

Twenty-nine participants were recruited from seven gyms. Twelve (n=12) participants were lost to inclusion. Two participants did not meet the inclusion criteria and ten declined participation when contacted, or failed to meet their scheduled appointment. The recruitment is depicted in Figure 4.1 on the following page.

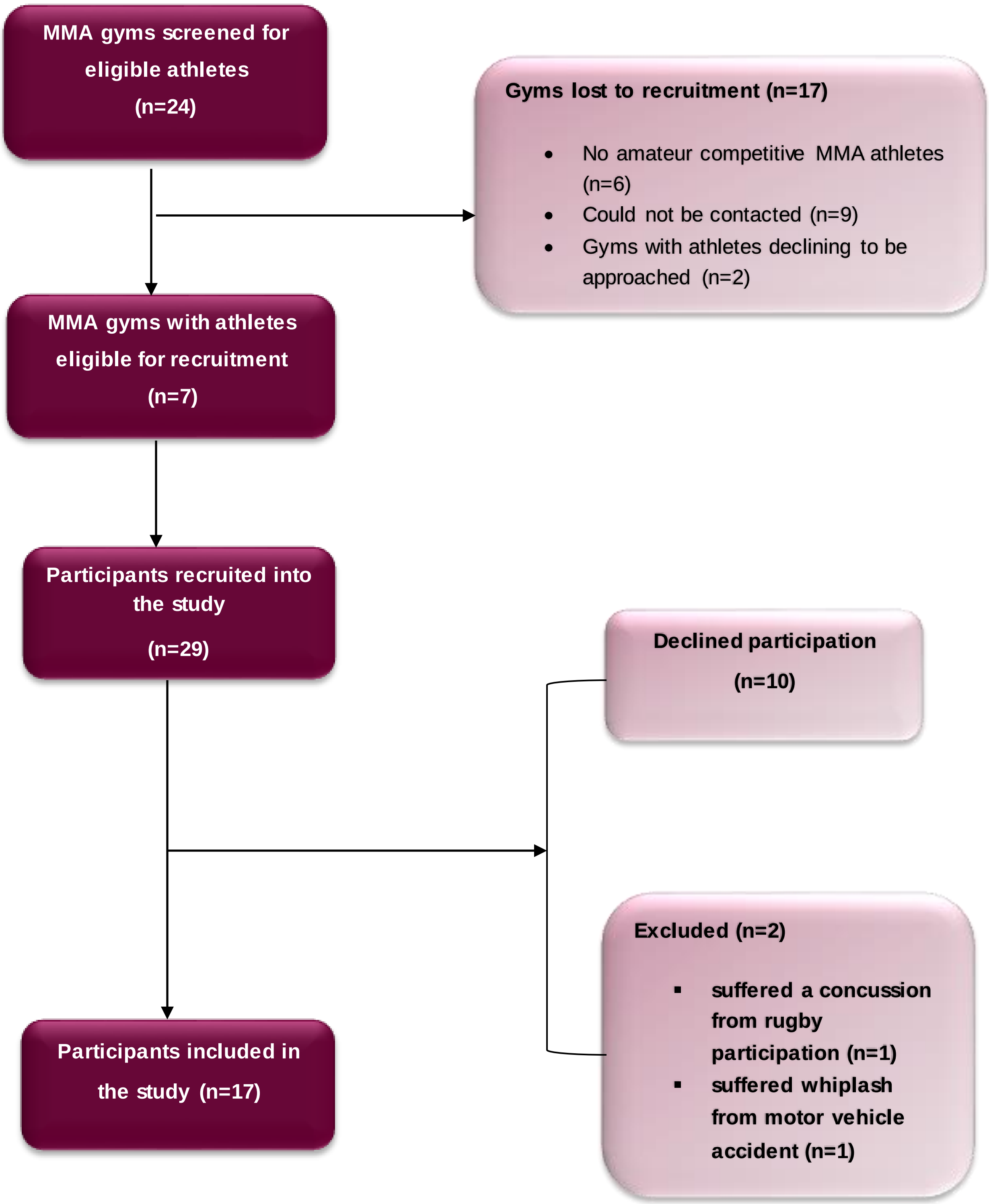

Figure 4.1 Participant recruitment

4.3 Demographic and Sport Specific Information

Demographic and MMA participation information was collected from all included participants and is presented in Table 4.1. Values reported are frequencies with percentages for categorical data and median with ranges for continuous data.

Table 4.1 Participant demographic and participation information

Demographic Information	Participants (n=17)
Age (years)	
Median (range)	24.7 [19.9 – 42.3]
Gender	
Male	15 (88.2%)
Female	2 (11.8%)
Residence	
Bloemfontein, FS	8 (47.1%)
Cape Town, WC	9 (52.9%)
Duration of MMA training (years)	
Median (range)	5.0 [2 - 10]
Duration of competitive participation in MMA (years)	
Median (range)	3.0 [1 – 9]
Number of competitive bouts in the previous year	
Median (range)	2.0 [1 – 4]
Participants knocked out in training	
Yes	5 (29.4%)
No	12 (70.6%)
Participants sustaining more than one knockout in training	3 (17.6%)
Participants knocked out in competition	
Yes	7 (41.2%)
No	10 (58.8%)
Participants sustaining more than one knockout in competition	2 (11.8%)
Participants diagnosed with concussion	4 (23.5%)
Time elapsed since last concussion (years)	
Median (range)	1.8 [1-4]
Participants diagnosed with whiplash	2 (11.8%)
Time elapsed since last whiplash (years)	
Median (range)	1.5 [1-2]

Most MMA athletes in this study were young adults (18-25 years), with a median age of 24.7 years. Most MMA athletes participating in this study were male (n=15) (88.2%). All of the participants had been training for two years or more, with a median of five years. All of the participants had been competitive in MMA at an amateur level for one year or longer (median of 3 years; range 1 to 9 years). All of the participants had participated in one or more competitive bouts in the previous year (median of 2 bouts; range 1 to 4 bouts).

More than half of the participants had been knocked out in either training or competition (n=12; 70.6%). Five participants (n=5; 29.4%) were knocked out in training, with three being knocked out on multiple occasions (n=3;17.6%). Seven participants (n=7; 41.2%), had been knocked out in competition, two of whom had been knocked out on multiple occasions (n=2;11.8%). Less than a quarter of the participants had been diagnosed with concussion (n=4; 23.5%) or whiplash (n=2; 11.8%).

A more detailed account of training aspects and components is provided in Table 4.2

4.4 Training Aspects and Components

Values reported on training specific aspects are frequencies with percentages for categorical data, and medians with ranges for continuous data.

Table 4.2 Training Specific Information

Training Information of participants (n=17)	**Median [range]**
Time spent training per week (hours) Median [range]	12 [4-30]
Components included in training (n=17)	**f (%)**
Cardiovascular exercise	12 (70.6%)
Resistance exercises	11 (64.7%)
Punching and striking	12 (70.6%)
Kicking	9 (52.9%)
Grappling	16 (94.1%)
Sparring	16 (94.1%)

Participants spent at least four hours per week training, with a median of twelve hours. Eleven participants (64.7%) spent 10 or more hours per week training and the highest reported training time was 30 hours, which was reported in two (n=2) participants.

Nearly three-quarters of the participants included cardiovascular exercise (n=12; 70.6%) and resistance exercises (n=11; 64.7%) in their training and all of the participants noted MMA specific techniques in their training. Grappling and sparring were the most popular components of training programmes, and were used by sixteen (94.1%) of the participants.

4.5 Presence and Severity of Cognitive and Cervical Symptoms

The presence and severity of cervical and cognitive symptoms associated with whiplash and concussion, as reported by participants on the RPQ are presented in Table 4.3. Values are reported as frequencies with percentages.

Table 4.3 Presence and severity of cervical and cognitive symptoms

Cognitive and Cervical Symptoms	Participants with different severities of symptoms * (n=17)				
	0*	1*	2*	3*	4*
Headache	7 (41.2%)	3 (17.7%)	5 (29.4%)	2 (11.7%)	0
Dizziness	6 (35.3%)	6 (35.3%)	3 (17.7%)	1 (5.9%)	1 (5.9%)
Nausea and vomiting	15 (88.2%)	1 (5.9%)	1 (5.9%)	0	0
Noise sensitivity	9 (52.9%)	4 (23.5%)	1 (5.88%)	1 (5.88%)	2 (11.8%)
Sleep disturbances	7 (41.2%)	2 (11.7%)	3 (17.7%)	3 (17.7%)	2 (11.8%)
Fatigue, tiring more easily	4 (23.5%)	3 (17.7%)	7 (41.2%)	3 (17.7%)	0
Being irritable, easily angered	7 (41.2%)	1 (5.88%)	6 (35.3%)	0	3 (17.7%)
Feeling depressed or tearful	7 (41.2%)	3 (17.7%)	5 (29.4%)	2 (11.8%)	0
Feeling frustrated or impatient	4 (23.5%)	3 (17.7%)	5 (29.4%)	3 (17.7%)	2 (11.8%)
Forgetfulness, poor memory	6 (35.3%)	5 (29.4%)	4 (23.5%)	2 (11.8%)	0
Poor concentration	5 (29.4%)	7 (41.2%)	2 (11.8%)	3 (17.7%)	0
Taking longer to think	5 (29.4%)	7 (41.2%)	3 (17.7%)	2 (11.8%)	0
Blurred vision	10 (58.8%)	5 (29.4%)	2 (11.8%)	0	0
Light sensitivity	8 (47.1%)	3 (17.7%)	2 (11.8%)	4 (23.5%)	0
Double vision	15 (88.2%)	1 (5.88%)	0	1 (5.8%)	0
Restlessness	5 (29.4%)	5 (29.4%)	4 (23.5%)	2 (11.8%)	1 (5.8%)

*A score of 0= no symptoms experienced, 1 = symptoms experienced but with no associated problems, 2 = mild symptoms causing mild problems; 3= moderate symptoms with moderate associated problems, 4= severe symptoms with severe associated problems.

Less than a third (<33%) of participants presented with moderate to severe symptoms. Symptoms most reported to be moderate to severe were sleep disturbances (n=5; 29.4%), feelings of frustration or impatience (n=5; 29.4%) and light sensitivity (n=4; 23.5%).

Cervical symptoms of headaches were reported in 10 participants (58.8%). Headaches were rated as moderate in two participants (n=2; 11.7%) Dizziness was reported to be moderate to severe in two participants (n=2; 11.7%).

The median RPQ score in participants was 16 (range of 0 to 37).

4.6 Disability due to Cervical Symptoms

Disability, impaired ADL and restrictions due to cervical symptoms as reported on the NDI is depicted in Table 4.4. Values are reported as frequencies with percentages.

Table 4.4 Disability due to cervical symptoms

	Degree of Disability in Participants (n=17)					
	0	**1**	**2**	**3**	**4**	**5**
Neck pain at the moment	9 (52.9%)	6 (35.3%)	2 (11.8%)	0	0	0
Personal care	17 (100%)	0	0	0	0	0
Lifting	10 (58.8%)	6 (35.3%)	0	1 (5.9%)	0	0
Reading	10 (58.8%)	4 (23.5%)	3 (17.7%)	0	0	0
Headaches	7 (41.2%)	6 (35.3%)	1 (5.9%)	3 (17.7%)	0	0
Concentration	7 (41.2%)	9 (52.9%)	1 (5.9%)	0	0	0
Work	15 (88.2%)	2 (11.8%)	0	0	0	0
Driving	9 (52.9%)	7 (41.2%)	1 (5.9%)	0	0	0
Sleep Disturbance	5 (29.4%)	6 (35.3%)	5 (29.4%)	0	0	1 (5.9%)
Recreation	8 (47.1%)	7 (41.2%)	2 (11.8%)	0	0	0

Individual items reported as causing moderate to severe pain or difficulty (score ≥3) included headaches (n=3;17.7%), sleep disturbance (n=1; 5.9%), and lifting (n=1; 5.9%).

