The prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area

A dissertation submitted in partial compliance with the requirements for a Master's Degree in Technology, in the Department of Chiropractic and Somatology at the Durban University of Technology.

By

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2016

I, Duncan Alexander Jack, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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DEDICATION

I dedicate this work

To my parents, Desireé and John Jack, whose constant love, support and encouragement has taught and empowered me to surpass my own expectations, achieve and be capable of things beyond my wildest imagination. Thank you for the many years of spiritual, intellectual, emotional and financial support that has enabled me to become the person I am today and achieve this goal.

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ABSTRACT

Background: Mixed martial arts (MMA) is a contact sport that has grown in popularity worldwide. MMA has been shown to be an activity that generates a high volume of injuries in its participants, especially when subjected to particular factors that are known to carry high risk in contact sports. Limited research has been conducted concerning the risk for injury development in MMA, with no South African statistics being produced to date. This study aims to bridge this gap.

Aim: The aim of this study was to determine the prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area of KwaZulu-Natal.

Method: This study was a prospective, quantitative survey that sampled 105 MMA athletes from 16 accredited gyms in the greater Durban area. The information captured from the questionnaires enabled compilation of a fighter profile, training profile and injury profile assessing injuries present at the time of data collection and a history of injuries over a 12 month period. Data was analysed with SPSS version 23.0. Inferential techniques included the use of correlations and chi square test values, displayed as p-values and Eta scores. Relationships were considered significant with a p-value of <0.05 and an effect size of >0.23.

Results: A 91% response rate was achieved with 83.3% male and 16.2% female participation. Overall, the most commonly injured areas were the upper extremity (36.5%), followed by the lower extremity (34.3%), spine (14.2%), head (8.6%) and trunk (6.5%) regions. In terms of single areas, the most common injuries were to the shoulder (30.9%), knee (29.2%) and elbow (14.4%). The most common injury types were joint sprains (31.1%), muscle strains (20.7%) and ligament tears (18.6%). The most common injury mechanisms were being struck (16.1%), falling (15.7%) and striking an opponent (13.6%). Participants were unsure of the mechanism of their injuries in 7.5% of the injury reports. The number of days missed from training due to injury ranged from zero to 270 days of incapacitation. Risk factors for injury were significant for favoring the dominant hand while fighting (p = 0.011), flexibility training/ stretching (p = 0.019), ground arm-bars (p = 0.014), ground strangles (p = 0.028), groundwork holds/pins (p = 0.028), falling (p = 0.006), increased age (η = 0,619) and increased body weight (η = 0.706). Participation in CrossFit as an additional sport/ conditioning program was a protective factor against injuries (p = 0.007).

Conclusion and recommendations: Favouring one side, falling, stretching, arm-bars, strangles, pins and increasing weight are some of the largely modifiable risk factors that play an important role in the development of injuries in MMA athletes. Coaches and their athletes will benefit from adapting training strategies to reduce injury rates from over-exposure to activities that present a high risk of injury as well as by furthering the extent of exposure to conditioning.

Key words: Mixed martial arts, prevalence, risk factors, musculoskeletal injuries

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LIST OF ABBREVIATIONS

=	-	Equals
>	-	Greater than
≥	-	Greater than or equal to
%	-	Percentage
<	-	Smaller Than
≤	-	Smaller than or equal to
N	-	Number of participants (total sample)
n	-	Number of participants (sample sub-group)
p	-	Rho
η	-	Eta
ADHD	-	Attention-Deficit/Hyperactivity Disorder
Aka	-	As known as
BJJ	-	Brazilian Jiu-Jitsu
DUT	-	Durban University of Technology
ECP	-	Extreme conditioning program
FOOSH	-	Falling on an outstretched hand
GCS	-	Glasgow coma scale
HIT	-	High intensity training
IPR	-	Injury proportion ratio
IREC	-	Institutional Research Ethics Committee
ITF	-	International Taekwondo Federation
Kg	-	Kilogram
Km	-	Kilometres
Km^2	-	Square kilometres
KO	-	Knock out (loss of consciousness)
KZN	-	Kwa-Zulu Natal
Max	-	Maximum
MCP	-	Metacarpal phalangeal joint
Min	-	Minimum
MOI	-	Mechanism of injury
MMA	-	Mixed Martial Arts
MMA SA	-	Mixed Martial Arts South Africa (Governing body)
MSK	-	Musculoskeletal
PTSD	-	Posttraumatic stress disorder

RR	-	Risk ratio
SDT	-	Self-defence training
SPSS	-	Statistical Package for the Social Sciences
Std.dev	-	Standard deviation
TKO	-	Technical Knockout
TMA	-	Traditional martial arts
USA	-	United States of America
UFC	-	Ultimate Fighting Championship
Vs	-	Versus
WTF	-	World Taekwondo Federation

DEFINITIONS

Amateur

Within MMA, an amateur is a fighter that participates in competitions in an amateur league circuit UFC (2015).