A total neck disability score was calculated as the sum of the individual item scored on the NDI. The median NDI total score for participants was 5 (range of 0 to 13).

4.6.1 Neck disability classification

Total scores were classified according to the measure specific classification system (Section 3.6.1.2). The extent of the disability associated with cervical symptoms is shown in Table 4.5. Values are reported as frequencies with percentages.

Table 4.5 Classification of disability

NDI total score range	Classification of Disability	n=17
0-4	No disability	6 (35.3%)
5-14	Mild disability	11 (64.7%)
15-24	Moderate disability	0 (0)
25-34	Severe disability	0 (0)
>34	Complete disability	0 (0)

Just more than a third (n=6; 35.3%) of the participants showed no disability. More than half of participants (n=11; 64.7%) of the participants were classified as having mild disability related to their cervical symptoms.

4.7 Presence of Neuropathic Pain

The determination of participants' pain as being non-neuropathic or more neuropathic in nature was established using the S-LANSS. The response of participants on the S-LANNS questionnaire items is reported in Table 4.6. Values are frequencies with percentages.

Table 4.6 Prevalence of non-neuropathic and neuropathic related pain

Aspect Relevant to the Area of Pain	Participants (n=17)
Presence of pins and needles, tingling, or prickling sensations	
Yes	5 (29.4%)
No	12 (70.6%)
Colour changes of the skin (mottled or more red)	
Yes	2 (11.8%)
No	15 (88.2%)
Hypersensitive to light touch	
Yes	3 (17.7%)
No	14 (82.4%)
Sudden burst onsets of pain for no apparent reason ('electric shock' pain)	
Yes	3 (17.7%)
No	14 (82.4%)
Skin feels unusually hot; like burning pain	
Yes	5 (29.4%)
No	12 (70.6%)
Abnormal sensations or response to light touch different than in non-painful area of the body	
Yes	5 (29.4%)
No	12 (70.6%)
Abnormal sensations or response to gentle pressure different than in non-painful area of the body	
Yes	9 (52.9%)
No	8 (47.1%)

The aspect relevant to the area of pain most frequently reported as present by participants was the abnormal sensory response to gentle pressure in the area of neck and shoulder (n=9; 52,9%). Presence of pins and needles, tingling, or prickling sensations; the skin feeling unusually hot; and an abnormal response to light touch was reported in nearly a third (n=5; 29%) of participants.

Pain was classified as being more non-neuropathic or neuropathic in nature based on the participant responses on the S-LANNS (Table 4.6). Scores for each item were tallied to give a total score. Total scores were interpreted using the measure-specific classification system. The nature of the participants' pain is presented in Table 4.7. Values are reported as frequencies with percentages.

Table 4.7 Classification of pain according to S-LANSS

S-LANSS total score	Classification of Pain	(n=17)
0-12	Non-neuropathic pain	13 (76.5%)
13-24	Neuropathic pain	4 (23.5%)

Only four participants (n=4; 23.5%) were found to have neuropathic pain. For the majority of participants (n=13; 76.5%) pain was non-neuropathic in nature.

4.8 Presence and Severity of Whiplash Associated Disorders

A clinical assessment evaluating the presence of neck pain, point tenderness and muscle spasm in the cervical musculature, decreased cervical range of motion, neurological dysfunction and neck instability was used to determine the presence and grade the severity of WAD according to the QTFC. Findings of the clinical assessment are described below.

4.8.1 Findings of the clinical assessment

4.8.1.1 Neck pain

Participants rated the intensity of neck pain on the visual analogue scale (VAS). Pain scores were used to classify the severity of participants' pain. Rated neck pain intensity is reported in Table 4.8. Values are reported as frequencies with percentages.

Table 4.8 Classification and severity of pain

Classification Descriptor	Pain Severity (/10)	Participants (n =17)
No Pain	0	7 (41.2%)
Mild	1-4	7 (41.2 %)
Moderate	5-7	3 (17.6%)
Severe	>8	0

More than half of the participants (n=10; 58.8%) indicated that they experienced neck pain. The pain was mild in most cases, but three participants (n=3; 17.6%) presented with moderate pain.

4.8.1.2 Presence of point tenderness and muscle spasm

Participants cervical musculature was palpated bilaterally for signs of point tenderness and muscle spasm. The presence of point tenderness in muscle groups is reported in Table 4.9. Values are reported as frequencies with percentages.

Table 4.9 Prevalence of point tenderness and muscle spasm in muscle groups

Muscle groups with spasm and point tenderness	Participants with muscle spasm and point tenderness (n=17)
Cervical extensors	**8 (47.1%)**
Suboccipitals	**11 (64.7%)**
Upper trapezius	**16 (94.1%)**
Scalene	**13 (76.5%)**
Sternocleidomastoideus	**8 (47.1%)**

The vast majority of participants presented with point tenderness and muscle spasm of the cervical musculature (n=16; 94.1%). Of these aforementioned participants (n=16), all of them (n=16, 100%) had muscle spasm and point tenderness in the upper fibres of their mm. trapezius. Muscle spasm and point tenderness was also frequently palpated in mm. scalene (n=13; 76.5%) and mm. occipitalis (n=11; 64.7%)

4.8.1.3 Cervical range of motion

Reported measurements were then used to grade the ROM as poor, average or good (Table 3.3.). The classification data for cervical ROM are presented in Table 4.10.

Table 4.10 Classification of cervical range of motion

Range of Motion Grading in Participants (n=17)			
Plane of Movement	**Good**	**Average**	**Poor**
Flexion	0	12 (70.6%)	5 (29.4%)
Extension	7 (41.2%)	10 (58.8%)	0
Latera flexion right	9 (52.9%)	8 (47.1%)	0
Lateral flexion left	10 (58.8%)	7 (41.2%)	0
Rotation right	9 (52.9%)	8 (47.1%)	0
Rotation left	8 (47.1%)	9 (52.9%)	0

Cervical ROM tended to be in the average to good range in all planes of movement for most participants, except for five participants (n=5; 29.4%) who had poor cervical flexion ROM.

4.8.1.4 Neurological findings

A neurological evaluation was used to determine the prevalence of neurological deficits, namely decreased sensation within dermatomes, decreased muscle strength within myotomes, and decreased or absent reflexes. Findings of the neurological evaluation is presented in Table 4.11. Values are reported as frequencies with percentages.

Table 4.11 Participants with deficits in cervical dermatomes and myotomes

Neurological Findings	Participants (n=17)
Decreased sensation	
Yes	3 (17.6%)
No	14 (82.4%)
Decreased muscle strength	
Yes	4 (23.5%)
No	13 (76.5%)
Decreased reflexes	
Yes	1 (6.9%)
No	16 (94.1%)

Decreased sensation in dermatomes was reported in three participants (17.7%) and decreased muscle strength in myotomes was reported in four participants (23.4%)

Decreased sensation and muscle strength within specific dermatomes and myotomes are reported in Table 4.12.

Table 4.12 Neurological findings in specific dermatomes and myotomes

Specific dermatomes with decreased sensation (n=3)								
	C2	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**T1**
Right	1 (33.3%)	1 (33.3%)	-	1 (33.3%)	1 (33.3%)	1 (33.3%)	-	-
Left	1 (33.3%)	1 (33.3%)	2 (66.7%)	1 (33.3%)	-	1 (33.3%)	1 (33.3%)	1 (33.3%)
Specific myotomes with decreased muscle strength (n=4)								
	C2	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**T1**
Right	-	-	-	1 (25%)	2 (50%)	1 (25%)	1 (25%)	1 (25%)
Left	-	1 (25%)	-	-	1 (25%)	-	2 (50%)	1 (25%)

Two of the three participants with decreased sensation (n=2; 67.7%) showed decreased sensation over the left C4 dermatome. Decreased muscle strength was most reported in the C6 and C8 myotomes (n=2; 50%).

A summary of the findings of the clinical findings is provided in Table 4.13

Table 4.13 Clinical assessment findings

Clinical findings	Participants (n=17)
Neck pain	10 (58.8%)
Intensity of pain in those with neck pain	
Median (range)	2 [0-7]
Muscle spasm and point tenderness in the cervical muscles	16 (94.1%)
Decreased cervical range of motion	17 (100%)
Decreased sensation	3 (17.7%)
Decreased muscle strength	4 (23.5%)
Abnormal deep tendon reflexes	1 (5.8%)
Cervical instability	0

The median value of neck pain intensity was 2 out 10 (range 0 to 7 out of 10). The majority of participants presented with muscle spasm in cervical musculature (n=16; 94.1%). All of the participants presented with decreased range of motion in one or more planes of movement (n=17;100%) (Table 4.10).

4.8.2 Prevalence and severity of whiplash associated disorders

The findings of the clinical assessment were used to determine the prevalence and the severity of WAD in accordance with grading criteria of the QTFC. The prevalence of WAD was calculated using a 95% confidence interval. The prevalence and severity of WAD is reported in Table 4.14. Values reported are frequencies with percentage and confidence intervals.

Table 4.14 Prevalence and grade of WAD according to QTFC

Grade	Clinical Presentation	Prevalence (n=17)	95% Confidence interval
WAD 0	No complaints of neck pain No physical signs	7 (41.18%)	0
WAD I	Complaints of neck pain, stiffness or point tenderness only No physical signs	0	0
WAD II	Neck complaints Musculoskeletal signs: • Decreased range of motion • Point tenderness and muscle spams in neck and shoulders	4 (23.53%)	[9.6%; 47.3%]
WAD III	Neck complaints Musculoskeletal signs Neurological signs: • Sensory deficits within dermatomes • Weakness/poor conduction within myotomes • Decreased or absent deep tendon reflexes	6 (35.29%)	[17.3%; 58.7%]
WAD IV	Neck complaint with fracture or dislocation	0	0

Ten participants (58.8%) met the grading criteria and were classified with WAD according to the QTFC. Four participants (n=4; 23.5%) presented with WAD II and six participants (n=6; 35.3%) with WAD III. The confidence interval (95% CI) for both WAD II and WAD III is reported above.

4.9 Association Between Neck Disability and Severity of Whiplash Associated Disorders

The relationship between the frequency of participants presenting with WAD and no or mild disability is reported in Table 4.15. Values are reported as frequencies and percentages. The probability (p-value) of the relationship between WAD and disability was calculated using Fisher's Exact Test.

Table 4.15 Association of WAD by NDI

	No Disability	Mild Disability	p-value
WAD 0 (n=7)	n= 5 (71.4%)	n= 2 (28.6%)	p= 0.04*
WAD II (n=4)	n=0 (0%)	n=4 (100%)	
WAD III (n=6)	n=1 (16.7%)	n=5 (83.3%)	

*Statistical significance is indicated by a p-value <0.05

The majority of the seven (n=7) participants who presented with WAD 0 had no disability on the NDI (n=5; 71.4%). All of the participants who presented with WAD II also presented with mild disability (n=4; 100%). Of the six participants (n=6) who presented with WAD III only one (n=1; 16.7%) presented with no disability and five (n=5; 83,3%) presented with mild disability. The probability of an association between the grade of WAD and the level of disability is significant (p=0.04).

4.10 Summary

Seventeen participants were included in this observational descriptive study. The sample size was limited by recruitment challenges. Most of the participants were male. Most of the participants were young adults, with a median age of 25 years (range of 20 to 42 years). All participants had been training in MMA for two or more years, with a median of five years.

More than half of the participants had been knocked out in either training or competition (n=12; 70.6%). Less than a quarter of the participants had been previously diagnosed with concussion or whiplash.

Less than a third of the participants reported moderate to severe post-whiplash symptoms. Symptoms included sleep disturbance, feelings of frustration and light sensitivity on the RPQ. The median for the RPQ total score was 16 (range of 0 to 37). More than half of participants (n=11; 64.7%) presented with mild disability related to their cervical symptoms, according to the NDI. The median for the NDI total score was 5 (range of 0-13). Less than a quarter of participants presented with neuropathic pain according to the S-LANSS.

The majority of participants presented with neck pain (n=10; 58.8%). The majority of participants (n=16; 94.1%) had muscle spasm and point tenderness in the cervical muscles especially in mm. upper fibres of m. trapezius, mm. scalene and mm. occipitalis. All participants showed some decrease in their cervical range of motion, however, in most cases cervical ROM was in the average to good range in all planes of movement.

Ten participants (58.8%) were classified with WAD according to assessment findings in line with criteria set out by the QTFC. Four participants (23.5%) presented with WAD II and six participants (35.3%) with WAD III. The confidence intervals for WAD II and WAD III were wide due to the small sample size.

The majority of participants who presented with WAD II and III (100% and 83.3% respectively) also presented with mild disability. There is a significant probability of an association between the grade of WAD and the level of disability in this study (p=0.04)

A more detailed interpretation of the findings will be discussed in context with published literature in Chapter five.

CHAPTER 5 DISCUSSION

5.1 Introduction

This chapter will discuss the results of this study. Participant recruitment and reasons for the small sample size will be considered. Demographic information, sport-specific information and training components will be discussed.

Outcomes assessed in this study, namely, the presence of cervical and cognitive whiplash-related symptoms, disability due to cervical symptoms, and the presence of neuropathic pain will be discussed. A brief analysis of the clinical findings on pain, cervical muscle spasm and point tenderness, cervical range of motion and neurological examination (sensation, strength and deep tendon reflexes) will be presented in the context of the QTFC and available published research. As the main study outcome, the prevalence and severity of WAD in participants will be interpreted, discussed and possible reasons for the findings considered.

Challenges and limitations experienced during the study will be highlighted and recommendations provided for future research.

5.2 Participant Recruitment and Sample Size

The sample included in this study was very small (n=17). The small sample was due to a small population, recruitment challenges, and athletes declining participation.

Since its origin, in 1993 in America and 2009 in Africa, MMA is still an emerging sport (Venter *et al.,* 2017; García *et al.,* 2010; Buse, 2006). The population of competitive MMA in Africa is small compared to more popular and mainstream sports. MMA is not only practiced for competitive reasons, but also for the health benefits of intensive exercise (Rainey, 2009). This explains the small population of competitive MMA athletes. Athletes in MMA compete as individuals, rather than as part of a 'team'. Each MMA event consists of multiple bouts between athletes from different parts of the country. This is a reason why it is harder to determine the participation rates and population size compared with more mainstream sports in SA.

Accurate information regarding the population of MMA athletes in Bloemfontein and Cape Town was difficult to attain. Most of the gyms that offer MMA training also train athletes in other forms of martial arts, such as boxing, kickboxing and muay thai. Athletes who want to compete in MMA may train in all these styles, but not all of the athletes at the gym necessarily train to be competitive in MMA.

The population of amateur competitive MMA athletes in these two cities are small. MMA trainers indicated to the researcher that athletes who participate in MMA may first compete in boxing, grappling and kick-boxing specific events, in preparation for an MMA event. This means that athletes have to spend time competing in other forms of martial arts before they can be ranked as amateur MMA athletes. This contributed to the small population of amateur MMA athletes in Cape Town and Bloemfontein.

Recruitment of participants was dependent on assistance from MMA gym owners and trainers. MMA trainers were asked to assist in the recruitment of MMA athletes. Many forms of martial arts may be offered at each gym with different classes offered at different times. Trainers would be able to specifically address the athletes who were competitive in MMA. However, a small number of participants were recruitment by MMA trainers and owners. Trainers and gym owners were contacted repeatedly via telephone or email to address the poor response. The reason for poor recruitment rates by gym owners and MMA trainers could not be established in the scope of the current study. It could be postulated that many athletes were not interested in participating in the study. The trainers from two gyms were specifically unable to recruit any athletes due to athletes having no interest in participating. The MMA community, including gym owners, trainers and athletes are also likely not as familiar with clinical sports research as other mainstream sporting communities, which may also make recruitment more of a challenge.

Further challenges in inclusion was that participants declined participation in the study. Although all efforts were made to accommodate the athletes according to their schedules and to re-schedule appointments if necessary, many of the athletes were unable to participate and declined due to work-related and personal reasons.

On consulting the available published literature, investigations into the prevalence of head and other injuries in MMA athletes have included sample sizes ranging between

14 and 1400 athletes (Venter *et al.,* 2017; Mayer *et al.,* 2015; Hutchison *et al.,* 2014; McClain *et al.,* 2014; Rainey *et al.,* 2009; Bledsoe *et al.,* 2006). However, these previous studies, for the most part, gathered and analysed existing data from medical professionals, Athletic Commissions, EFC Africa, UFC, video analysis of fights and by means of questionnaires. The methods of this current study required an in-person appointment and clinical assessment of participants.

Research in smaller MMA samples has been done (Mayer *et al.,* 2015; Heath, 2014). Heath (2014) conducted a study where he assessed the cognitive functioning of MMA athletes. The sample of the study (Heath, 2014) was limited to 28 MMA athletes and 28 controls. This study was conducted in the United States, where MMA is most popular and the population of MMA much larger (Hamid, 2017). Nevertheless, even Heath (2014) recognised that his study was limited by a small sample of MMA athletes. Mayer et al. (2015) conducted research in a small MMA sample during a longitudinal study with 14 MMA athletes and 16 healthy controls. They also recommended that further research be done in larger samples of MMA athletes.

A number of participants (n=10) were lost to inclusion as they failed to comply with the scheduled assessment appointment. Newington et al. (2014) similarly found that participants in clinical research declined participation or withdrew due to practical reasons such as being unable to take time off from work and travel requirements.

5.3 Demographic and Sport Specific Information

The majority of participants in this study were male (n=15; 88.2%). Most active participants in competitive MMA are known to be male and the gender distribution in this current study is similar to that in other studies (Venter, *et al.,* 2017; Minjoon, 2016; Lystad *et al.,* 2014; Hutchison, 2014; Schick *et al.,* 2012). The median age of participants in this study was 25 years, with a range of 20 to 42 years. The ages of the participants are comparable to the ages of the participants reported in other published MMA studies. These studies reported ages to be between 19 and 58 years (Venter, *et al.,* 2017; Minjoon, 2016; Hutchison, 2014; McClain, 2014; Heath, 2014; Rainey, 2009).

In this current study, 70.6% (n=12) of participants had suffered a previous KO, either during training or competition. Five participants had suffered more than one KO in their

MMA career (n=5; 29%). Making direct comparisons with the occurrence of KOs in the published literature has proven difficult. This is due to different study methodologies employed in individual studies. Most studies have evaluated the number of KOs in relation to athletic exposures (Venter *et al.,* 2017; Hutchison *et al.,* 2014). Hutchison et al. (2014) determined the incidence of KO's using video analysis. Athletic exposures were not measured and video analysis not undertaken in the current study making these comparisons beyond the scope of the current study.

Five participants (n=5; 29.4%) in the current study indicated that they had suffered a KO during training. Only one previous study was found to report the prevalence of KO's during training (Heath *et al.,* 2013). Heath et al. (2013) found that 15% of participants had sustained KO's during training (Heath *et al.,* 2013). The number of KOs sustained during training in the current study is of concern. Possible reasons for KO's sustained could be the amount of time participants spend training in MMA, as well as the training components incorporated into MMA training regimes.

It was found that participants of this study spent a median of 12 hours per week training, with a range of 4 to 30 hours per week. The majority of participants (n=16; 94.1%) incorporated sparring in their training regime. The use of sparring as a training technique is supported by Heath et al. (2013) who similarly reported that during training participants in their study spent at least 3 hours per week sparring. Sparring involves the practice of striking, grappling and take-downs as if during a competitive bout. Although less violent than during a competitive bout, athletes aim to perfect their techniques (Stiller *et al.,* 2014) and it would be reasonable to conclude that athletes are at risk of sustaining both direct and indirect head impact when training.

The current study found that less than a quarter (n=4; 23.5%) of the participants had previously been diagnosed with a concussion. The occurrence of concussion in MMA has been noted in previous studies, but it has never been the injury of highest incidence (Hammami *et al.,* 2017; Jensen *et al.,* 2017; Hutchison *et al.,* 2014; Ngai, *et al.,* 2008). It has been determined that a KO meets the defining criteria for concussion (Hutchison et al. 2014; Ngai, *et al.,* 2008). Ngai et al. (2008) went on to suggest that a concussion incident occurred in as many as 3% of all bouts. Hutchison et al. (2014) reported 6.4 KOs, and therefore concussions, per 100 athletic exposures. Concussion has been reported to occur in between 2 and 20% of MMA athletes (Hammami *et al.,* 2017). The occurrence of concussion in this study can be considered comparable, being just outside of the upper range reported in the literature.

Although 70.6% of participants in the current study had sustained a KO, only a 23.5% had been diagnosed with concussion with most participants reporting their last concussion at median of 1.8 years ago. The lower report of concussion diagnoses in this study may be due to the fact that concussion diagnoses are clinically challenging and often go unnoticed by clinicians (McCrory *et al.,* 2018; Meechan *et al.,* 2013; Harmon *et al.,* 2013). The knowledge of clinicians regarding concussions may have affected these rates and athletes may not always present with prominent neurological findings or an altered state of consciousness (McCrory *et al.*, 2018).

It has been suggested that 30 to 50% of concussions go undiagnosed (Meechan *et al.,* 2013; Harmon *et al.,* 2013). If a concussion is not witnessed the diagnosis is based on the report of the athletes. Athlete knowledge about concussion has also been shown to play a role in the reporting of concussion (Register-Mahilak, 2013). Another point of consideration for the low finding of whiplash and concussion diagnoses in participants of the current study is that it has been suggested that MMA athletes tend to disregard medical attention and advice. The aim seems to be to return to sport participation as soon as possible (Dhillon *et al.,* 2017; Roy *et al.* 2010).

Whiplash diagnoses were even less frequently found in this study (11.8%). The literature states that the forces required to cause whiplash are far lower than the forces required to cause a concussion (Panzer *et al.* 2011). It has also been reported that whiplash and concussion occur simultaneously (Marshall *et al.,* 2015; Leslie *et al.*, 2013). From the findings of this study it can be postulated that there is a higher rate of whiplash and concussion incidents than those reported. Some of these may have gone unnoticed. In addition, participants were asked to recall these incidents and recall bias may also have played a role in underreporting.

5.4 Presence and Severity of Cognitive and Cervical Symptoms

Symptoms reported to be moderate to severe were sleep disturbances (n=5; 29.4%), feelings of frustration or impatience (n=5; 29.4%) and light sensitivity (n=4; 23.5%). Although only reported to be mild, headaches (n=10; 58.8%) and fatigue (n=13;76.5%) were frequently noted by participants. Similar findings of moderate to severe intensity and a high frequency of sleep disturbance, fatigue, and irritability on the RPQ has been reported in previous studies (McGarry, 2016; Stålnacke, 2012). It should be noted that findings by Stålnacke (2012) were in participants who had suffered whiplash injuries.

The suggested cut off score of the RPQ to minimise the risk of false positives is a score of ≥16 (Thompson *et al.,* 2016). In this current study the median of the total score on the RPQ was 16 (range of 0 to 37). Nine participants (n=9; 52.9%) had a total score of ≥16 and it is therefore very likely that they experienced these cervical and cognitive symptoms due to a whiplash or concussion inducing incident (Thompson *et al.,* 2016).

5.5 Disability due to Cervical Symptoms

Higher scores of individual items on the NDI (score of ≥3) were found in three participants (n=3; 17.7%) for headaches, one participant (5.9%) for lifting, and one participant (5.9%) for sleep disturbance. When the total score on the NDI was used to classify disability due to cervical symptoms, it was found that more than half of the participants (n=11; 64.7%) had mild disability. This is comparable to findings by Watson et al. (2014) who used the NDI to measure disability due to cervical symptoms in rugby players, also a full contact sport. In their study 41.9% of participants presented with mild disability (Watson *et al.,* 2014). Similarly, a previous whiplash study found that 31.5% of participants presented with mild disability up to five years after the whiplash incident (Merrick *et al.,*2010).

The suggested cut-off on the NDI total score to differentiate whether patients consider themselves as recovered is 15 and is considered to be within the normal range (Croft *et al.,* 2015). The median NDI total score for participants in this current study was 5 (range of 0 to 13). Considering the suggested cut-offs all of the participants of this study fell within normal ranges on the NDI.

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5.6 Presence of Neuropathic Pain

The occurrence of neuropathic pain in participants in this study was low (n=4; 23.5%). Neuropathic pain has been described as pain experienced due to inflammation or injury of nervous tissue, whether central or peripheral (Basson *et al.,* 2014). Hyper-excitability of the central nervous system, or central sensitisation, can result in further aggravation of neuropathic related pain (Meacham *et al.,* 2017; Persson *et al.,* 2016; Sterling *et al.,* 2009). It can be postulated that the low occurrence of neuropathic related pain in participants was due to a lack of central sensitisation and/or neural tissue injury. Participants in this study had no reports of catastrophic spinal cord injuries or cervical instability to further support the lack of more significant neurological findings. It is also important to note that it is not uncommon to find the presence of these neurological deficits (altered sensation and muscle strength) without the presence of neuropathic pain (Sharma *et al.,* 2012). The findings of neurological findings such as decreased sensation and muscle weakness is discussed in 5.7.

5.7 Findings of the Clinical Assessment

Most participants presented with neck pain (n=10; 58.8%), muscle spasm and point tenderness in cervical muscles (n=16; 94.1%), and decreased cervical range of motion (n=17; 100%). More than half of the participants had complaints of neck pain, but the intensity of neck pain was rated as mild (median of 2 out of 10). This study evaluated the participants' neck pain intensity at the time of assessment. Neck pain was not reported post-incident and so it is not possible to distinguish whether participants' neck pain was acute (0 to 3 months) or chronic (≥3 months) (Sterling, 2014; Athertone, 2006). Considering that most participants reported their last concussion at a median of 1.8 years ago and their last whiplash diagnosis at a median of 1.5 years ago, symptoms may have been chronic. As a contrary point of view it could be postulated, when considering the likelihood of unreported whiplash and concussive incidents, that incidents occurred earlier, even during training. Hence, symptoms may very well have been acute. It was beyond the scope of this study to make this determination.

Neck pain has been reported to persist for one year in 27 to 50% of whiplash populations (Carroll *et al.,* 2011*;* Athertone, 2006). Prognostic factors for chronic neck pain following a whiplash injury have been associated with the pain severity of the initial injury, psychological aspects and the level of self-rated disability (Nieto *et al.,*2013: Merrick *et al.,* 2010; Carroll *et al.,* 2009; Atherton *et al.,* 2006; Yoganandan, *et al.,* 2002). The findings of this current study did find that participants had a low level of disability associated with their cervical symptoms.

Muscle spasm and point tenderness was found to be present in the majority of participants (n=16; 94.1%) in this current study, with fibres of mm upper trapezius (n=16, 100%) mm. scalene (n=13; 76.5%) and mm. occipitalis (n=11; 64.7%) most frequently affected. Tenderness or pain with palpation, and increased muscle tone are marked characteristics of muscle spasm (Mense 2008). Similar findings were reported by Cruz et al. (2004). They reported that all the participants who had suffered whiplash 36 hours prior to examination presented with posterior cervical muscle spasm. The majority of the participants also presented with lateral and anterior cervical muscle spasm (66.7% and 70.8% respectively). These findings by Cruz et al. (2004) were based on palpation as well as evaluating muscle activity by means of electromyography. This study did not test for increased muscle activity within tender points and this was beyond the scope of the study.

This current study found that all of the athletes (100%) presented with impaired cervical ROM in one or more planes of movement. Flexion was the plane of movement most restricted with five participants (n=5; 29.4%) having poor ROM. It could be postulated that the loss of ROM in flexion could be associated with the frequency of muscle spasm found in mm upper Trapezius, and mm occipitalis in this study. Similarly, decreased cervical ROM has previously been noted in a study on rugby, also a contact sport (Lark *et al.,* 2007).

Similar to the assessment findings in the current study, the presence of neck pain and restricted cervical ROM were found to be associated with WAD (WAD I to WAD III) (Treleaven *et al.,* 2011; Howell, 2011; Woodhouse *et al.,* 2008) (section 5.8).

Decreased sensation was reported in three participants (n=3; 17.6%) and decreased muscle strength in four participants (n=4; 23.5%). The presence of neurological findings in participants of this current study are most likely due to brachial plexus injury or nerve root irritation (Tosti *et al.,* 2013; Torg, 2009). It has been found that athletes who participate in high-velocity contact sports may experience brachial plexus neuropraxia. This injury to the brachial plexus may occur due to compression or traction, causing upper limb weakness, pain or numbness (Tosti *et al.,* 2013).

When considering a frontal or rotational strike to the head, as occurs in MMA, the head and neck is displaced to end ranges extension, side flexion and rotation, causing traction and compression of neural structures (Torg, 2009) (Figure 5.1). This also places the athlete at risk for nerve root irritation, which usually occurs in response to hyperextension of the cervical spine (Torg, 2009) When the head 'rebounds', neural structures on opposite sides of the neck are now placed under traction or compression (Chen, *et al,* 2009; Siegmund *et al.*, 2009) (section 2.5.1). Traction injuries of the brachial plexus, nerve root compression, and dorsal root ganglion compression usually occur in the young adult (Torg, 2009). As stated in 5.6, there were no reports of catastrophic spinal cord injuries or cervical instability to support the lack of more significant neurological findings.

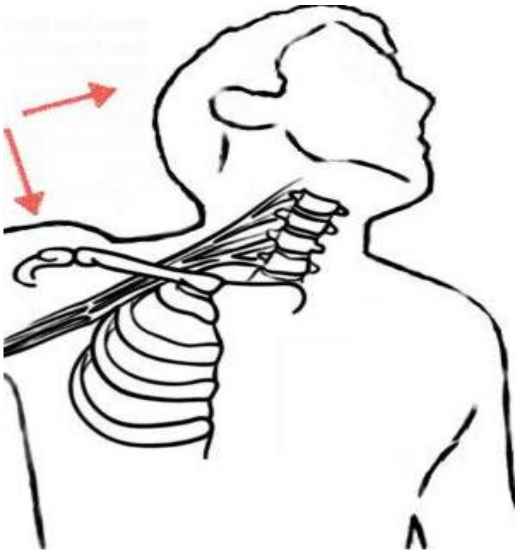

Figure 5.1 Example of brachial plexus traction (Tosti et al., 2016:275*)*

5.8 Prevalence and Severity of Whiplash Associated Disorders

The findings from the clinical assessment of pain, the presence of muscle spasm and point tenderness in cervical musculature, decreased cervical ROM, and neurological findings were used in combination to determine the prevalence and severity of WAD according to the QTFC. In fulfilling the objective of the study it was found that more than half of the participants (n=10; 58.8%) presented with WAD. One study was found to report on findings of WAD in sport, namely hockey. Hynes et al. (2009) found that all of the participants (100%) who had sustained a whiplash or concussion injury presented with WAD, as well as concussion symptoms. The majority of participants in their study presented with WAD II (76.9%). Cruz et al. (2004) reported that 58.3% of participants presented with WAD II and 16.7% of participants with WAD III after a whiplash incident.

In both the studies of Hynes *et al.* (2009) and Cruz *et al.,* (2004) WAD II was reported as most prevalent. A different finding was reported in this current study. The current study found WAD III to be prevalent in 35.3% of participants and WAD II in 23.5% of participants. It could be postulated that the difference in findings between these studies is linked to the fact that MMA athletes repeatedly suffer from whiplash and direct head impact, causing increased strain on neural structures.

5.9 Association Between Neck Disability and Severity of Whiplash Associated Disorders

It has been found that mild, moderate and severe disability classifications on the NDI after whiplash have been correlated to ongoing disorders associated with WAD 9(Howell, 2011; Merrick *et al.*, 2010). This includes neck pain and headaches, cognitive manifestation and psychological factors, thereby deterring a good clinical outcome (Howell, 2011; Merrick *et al.*, 2010). Symptoms of headaches, neck pain, and cognitive manifestations associated with WAD are more prevalent in patients with higher levels of disability, whereas patients with mild disability present with these to a lesser extent (Merricke *et al.* 2010). The grade of WAD has also been found to be prognostic factor in recovery after whiplash (Sarrami *et al.,* 2017).

From the literature there seems to be a relationship between the level of disability, WAD severity, and recovery prognosis of WAD. This study did not evaluate the prognosis of WAD in relation to the NDI and was outside of its scope. The probability of an association between the grade of WAD and the level of disability was found to be significant in this study (p=0.4), but this finding should be interpreted with great care and cannot be generalized to the MMA population due to limitations.

5.10 Limitations of the Study

The study findings need to be interpreted in the light of several limitations. The study was limited by small sample size. The small sample size limited the statistical analysis and the generalising of the findings to the MMA population at large. The sample size is such that the current study should be considered an exploratory study. Conclusions of this study could not be generalised to the MMA population due to the small sample recruited and the study may not have good external validity.

Recruiting of participants through a third party (MMA gym owners and trainers) and not by the researcher directly was a limitation in the recruitment strategy of this study. A direct approach to recruiting participants may have resulted in a better sample size. The researcher faced challenges with regards to this recruitment strategy, namely, time constraints and a lack of resources. This recruitment strategy would have been costly to the researcher, especially since the researcher was responsible for the gathering of all data and did not make use of research assistants. Data were collected over a short time frame due to delays caused by recruitment challenges and the set time allowed for the conduction of research in partial fulfilment of a degree.

The study also had some methodological limitations, in part due to the limited research conducted to date on WAD, whiplash and concussion in the MMA population. This study did not collect data on the frequency of head impact or direct blows sustained on average during a bout. No distinction was made between participants with a history of head and/ or neck trauma.

A distinction between a concussion and whiplash injury was not made in this study. Participants were asked to record whether they had an incident of whiplash or concussion on the demographic questionnaire, but this could have resulted in recall bias. Participants were not evaluated directly after an observed incident. A distinction between concussion and whiplash in participants was beyond the scope of this study. Objectives also did not include distinguishing initial (acute) from chronic participant characteristics.

The study also did not investigate relationships between the key variables e.g. post-concussion symptoms, disability associated with cervical symptoms, presence of neuropathic pain, and the presence and severity of WAD. This study did do an analysis on the associated between WAD severity and disability. The significance of the relationship found in the current study needs to be interpreted with caution due to the small sample size. This finding cannot be generalised to the MMA population in South Africa due to the small sample size.

Manually conducted tests, including the palpation of muscle spasm and point tenderness, and conduction of a neurological exam, have short comings (Section 3.6.2.5.2-3.6.2.5.5).

The determining of muscle spasm was limited by the subjective experience of pain/tenderness by the participant when palpating an area with increased muscle tone. Due to the limited time and lack of resources the researcher did not assess for the presence of muscle spasm by means of electromyography and this was outside of the scope of this study. In order to assure objectivity and quality control, the researcher alone evaluated for muscle spasm and point tenderness, according to the accepted protocol and as supported by literature. Inter-examiner reliability has been found to be poor during manual palpation of trigger points, but assessments from an individual examiner may be more consistent (Sanz *et al.,* 2016; Quinter *et al.,* 2015). The researcher had a good level of clinical experience and had practiced all manual testing techniques prior to the collection of data to improve reliability and reduce bias (Sanz *et al.,* 2016; Quinter *et al.,* 2015; Myburgh *et al.,* 2008; Cuthbert *et al.,* 2007).

There are not strong reports on the validity and reliability of a neurological examination, including testing sensation, testing muscle strength, testing deep tendon reflexes, and cervical instability tests (Lemeunier *et al.,* 2017). In order to improve the reliability, neurological and cervical instability tests were done according to an accepted protocol and the researcher was trained in conducting these examinations prior to collecting data (Sanz *et al.,* 2016; Quinter *et al.,* 2015; Myburgh *et al.,* 2008; Cuthbert *et al.,* 2007).

Being the principle investigator, the researcher performed all the assessments and there was a risk for bias to outcomes. The researcher was the principle investigator and performed all the assessments as a means of controlling the quality and objectivity of the examinations. In order to address the concern of bias the researcher had been trained in conducting all the examinations, had the necessary experience to objectively conduct these tests, and had practiced all these examinations prior to collecting data.

5.11 Recommendations for Clinical Practice

Clinical recommendations will be based on the key outcomes of this study.

The prevalence of WAD in this study supports that athletes who sustain repeated and forceful blows to the head should be assessed immediately following the trauma for WAD. The assessment should be done by a multi-professional healthcare team, including physicians and physiotherapists. The diagnoses of WAD II and III is primarily determined by findings of a clinical assessment as neuroimaging and x-rays may not give insight into the severity and presentation of whiplash (Sterling, 2014; Stanley *et al.,* 2011). Only athletes suspected of WAD IV should be referred for specialist assessment and neuroimaging studies (Sterling, 2014; Stanley *et al.,* 2011).

Educational programmes regarding symptoms and risks associated with whiplash and concussion should be undertaken by healthcare professionals, including physiotherapists, for both coaches and athletes. This could reduce the number of unnoticed or unreported cases of whiplash and concussion, and assist in the earlier detection of WAD. Early identification of WAD will facilitate appropriate referrals for assessment and interventions, including psychological and rehabilitation services.

The current study's findings support that specific clinical assessments by a physiotherapist should be done, if it is suspected that the MMA athlete is at risk of WAD. Assessment should include the assessment of post-concussion and whiplash symptoms (using the RPQ), cervical pain intensity (using VAS or the numeric pain scale), and physical testing (including assessment of CROM, muscle spasm and point tenderness, muscle strength, sensation and tendon reflexes). If a concussion is witness, or suspected, the patient should be referred to a medical doctor for further investigation, diagnosis and management. The presence and severity of WAD can be determined by means of the QTFC. For the diagnosis of WAD, the QTFC should be administered in conjunction with supporting measurements and questionnaires. Disability associated with cervical symptoms can be assessed using the NDI. In this study it was found that more than half of participants presented with WAD (WAD II or WAD III) but only mild levels of disability were reported. There is the risk of clinicians perceiving a problem even when the person under evaluation is functional or has perceived disability. Nevertheless, early identification of WAD, and the risk of WAD, may provide clinical insight into the appropriate interventions to reduce the risk of possible disability.

5.12 Future Research Recommendations

Further studies on the prevalence and incidence of WAD in MMA is required to inform clinicians and athletes about risks and injury profiles of MMA athletes. Research that is focused specifically on WAD in MMA athletes is recommended in larger samples. A direct recruitment strategy should be implemented, rather than making us of a third party for the sampling of participants. Researchers should attempt to approach each gym, and all athletes training within these gyms, directly and over a longer period of time.

Future studies should compare the effect of direct head trauma due to KO's, TKO's, and indirect head impact on the severity of WAD. These findings should be compared to control groups i.e. populations with non-traumatic neck pain. Future research should also aim to distinguish between concussion and WAD in this population. A possible way to distinguish between concussion and whiplash is to conduct longitudinal studies where athletes are evaluated directly after head impact to determine a concussion or whiplash diagnosis. These athletes can then be followed up on for a period of time.

Prospective longitudinal studies are required from the acute phase to determine the course and progression of WAD over time in MMA athletes. Longitudinal research will also give insight into the long-term effect of sustaining repeated head trauma. In light of these findings, return to play protocols can be analysed and, if needed, reconsidered.

It will be suggested that investigators include the collection of data on the number of strikes to the head, neck or face of the MMA athlete per bout during both training and competition. These findings would be able to more accurately determine the whiplash and concussion rate. Further research should also make use of advances in Video imaging and analyses of the biomechanics and forces imparted during specific MMA techniques and manoeuvres, and compared to findings of WAD.

Reporting rates on concussion and WAD could be affected by athlete and clinician knowledge. Studies into the knowledge of and approach to concussion and WAD among clinicians working with MMA athletes, as well as MMA athletes themselves, would provide beneficial information.

5.13 Conclusion

Participants of this study reported KO's being sustained in both training and competition. Cervical and cognitive symptoms related to concussion and whiplash were similar in frequency and severity when compared to earlier research done into MMA and whiplash populations. More than half of the participants met the cut-off value on the RPQ for accurately associating the presence of symptoms with an incident.

Disability was rated as mild in the majority of participants. It was found that the probability of an association between the grade of WAD and the level of disability is significant (p=0.4), but this finding should be interpreted carefully. When considering the cut off values for the total score of the NDI, all of the participants fell within normal values, indicating that did not classify themselves as 'un-recovered'.

The key finding of this study was that WAD was described in over half of participants. Based on this study's findings, and in light of the literature, it is reasonable to conclude that MMA fighters are at increased risk of head trauma, and therefore whiplash and concussion resulting in WAD.

CHAPTER 6 CONCLUSION

MMA is not a mainstream sport, but its popularity continues to rise globally. As more athletes compete in this full contact sport there is growing concern about the risk and consequences of the repeated, high velocity head trauma inflicted on and by athletes during bouts. Whiplash and concussion are often the consequence of this trauma. The body of evidence on the prevalence, severity and course of whiplash in MMA athletes is scant.

Whiplash is often accompanied by a collection of symptoms known as WAD. The prevalence and severity of WAD in MMA athletes is unknown. This study adds to the limited body of evidence on whiplash injuries in MMA athletes, and is the first to report on the prevalence and severity of WAD in this population.

This descriptive observational study aimed to determine the prevalence and severity of WAD in MMA athletes in Bloemfontein, FS and Cape Town, WC in South Africa. Demographic and MMA sport participation information was captured using a self-developed questionnaire, the presence of post-concussion and post-whiplash symptoms was assessed using the RPQ, disability associated with neck symptoms was established using the NDI, and the presence of neuropathic pain was determined using the S-LANNS.

A clinical assessment included determining the intensity of neck pain, the measurement of cervical ROM, and the palpation of the cervical musculature for point tenderness and muscle spasm. A neurological examination included the testing of sensation, muscle strength and reflexes (C1-T1). The clinical assessment findings were used to determine the prevalence and severity if WAD according to the QTFC.

Data were collected for 17 participants included in the study. Sample size was limited by recruitment challenges. Most MMA athletes were young adults and male (15; 88.2%). All athletes had been training in MMA for two years or more. More than half of the participants (n=12; 70.6%) had been knocked out in either training or competition. Less than a quarter of the participants had been previously diagnosed with concussion (n=4; 23.5%) or whiplash (n=2; 11.8%).

Less than a third of the participants presented with moderate to severe post-whiplash symptoms which included sleep disturbances (n=5; 29.4%), feelings of frustration (n=5; 29.4%) and light sensitivity (n=4; 23.5%). Although mild, headaches (n=10; 58.8%) were frequently reported. The median for the total score on the RPQ was 16 (range of 0 to 37). More than half of participants (n=11; 6.7%) reported mild disability due to cervical symptoms on the NDI. The median total score for the NDI was 5 (range of 0 to 13).

On assessment the majority of the participants (n=7; 41.2%) presented with neck pain which was mild in intensity (median of 2 out of 10). Most of the participants presented with point tenderness and muscle spasm in the cervical muscles (n=16; 94.1%), especially in mm. upper fibres of m. trapezius (n=16; 94.1%), mm. scalene (n=13; 76.5%) and mm. occipitalis (n=11; 64.7%). All participants showed some decrease in their cervical range of motion, however, in almost all cases, cervical ROM was in the average to good range in all planes of movement. Three participants (%) had decreased cervical flexion ROM. Decreased sensation was reported in three participants (n=3; 17.7%) and decreased muscle strength in four participants (n=4; 23.4%). Less than a quarter of participants (n=4; 23.5%) had neuropathic pain.

More than half of the participants (n=10; 58.8%) presented with WAD when findings of the clinical assessment were considered using the QTFC. Four athletes (n=4; 23.5%) had WAD II and six participants (n=6; 35.3%) had WAD III. The probability of an association between the grade of WAD and the level of disability is significant in this study (p=0.4), but this finding should be interpreted within the limitations of the study.

This study was limited by a small sample size and the findings are not generalizable to the MMA athletes in South Africa or the larger population of MMA athletes further afield. The sample size is such that the current study should be considered an exploratory study. The nature of the statistical analysis undertaken limited further interpretation of the findings on the RPQ and NDI.

The findings in the current study supports the need for further studies in larger populations of MMA athletes. Studies are needed to explore the risk and consequences of the repetitive head trauma in MMA athletes.

To conclude, MMA athletes in South Africa are at risk of repetitive head trauma resulting in concussion and whiplash. Although participants were not found to have severe disability associated with cervical symptoms, it is a point of concern that more than half of the participants were classified as having WAD. The findings suggest that recurrent head trauma, including concussive and whiplash injuries, may occur during bouts and likely be missed by clinicians or coaches, or are not reported by athletes.

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Appendices

Appendix A

Ethical Clearance Letters

Health Sciences Research Ethics Committee, UFS

Appendix A: Ethical Clearance Letters

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

20 April 2016

DANIELLE HAUMAN
DEPT CLINICAL SPORTS PHYSIOTHERAPY
FACULTY OF HEALTH SCIENCES
UFS

Dear Danielle Hauman

HSREC 64/2016
PROJECT TITLE: WHIPLASH ASSOCIATED DISORDERS IN MIXED MARTIAL ARTS ATHLETES

1. You are hereby kindly informed that the Health Sciences Research Ethics Committee (HSREC) reviewed the above research project and it was presented at the meeting on 19 April 2016. Research may not be conducted before the following condition(s) has/have been met and the HSREC grants final approval for the project:

   - *Permission from the organisation and physiotherapy practise where measurements will be made must be submitted before final approval will be granted.*

   *Upon receipt of the above document(s), the HSREC will issue a final approval letter. Only thereafter may the study be conducted.

2. The Committee must be informed of any serious adverse event and/or termination of the study.

3. Any amendment, extension or other modifications to the protocol must be submitted to the HSREC for approval.

4. Kindly use the **HSREC NR** as reference in correspondence to HSREC Administration.

5. Thus, this letter only serves as **conditional** approval.

6. The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services-(HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the Ethics Committee of the Faculty of Health Sciences.

Yours faithfully

DR SM LE GRANGE
CHAIR: HEALTH SCIENCES RESEARCH ETHICS COMMITTEE

Cc: Mrs Robyn Smith

Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | F: +27 (0)51 444 4359 | E: ethicsfhs@ufs.ac.za
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
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UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

02 March 2018

DANIELLE HAUMAN
DEPT OF CLINICAL SPORTS PHYSIOTHERAPY
FACULTY OF HEALTH SCIENCES
UFS

Dear Danielle Hauman

HSREC 64/2016
PROJECT TITLE: WHIPLASH ASSOCIATED DISORDERS IN MIXED MARTIAL ARTS ATHLETES

1. You are hereby kindly informed that the Health Sciences Research Ethics Committee (HSREC) took note and approved the following at the meeting held on 27 February 2018:

    - *Changes to protocol*
        - *Include MMA athletes from Bloemfontein, FS and Cape Town, WC*

2. Kindly use the **HSREC NR** as reference in correspondence to HSREC Administration.

3. The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the Ethics Committee of the Faculty of Health Sciences.

Yours faithfully

DR SM LE GRANGE
CHAIR: HEALTH SCIENCES RESEARCH ETHICS COMMITTEE

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Appendix B

Permission from Anna Swanepoel for use of a private room for research

Appendix B: Permission Letter from Anna Swanepoel for use of a private room for research

Anna Swanepoel

egistered Physiotherapists · Geregistreerde Fisioterapeute PR: 7224656

Tel: 051 444 2391 | Sel: 082 925 3926

50 Donald Murray Ave · Bloemfonte

ontvangs@annaphysios.co.za

www.annaphysios.co.za

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Dear Danielle,

RE: Permission to use a private room/cubicle in the practice for research purposes

In response to your letter asking for permission to use a private cubicle or room in the practice I would like to inform you that you are very welcome to do so. You may use the private Women's Health room at any time for research purposes.

You can contact our reception with dates and times to confirm the availability of the room.

Sincerely,

Anna Swanepoel

Appendix C

<u>Permission from Celia Smith for use of a private room for research</u>

Appendix C: Permission from Celia Smith for use of a private room for research

CELIA SMITH & ASSOCIATES
REGISTERED PHYSIOTHERAPISTS

BSc Physio (UCT) MSc Physio (US)
Practice No.: 7210620

The Wellness Centre
The Quadrant
31 Wilderness Road
Claremont
csmith@netactive.co.za

Tel.: 021-6715300
Fax.: 021-6717760
Accounts: 021-6715318

csmithadmin@netactive.co.za

12 March 2018

Dear Danielle

I hereby give you permission to use a room within my private practice for research purposes. Appointments need to be co-ordinated in advance with my secretary so that there is no conflict with bookings for the practice.

Yours sincerely

CSmith

Celia Smith

Appendix D

Participant Information Letter and Informed Consent

Appendix D: Participant Information Letter and Informed Consent

PREVALENCE AND SEVERITY OF WHIPLASH ASSOCIATED DISORDERS IN MIXED MARTIAL ARTS ATHLETES

Dear Participant,

I am a Master's student in Clinical Sport Physiotherapy at the University of the Free State. I am conducting research in partial fulfilment of my degree. I would like to invite you to participate in a research study on the prevalence and severity of whiplash associated symptoms in mixed martial arts (MMA) athletes in Bloemfontein and Cape Town.

The intense physical demands and the methods used to gain victory over an opponent place MMA athletes are at risk of cervical (neck) acceleration-deceleration injuries, also known as whiplash. The symptoms associated with whiplash can often go unnoticed or even ignored. These symptoms are known as 'whiplash associated disorders (WAD) and include headaches, neck pain, neck stiffness, radiating pain in upper limbs, and even dizziness. WAD can cause pain and dysfunction in an athlete, and have the potential to negatively impact on their sport, work and personal life

<u>Aims of the study:</u>

The aims of this study are to investigate how common whiplash associated disorders are in MMA athletes, as well as to determine how severe these symptoms are.

<u>*Format of the study:*</u>

Information will be gathered by completing a four (4) part data form. The first section will gather information such as your age, number of year's competitive fighting experience and previous injuries sustained. Please note that you will not have to give out personal information such as your name or address. Three (3) different standardised questionnaires will be used to determine different aspects of whiplash associated symptoms and the intensity of these symptoms, if these symptoms are experienced.

The second part of the study will include an objective evaluation. A short evaluation of the cervical spine will be done to test for neck pain, neck tenderness, and muscle spasm of the neck and shoulders; decreased range of motion; muscle weakness of upper limbs, and decreased sensation of the upper limbs. From the findings of the evaluation your symptoms will be classified according to the Quebec Task Force Classification.

If you chose to participate in this study data will be gathered at a private practice namely, *Anna Swanepoel Physiotherapy* in Bloemfontein or *Celia Smith and Associates* in Cape Town. You will complete the questionnaire in a private room. After completing the questionnaire, the objective evaluation will be performed by the researcher. It is anticipated that the duration of your participation will be approximately one hour.

Benefit of participation:

The high intensity and brutality of MMA place athletes at a high risk of sustaining cervical acceleration-deceleration or 'whiplash' injuries. Participation in this study could shed light on symptoms that often go unnoticed in MMA athletes and motivate for further research into prevention strategies. There will be no remuneration/payment for participating in this study, but you will be reimbursed for any travelling costs. There will be no consequences for declining to participate in or withdrawing from the study.

Ethical considerations:

This study has been approved by the University of the Free State Health Sciences Research Ethics Committee (HSREC). All personal information will be treated as confidential. However, complete confidentiality cannot be guaranteed as this information may be required to be disclosed by law or in the case of an HSREC review.

There are no risks associated with your participation. Your participation is voluntary and you may withdraw from this study at any point in time. Declining to participate will hold no penalty or loss of benefits. The results of this study may be published and presented at academic forums or congress.

CONSENT TO PARTICIPATE IN RESEARCH

PREVALENCE AND SEVERITY OF WHIPLASH ASSOCIATED DISORDERS IN MIXED MARTIAL ARTS ATHLETES

You have been asked to participate in a research study.

You have been informed about this study by the researcher. You may contact the researcher, Danielle Hauman, at 0736636820 if you have any questions regarding this research study.

You may contact the Secretariat of the University of the Free State Health Sciences Research Ethics Committee at (051) 401 7794/5 if you have any questions about your rights as a research participant.

Your participation in this research is voluntary, and you will not be penalised or lose benefits if you refuse to participate or decide to withdraw from the study

I, the participant declare that the research study, including the above information has been verbally described to me. I understand what my participation requires and I voluntarily agree to participate.

______________________ ______________________

Signature of Participant Date

______________________ ______________________

Signature of Witness Date

Appendix E and F

Data Form (self-developed demographic data, RPQ, NDI, S-LANSS, Physical examination)

Appendix E: Data Form

Please answer all questions honestly and accurately. Mark the appropriate answer with an ‘X’.
Please ask for assistance if you have any questions.

Section A: Demographic Details

Questionnaire No: ☐☐☐ (1-3)

<u>Fill in the correct information in writing or by marking the correct answer with an 'X'.</u>

-

<u>For office use only.</u>

1.	Date of interview: ☐☐☐☐☐☐ (dd/mm/yy)		☐☐☐☐☐☐ (4-9)
2.	What is your date of birth? ☐☐☐☐☐☐ (dd/mm/yy)		☐☐☐☐☐☐ (10-15)
3.	What is your gender?	☐ Male ☐ Female	☐ (16)
4.	How many years have you been training as an MMA athlete?	☐☐	☐☐ (17-18)
5.	How many years have you been competing in MMA tournaments?	☐☐	☐☐ (19-20)
6.	Have you ever been knocked out during a training session?	☐ Yes ☐ No	☐ (21)

6.1.	If yes, how many times have you been knocked out during training sessions?	☐☐	☐☐ (22-23)
7.	Have you ever been knocked our during a competitive fight?	☐ Yes ☐ No	☐ (24)
7.1.	If yes, how many times have you been knocked out during competitive fights?	☐☐	☐☐ (25-26)
8.	Have you ever been medically diagnosed with a concussion after a fight?	☐ Yes ☐ No	☐ (27)
8.1.	If yes, how many years ago?	☐☐	☐☐ (28-29)
9.	Have you ever been medically diagnosed with a whiplash injury after a fight?	☐ Yes ☐ No	☐ (30)
9.1	If yes, how many years ago?	☐☐	☐☐ (31-32)
10.	How many hours a week do you spend training?	☐☐	☐☐ (33-34)
11.	Which of the following components of training form the majority of your training regime? You may	☐ cardio ☐ weight/resistance training ☐ punching against a bag or mits ☐ kicking against a bag or mits	☐ (35) ☐ (36) ☐ (37) ☐ (38)

	indicate more than one answer	☐ grappling	☐	(39)
		☐ sparring with an opponent	☐	(40)
12.	How many competitive fights have you participated in over the past year?	☐☐	☐☐	(41-42)

Section B: Rivermead Post Concussion Symptoms Questionnaire

Please score the following symptoms. A score of 0 indicates that you do not have any problems with the symptoms. A score of 4 indicates that the symptom is severe and causes problems with everyday activities. Please circle the correct level of severity.

13.	Headaches	0	1	2	3	4	☐	(43)
14.	Feelings of Dizziness	0	1	2	3	4	☐	(44)
15.	Nausea and/or Vomiting	0	1	2	3	4	☐	(45)
16.	Noise Sensitivity (easily upset by loud noise)	0	1	2	3	4	☐	(46)
17.	Sleep Disturbance	0	1	2	3	4	☐	(47)
18.	Fatigue, tiring more easily	0	1	2	3	4	☐	(48)
19.	Being Irritable, easily angered	0	1	2	3	4	☐	(49)

20.	Feeling Depressed or Tearful	0	1	2	3	4	☐	(50)
21.	Feeling Frustrated or Impatient	0	1	2	3	4	☐	(51)
22.	Forgetfulness, poor memory	0	1	2	3	4	☐	(52)
23.	Poor Concentration	0	1	2	3	4	☐	(53)
24.	Taking Longer to Think	0	1	2	3	4	☐	(54)
25.	Blurred Vision	0	1	2	3	4	☐	(55)
26.	Light Sensitivity (easily upset by bright light)	0	1	2	3	4	☐	(56)
27.	Double Vision	0	1	2	3	4	☐	(57)
28.	Restlessness	0	1	2	3	4	☐	(58)
	Are you experiencing any other difficulties?	Please name them and score them.						
29.	______________________________	0	1	2	3	4	☐	(59)
30.	______________________________	0	1	2	3	4	☐	(60)

Section C: Neck Disability Index

Please answer every section and mark in each section only the <u>one</u> statement which applies to you. Mark the correct answer with an 'X'.

31. *Section 1: Neck Pain Intensity*

- I have no pain at the moment ☐
- The pain is very mild at the moment ☐
- The pain is moderate at the moment ☐
- The pain is fairly severe at the moment ☐
- The pain is very severe at the moment ☐
- The pain is the worse imaginable at the moment ☐

☐ (61)

32. *Section 2: Personal Care (washing, dressing, etc.)*

- I can look after myself normally without causing extra pain. ☐
- I can look after myself normally but is causes extra pain. ☐
- It is painful to look after myself and I am slow and careful. ☐
- I need some help but manage most of my personal care. ☐

I need help every day in every aspect of self-care. ☐

I do not get dressed, I wash with difficulty and stay in bed. ☐ ☐ (62)

Section 3: Lifting

33.

I can lift heavy weights without extra pain. ☐

I can lift heavy weights but it gives extra pain. ☐

Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table. ☐

Pain prevents me from lifting heavy weights off the floor, but I can manage light to medium weights if they are conveniently positioned. ☐

I can lift very light weights. ☐

I cannot lift or carry anything at all. ☐ ☐ (63)

34. *Section 4: Reading*

I can read as much as I want to with no pain in my neck. ☐

I can read as much as I want to with little pain in my neck. ☐

I can read as much as I want to with moderate pain in my neck. ☐

I can't read as much as I want because of moderate pain in my neck. ☐

I can hardly read at all because of severe pain in my neck. ☐

I cannot read at all. ☐

☐ (64)

35. *Section 5: Headaches*

I have no headaches at all. ☐

I have slight headaches which come infrequently. ☐

I have moderate headaches which come infrequently. ☐

I have moderate headaches which come frequently. ☐

I have severe headaches which come frequently. ☐

I have headaches almost all of the time. ☐ ☐ (65)

36. *Section 6: Concentration*

I can concentrate fully when I want to without difficulty. ☐

I can concentrate fully when I want to with slight difficulty. ☐

I have a fair degree of difficulty in concentrating when I want to. ☐

I have a lot of difficulty in concentrating when I want to. ☐

I have a great deal of difficulty when concentrating when I want to. ☐

I cannot concentrate at all. ☐ ☐ (66)

37. *Section 7: Work*

I can do as much work as I want to. ☐

I can only do my usual work but no more. ☐

I can do most of my usual work but no more. ☐

I cannot do my usual work. ☐

I can hardly do any work at all. ☐

I can't do any work at all. ☐ ☐ (67)

38. *Section 8: Driving*

I can drive my car without any neck pain. ☐

I can drive my car as long as I want with slight pain in my neck. ☐

I can drive my car as long as I want with moderate pain in my neck. ☐

I cannot drive my car as long as I want because of moderate pain in my neck. ☐

I can hardly drive my car at all because of severe pain in my neck. ☐

I can't drive my car at all. ☐ ☐ (68)

39. *Section 9: Sleeping*

I have no trouble sleeping. ☐

My sleep is slightly disturbed (less than 1h sleepless). ☐

My sleep is mildly disturbed (1-2h sleepless). ☐

My sleep is moderately disturbed (2-3h sleepless). ☐

My sleep is greatly disturbed (3-5h sleepless). ☐

My sleep is completely disturbed (5-7h sleepless). ☐ ☐ (69)

40. *Section 10: Recreation*

I am able to engage in all my recreation activities with no neck pain at all. ☐

I am able to engage in all my recreation activities with some pain in my neck. ☐

I am able to engage in most but not all my usual recreation activities because of my neck pain. ☐

I am able to engage in few of my usual recreation activities because of my neck pain. ☐

I can hardly do any recreation activities because of my neck pain. ☐

I can't do any recreational activities due to neck pain. ☐ ☐ (70)

Total score ☐☐ (71-72)

x 2 = ____ % ☐☐ (73-74)

Section D: The Leeds Assessment of Neuropathic Symptoms and Signs pain scale (S-LANSS)

Think about how your pain has felt over the last week. Put an 'X' again the description that best matches your pain. These descriptions may, or may not, match your pain no matter how severe it feels.

41. In the area where you have pain, do you also have 'pins and needles', tingling, or prickling sensations?

a) No ☐ I don't get these sensations

b) Yes ☐ I get these sensations often ☐ (75)

42. Does the painful area change colour Perhaps looks mottled or more red) when the pain is particularly bad?

a) No ☐ The pain does not affect the colour of my skin

b) Yes ☐ I have noticed that the pain does make my skin look different than normal. ☐ (76)

43. Does your pain make the affected skin abnormally sensitive to touch? Getting unpleasant sensations or pain when lightly stroking the skin might describe this.

a) No ☐ The pain does not make my skin in that area abnormally sensitive to touch.

b) Yes ☐ My skin in that area is particularly sensitive to touch.

☐ (77)

44. Does your pain come on suddenly and in bursts for no apparent reason when you are completely still? Words like 'electric shocks', jumping and bursting might describe this.

a) No ☐ My pain doesn't really feel like this.

b) Yes ☐ I get these sensations often.

☐ (78)

45. In the area where you have pain, does your skin feel unusually hot like a burning pan?

a) No ☐ I don't have burning pain.

b) Yes ☐ I get burning pain often.

☐ (79)

46. Gently rub the painful area with your index finger and then rub a non-painful area (for example, an area of skin further away or on the opposite side from the painful area).
How does this rubbing feel on the painful area?

a) ☐ The painful area feels no different from the non-painful area.

b) ☐ I feel discomfort, like pins and needles, tingling, or burning in the painful area that is different from the non-painful area. ☐ (80)

47. Gently press on the painful area with your finger tip then gently press in the same way onto a non-painful area (the same non-painful area that you chose in the last question). How does this feel in the painful area?

a) ☐ The painful area does not feel different from the non-painful area.

b) ☐ I feel numbness or tenderness in the painful area that is different from the non-painful area. ☐ (81)

Total Score: ________ ☐☐ (82-83)

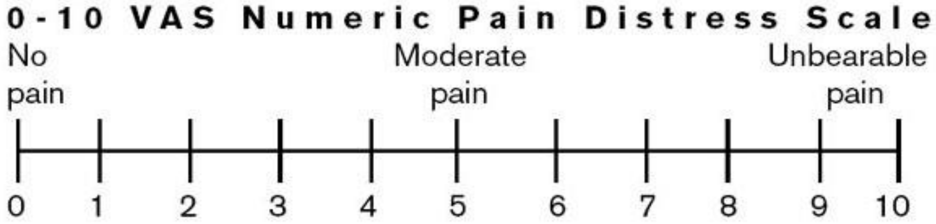
Thank you for your participation! Please do not fill in any more information.

Appendix F: Physical Examination Record Form

Objective Testing

<u>Complaint of Neck Pain:</u>

48. On a scale of 0 - 10 how much is your pain?



☐☐ (84-85)

<u>Physical Signs:</u>

49. Tenderness or muscle spasm

☐ Yes
☐ No

☐ (86)

49.1 If yes, where?

☐ Cervical Extensors ☐ (87)
☐ Suboccipital muscles ☐ (88)
☐ Upper Trapezius ☐ (89)
☐ Scaleni muscle group ☐ (90)
☐ Sternocleidomastoideus ☐ (91)

Cervical Range of Motion:

50.	Flexion	☐ Good ☐ Average ☐ Poor	☐	(92)
51.	Extension	☐ Good ☐ Average ☐ Poor	☐	(93)
52.	Lateral Flexion (R)	☐ Good ☐ Average ☐ Poor	☐	(94)
53.	Lateral Flexion (L)	☐ Good ☐ Average ☐ Poor	☐	(95)
54.	Rotation (R)	☐ Good ☐ Average ☐ Poor	☐	(96)
55.	Rotation (L)	☐ Good ☐ Average ☐ Poor	☐	(97)

Neural Conduction:

56.	Decreased sensation?		☐ Yes		
			☐ No	☐	(98)
56.1	If yes, which dermatome?	Right	☐ C2	☐	(99)
			☐ C3	☐	(100)
			☐ C4	☐	(101)
			☐ C5	☐	(102)
			☐ C6	☐	(103)
			☐ C7	☐	(104)
			☐ C8	☐	(105)
			☐ T1	☐	(106)
		Left	☐ C2	☐	(107)
			☐ C3	☐	(108)
			☐ C4	☐	(109)
			☐ C5	☐	(110)
			☐ C6	☐	(111)
			☐ C7	☐	(112)
			☐ C8	☐	(113)
			☐ T1	☐	(114)
57.	Decreased muscle strength?		☐ Yes		
			☐ No	☐	(115)

57.1	If yes, which myotome?	Right	☐ C2	☐ (116)
			☐ C3	☐ (117)
			☐ C4	☐ (118)
			☐ C5	☐ (119)
			☐ C6	☐ (120)
			☐ C7	☐ (121)
			☐ C8	☐ (122)
			☐ T1	☐ (123)
		Left	☐ C2	☐ (124)
			☐ C3	☐ (125)
			☐ C4	☐ (126)
			☐ C5	☐ (127)
			☐ C6	☐ (128)
			☐ C7	☐ (129)
			☐ C8	☐ (130)
			☐ T1	☐ (131)
58.	Reflexes absent or decreased?		☐ Yes	
			☐ No	☐ (132)
58.1	If yes, which reflex?	Right	☐ Biceps Jerk	☐ (133)
			☐ Triceps Jerk	☐ (134)
		Left	☐ Biceps Jerk	☐ (135)
			☐ Triceps Jerk	☐ (136)

Instability Testing:

59.	Posterior Atlanto-occipital Stability Test	☐ Positive ☐ Negative	☐	(137)
60.	Anterior Atlanto-occipital Stability Test	☐ Positive ☐ Negative	☐	(138)
61.	Lateral Stability Stress Test Atlanto-Axial Joint	☐ Positive ☐ Negative	☐	(139)

Appendix G

Rivermead Post Concussion Symptoms Questionnaire

Appendix G: Rivermead Post Concussion Symptoms Questionnaire

The Rivermead Post-Concussion Symptoms Questionnaire*

After a head injury or accident some people experience symptoms which can cause worry or nuisance. We would like to know if you now suffer from any of the symptoms given below. As many of these symptoms occur normally, we would like you to compare yourself now with before the accident. For each one, please circle the number closest to your answer.

0 = Not experienced at all
1 = No more of a problem
2 = A mild problem
3 = A moderate problem
4 = A severe problem

Compared with before the accident, do you now (i.e., over the last 24 hours) suffer from:

Headaches	0	1	2	3	4
Feelings of Dizziness	0	1	2	3	4
Nausea and/or Vomiting	0	1	2	3	4
Noise Sensitivity, easily upset by loud noise	0	1	2	3	4
Sleep Disturbance	0	1	2	3	4
Fatigue, tiring more easily	0	1	2	3	4
Being Irritable, easily angered	0	1	2	3	4
Feeling Depressed or Tearful	0	1	2	3	4
Feeling Frustrated or Impatient	0	1	2	3	4
Forgetfulness, poor memory	0	1	2	3	4
Poor Concentration	0	1	2	3	4
Taking Longer to Think	0	1	2	3	4
Blurred Vision	0	1	2	3	4
Light Sensitivity, Easily upset by bright light	0	1	2	3	4
Double Vision	0	1	2	3	4
Restlessness	0	1	2	3	4

Are you experiencing any other difficulties?

1. ______________________	0	1	2	3	4
2. ______________________	0	1	2	3	4

*King, N., Crawford, S., Wenden, F., Moss, N., and Wade, D. (1995) J. Neurology 242: 587-592

Appendix H

Neck Disability Index

Appendix H: Neck Disability Index

Neck Disability Index

THIS QUESTIONNAIRE IS DESIGNED TO HELP US BETTER UNDERSTAND HOW YOUR **NECK PAIN** AFFECTS YOUR ABILITY TO MANAGE EVERYDAY -LIFE ACTIVITIES. PLEASE MARK IN EACH SECTION THE **ONE BOX** THAT APPLIES TO YOU.

ALTHOUGH YOU MAY CONSIDER THAT TWO OF THE STATEMENTS IN ANY ONE SECTION RELATE TO YOU, PLEASE MARK THE BOX THAT **MOST CLOSELY** DESCRIBES YOUR PRESENT -DAY SITUATION.

SECTION 1 - PAIN INTENSITY

- ❑ I have no neck pain at the moment.
- ❑ The pain is very mild at the moment.
- ❑ The pain is moderate at the moment.
- ❑ The pain is fairly severe at the moment.
- ❑ The pain is very severe at the moment.
- ❑ The pain is the worst imaginable at the moment.

SECTION 2 - PERSONAL CARE

- ❑ I can look after myself normally without causing extra neck pain.
- ❑ I can look after myself normally, but it causes extra neck pain.
- ❑ It is painful to look after myself, and I am slow and careful.
- ❑ I need some help but manage most of my personal care.
- ❑ I need help every day in most aspects of self -care.
- ❑ I do not get dressed. I wash with difficulty and stay in bed.

SECTION 3 – LIFTING

- ❑ I can lift heavy weights without causing extra neck pain.
- ❑ I can lift heavy weights, but it gives me extra neck pain.
- ❑ Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, ie. on a table.
- ❑ Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned.
- ❑ I can lift only very light weights.
- ❑ I cannot lift or carry anything at all.

SECTION 4 – READING

- ❑ I can read as much as I want with no neck pain.
- ❑ I can read as much as I want with slight neck pain.
- ❑ I can read as much as I want with moderate neck pain.
- ❑ I can't read as much as I want because of moderate neck pain.
- ❑ I can't read as much as I want because of severe neck pain.
- ❑ I can't read at all.

SECTION 5 – HEADACHES

- ❑ I have no headaches at all.
- ❑ I have slight headaches that come infrequently.
- ❑ I have moderate headaches that come infrequently.
- ❑ I have moderate headaches that come frequently.
- ❑ I have severe headaches that come frequently.
- ❑ I have headaches almost all the time.

SECTION 6 – CONCENTRATION

- ❑ I can concentrate fully without difficulty.
- ❑ I can concentrate fully with slight difficulty.
- ❑ I have a fair degree of difficulty concentrating.
- ❑ I have a lot of difficulty concentrating.
- ❑ I have a great deal of difficulty concentrating.
- ❑ I can't concentrate at all.

SECTION 7 – WORK

- ❑ I can do as much work as I want.
- ❑ I can only do my usual work, but no more.
- ❑ I can do most of my usual work, but no more.
- ❑ I can't do my usual work.
- ❑ I can hardly do any work at all.
- ❑ I can't do any work at all.

SECTION 8 – DRIVING

- ❑ I can drive my car without neck pain.
- ❑ I can drive my car with only slight neck pain.
- ❑ I can drive as long as I want with moderate neck pain.
- ❑ I can't drive as long as I want because of moderate neck pain.
- ❑ I can hardly drive at all because of severe neck pain.
- ❑ I can't drive my car at all because of neck pain.

SECTION 9 – SLEEPING

- ❑ I have no trouble sleeping.
- ❑ My sleep is slightly disturbed for less than 1 hour.
- ❑ My sleep is mildly disturbed for up to 1-2 hours.
- ❑ My sleep is moderately disturbed for up to 2-3 hours.
- ❑ My sleep is greatly disturbed for up to 3-5 hours.
- ❑ My sleep is completely disturbed for up to 5-7 hours.

SECTION 10 – RECREATION

- ❑ I am able to engage in all my recreational activities with no neck pain at all.
- ❑ I am able to engage in all my recreational activities with some neck pain.
- ❑ I am able to engage in most, but not all of my recreational activities because of pain in my neck.
- ❑ I am able to engage in only a few of my recreational activities because of neck pain.
- ❑ I can hardly do recreational activities due to neck pain.
- ❑ I can't do any recreational activities due to neck pain.

PATIENT NAME ______________________________ DATE ____________

SCORE ________ [50]

Appendix I

<u>Mapi Agreement for the use of the NDI</u>

Appendix I: Mapi Agreement for the use of the NDI

User agreement Special Terms

Mapi Research Trust, a non-for-profit organisation subject to the terms of the French law of 1st July 1901, registered in Carpentras under number 453 979 346, whose business address is 27 rue de la Villette, 69003 Lyon, France, hereafter referred to as "MRT" and the User, as defined herein, (each referred to singularly as a "Party" and/or collectively as the "Parties"), do hereby agree to the following User Agreement Special and General Terms:

Mapi Research Trust
PROVIDE™
27 rue de la Villette
69003 Lyon
France
Phone: +33 (0)4 72 13 66 66

Recitals

The User acknowledges that it is subject to these Special Terms and to the General Terms of the Agreement, which are included in Appendix 1 to these Special Terms and fully incorporated herein by reference. Under the Agreement, the Questionnaire referenced herein is licensed, not sold, to the User by MRT for use only in accordance with the terms and conditions defined herein. MRT reserves all rights not expressly granted to the User.
The Parties, in these Special Terms, intend to detail the special conditions of their partnership.
The Parties intend that all capitalized terms in the Special Terms have the same definitions as those given in article 1 of the General Terms included in Appendix 1.
In this respect, the Parties have agreed as follows:

Article 1. Conditions Specific to the User

Section 1.01 Identification of the User

User Name	Danielle Hauman
Legal Form	Student
Address	11 Audrey Blignault Street Langenhovenpark Free State 9330 Bloemfontein
Country	South Africa
Email address	daniellehauman@yahoo.com
Telephone number	0736636820

Section 1.02 Identification of the Questionnaire

Title	Neck Disability Index (NDI)
Author(s)	Vernon H, Mior S
Copyright	NDI © Dr Howard Vernon, 1991. All Rights Reserved
Original bibliographic references	Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. J Manipulative Physiol Ther. 1991 Sep;14(7):409-15. Erratum in: J Manipulative Physiol Ther 1992 Jan;15(1) (PubMed abstract)

Article 2. Rights to Use

Section 2.01 Context of the Use of the Questionnaire

The User undertakes to only use the Questionnaire in the context of the Study as defined hereafter.

Context of Use	Clinical project or study
Title	Whiplash Associated Disorders in Mixed Martial Arts Athletes
Disease or condition	Whiplash Associated Disorders
Type of research	Epidemiologic/Observational
Questionnaire used as primary endpoint	Yes
Number of patients expected	60-80
Number of submissions to the questionnaire for each patient	1
Term of clinical follow-up for each patient	No follow up
Start	01/2016
End	07/2018
Mode of administration	Paper administration

Section 2.02 Conditions for Use

The User undertakes to use the Questionnaire in accordance with the conditions for use defined hereafter.

(a) Rights transferred
Acting in the Owner's name, MRT transfers the following limited, non-exclusive rights, to the User (the "Limited Rights")

(i) to use the Questionnaire, only as part of the Study; this right is made up exclusively of the right to communicate it to the Beneficiaries only, free of charge, by any means of communication and by any means of remote distribution known or unknown to date, subject to respecting the conditions for use described hereafter; and

(ii) to reproduce the Questionnaire, only as part of the Study; this right is made up exclusively of the right to physically establish the Questionnaire or to have it physically established, on any paper, electronic, analog or digital medium, and in particular documents, articles, studies, observations, publications, websites whether or not protected by restricted access, CD, DVD, CD-ROM, hard disk, USB flash drive, for the Beneficiaries only and subject to respecting the conditions for use described hereafter; and

(iii) Should the Questionnaire not already have been translated into the language requested, the User is entitled to translate the Questionnaire or have it translated in this language, subject to informing MRT of the same beforehand by the signature of a Translation Agreement indicating the terms of it and to providing a copy of the translation thus obtained as soon as possible to MRT.

The User acknowledges and accepts that it is not entitled to amend, modify, condense, adapt, reorganise the Questionnaire on any medium whatsoever, in any way whatsoever, even minor, without MRT's prior specific written consent.

(b) Specific conditions for the Questionnaire

- Use in Individual clinical practice or Research study/ project

The User undertakes never to duplicate, transfer or publish the Questionnaire without indicating the Copyright Notice.

- Use in a publication or on a website with unrestricted access:

In the case of a publication, article, study or observation on paper or electronic format of the Questionnaire, the User undertakes to respect the following special obligations:

- not to include any full copy of the Questionnaire, but a protected version with the indication "sample copy, do not use without permission"
- to indicate the name and copyright notice of the Owner
- to include the reference publications of the Questionnaire
- to indicate the details of MRT for any information on the Questionnaire as follows: contact information and permission to use: Mapi Research Trust, Lyon, France – Internet: https://eprovide.mapi-trust.org/
- to provide MRT, as soon as possible, with a copy of any publication regarding the Questionnaire, for information purposes
- to submit the screenshots of all the Pages where the Questionnaire appears to MRT before release to check that the above-mentioned requirements have been respected.

- Use for dissemination:

- On a website with restricted access:

In the case of publication on a website with restricted access, the User may include a clean version of the Questionnaire, subject to this version being protected by a sufficiently secure access to only allow the Beneficiaries to access it.

The User undertakes to also respect the following special obligations:

- to indicate the name and copyright notice of the Owner
- to include the reference publications of the Questionnaire
- to indicate the details of MRT for any information on the Questionnaire as follows: contact information and permission to use: Mapi Research Trust, Lyon, France – Internet: https://eprovide.mapi-trust.org/
- to submit the screenshots of all the Pages where the Questionnaire appears to MRT before release to check that the above-mentioned requirements have been respected.

- On promotional / marketing documents

In the case of publication on promotional/marketing documents, the User undertakes to respect the following special obligations:

- to indicate the name and copyright notice of the Owner
- to include the reference publications of the Questionnaire
- to indicate the details of MRT for any information on the Questionnaire as follows: contact information and permission to use: Mapi Research Trust, Lyon, France – Internet: https://eprovide.mapi-trust.org/
- to provide MRT, as soon as possible, with a copy of any publication regarding the Questionnaire, for information purposes
- to submit the screenshots of all the Pages where the Questionnaire appears to MRT before release to check that the above-mentioned requirements have been respected.

For any other use not defined herein, please contact MRT for the specific conditions of use and access fees (if applicable).

Article 3. Term

MRT transfers the Limited Rights to use the Questionnaire as from the date of delivery of the Questionnaire to the User and for the whole period of the Study.

Article 4. Beneficiaries

The Parties agree that the User may communicate the Questionnaire in accordance with the conditions defined above to the Beneficiaries involved in the Study only, in relation to the Study defined in section 2.01.

Article 5. Territories and Languages

MRT transfers the Limited Rights to use the Questionnaire on the following territories and in the languages indicated in the table below:

Questionnaire	Language
NDI	English for Canada

Article 6. Price and Payment Terms

The User undertakes in relation to MRT to pay the price owed in return for the availability of the Questionnaire, according to the prices set out below, depending on the languages requested and the costs of using the Questionnaire, in accordance with the terms and conditions described in section 6.02 of the General Terms included in Appendix 1.

ROYALTY FEES*	Commercial users	Cost per study	1 100 €
		Cost per language	550 €
	Funded academic research	Cost per study	Free
		Cost per language	Free
	Not funded academic users	Cost per study	Free
		Cost per language	Free
DISTRIBUTION FEES*	Commercial users	Cost per study	1 000 €
		Cost per language	500 €
	Funded academic research	Cost per study	300 €
		Cost per language	50 €
	Not funded academic users	Cost per study	Free
		Cost per language	Free

Agreed and acknowledged by

Danielle Hauman

17-Mar-2018

Appendix J

Leeds Assessment of Neuropathic Symptoms and Signs pain scale

S-LANSS

Appendix J: Leeds Assessment of Neuropathic Symptoms and Signs pain scale

The S-LANSS Pain Score

1.	**In the area where you have pain, do you also have "pins and needles", tingling or prickling sensations?**	
	☐ NO – I don't get these sensations	0
	☐ YES – I get these sensations	5
2.	**Does the painful area change colour (perhaps look mottled or more red) when the pain is particularly bad?**	
	☐ NO – The pain does not affect the colour of my skin	0
	☐ YES – I have noticed that the pain does make my skin look different from normal.	5
3.	**Does your pain make the affected skin abnormally sensitive to touch? Getting unpleasant sensations or pain when lightly stroking the skin might describe this.**	
	☐ NO – The pain does not make my skin abnormally sensitive to touch.	0
	☐ YES – My skin in that area is particularly sensitive to touch.	3
4.	**Does your pain come on suddenly and in bursts for no apparent reason when you are completely still? Words like "electric shocks", jumping and bursting might describe this.**	
	☐ NO – My pain doesn't really feel like this.	0
	☐ YES – I get these sensations often.	2
5.	**In the area where you have pain, does your skin feel unusually hot like a burning pain?**	
	☐ NO – I don't have burning pain	0
	☐ YES – I get burning pain often	1
6.	**Gently rub the painful area with your index finger and then rub a non-painful area (for example, an area of skin further away or on the opposite side from the painful area). How does this rubbing feel in the painful area?**	
	☐ The painful area feels no different from the non-painful area	0
	☐ I feel discomfort, like pins and needles, tingling or burning in the painful area that is different from the non-painful area.	5
7.	**Gently press on the painful area with your finger tip and then gently press in the same way onto a non-painful area (the same non-painful area that you chose in the last question). How does this feel in the painful area?**	
	☐ The painful area does not feel different from the non-painful area.	0
	☐ I feel numbness or tenderness in the painful area that is different from the non-painful area.	3
	Total score:	

Scoring a score of 12 or more suggests pain of predominantly neuropathic origin

Source: Bennett, M et al J Pain, Vol 6, No 3 March, 2005 pp 149–158 The S-LANSS Score for Identifying Pain of Predominantly Neuropathic Origin: Validation for Use in Clinical and Postal Research.

Appendix K

Permission to use the S-LANSS

Appendix K: Permission to use the S-LANSS

6/18/2018

Subject: RE: Permission to use the S-LANSS

From: M.I.Bennett@leeds.ac.uk
To: daniellehauman@yahoo.com
Date: Monday, November 3, 2014, 10:01:28 AM GMT+2

Hi Danielle

The SLANSS is free to use for academic purposes. Good luck with your study

Best wishes

Mike

Mike Bennett MD FRCP FFPMRCA
St. Gemma's Professor of Palliative Medicine
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Learn more about the Academic Unit of Palliative Care

Appendix L

<u>Cervical Range of Motion Table</u>

Appendix L: Cervical Range of Motion Table

Cervical Range of Motion

Participant No:

	1	2	3	Average
Flexion				
Extension				
SF (R)				
SF(L)				
Rotation (R)				
Rotation (L)				

Appendix M

Turnitin Similarity Report

(PDF file of complete Turnitin report can be found on the submitted CD disk)