Grappling

A physical, close-quarters encounter with an opponent, involving a gripping and seizing basis of fighting (*Collins English Dictionary* 2015)

Kwa-Zulu Natal

One of nine provinces in South Africa, and home to eThekwini, the second largest municipality in the country (Ulwazi Programme 2015).

Martial Arts

Fighting sports, suitable to or appropriate for warfare (*Concise Oxford English dictionary* 2002).

Mixed Martial Arts

An activity that combines fighting skills that enable the practitioner to fight while standing or on the floor (UFC 2015).

MMA athlete

For the purposes of this study, an individual is considered to be participating in MMA if he/she meets any one of the following criteria:

- He/she trains at a gym that teaches fighting techniques from more than one martial art discipline in an integrated program (e.g. for purposes of cage fighting or no-rules fighting etc).
- He/she trains at a gym that teaches multiple disciplined martial arts and practices/participates in more than one of these martial art disciplines concurrently.
- He/she practices/participates in separate disciplined martial arts at multiple gyms at the same point in time.

Professional

Within MMA, a professional is a fighter that participates in competitions in a professional league circuit (UFC 2015).

Prevalence

The proportion of a population that have a specified condition or set of conditions at a particular point in time (*Dorland's Pocket Medical Dictionary* 2004).

Risk factor

A factor, such as an environmental situation or circumstance that predisposes an individual to develop a particular condition (*Collins English Dictionary* 2015).

Roundhouse kick

A roundhouse kick, particularly as seen in Taekwondo, involves the attacking leg starting in a chambered position (leg raised and bent at the knee) with the leg extending sharply while moving in an arc from the side to the front and striking the opponent with the ball of the foot with the metatarsals extended. A roundhouse kick with the right leg involves the leg moving in an anti-clockwise direction (Falco *et al.* 2009).

Self-defence

The use of multiple strategies to keep oneself safe from harm initiated by an aggressor (Nower 2007).

Striking

The application of a body part onto a target area with velocity and magnitude so as to inflict damage (*Collins English Dictionary* 2015).

1. INTRODUCTION

1.1. INTRODUCTION

The purpose of this chapter is to introduce the topic of MMA injuries and to create a background to the study that assists in the understanding of this dissertation.

1.2. BACKGROUND

Mixed martial arts (MMA) is a modern fighting sport that has rapidly grown in popularity since its inception in America in the 1990's, having recently replaced boxing as the world's most popular full-contact sport (Ngai, Levy and Hsu 2008; Dooley 2013). MMA fighters make use of techniques from across many forms of striking and grappling disciplines (Rainey 2009; Woodward 2009). Using these techniques, a fighter may win a match by way of knockout, technical knockout (referee stoppage), submission or by gaining a higher score than the opponent based on the judge's decision at the end of the allocated fighting time (Ngai, Levy and Hsu 2008). In stark contrast to the highly regulated disciplines that have given rise to this new sport, MMA fighting is governed only by fundamental and very limited rule sets, which is necessitated by the diverse nature of the sport, despite a growing global campaign to reduce injury and increase safety in MMA (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; Bledsoe 2009; Dooley 2013). Consequently, this places participants at high risk of injury with varying/diverse aetiologies and injury profiles.

Risk factors have been assessed in various contact sports, largely with attention to the development of traumatic injury. Gabbett *et al.* (2012) investigated the relationship been skill quality and injury risk in professional rugby league players. Although there was no link found between the above, it was expressed that players with a slower reaction time had a lower risk of injury. This unexpected finding can be understood in that a greater degree of high velocity movements in contact situations presents as a high risk for injury. This is further substantiated by Gabbett, Ullah and Finch (2012) who affirmed that impact forces experienced by heavier players at a high velocity is a strong indicator for recurrent injuries in professional rugby league players. These principles are similar in nature to evidence of injury aetiology in martial arts, as manoeuvres such as gripping, throwing, strangling, timed moving, force redirecting, joint locks, punching, kicking and blocking all require a level of explosivity and precision in contact situations (Lantz 2002; Douris *et al.* 2004; Yamashita *et al.* 2005; Kazemi *et al.* 2009).

Risk for leg injuries in female soccer players has been shown to be directly related to joint laxity, knee hyperflexion and low hamstring-to-quadriceps ratio during concentric action (Söderman *et al.* 2001). While not all are traumatic in nature, these factors can be expected to produce substantial risk as they affect the integrity of the knee joint. This is especially true in the case of players participating in a high velocity and explosive sport. There are other factors for injury that are less obvious. This is exemplified in a systematic review on interventions and risk factors for knee Injuries in team ball sports, where it was concluded that there is need for further risk profiling in order to understand and implement specific prevention programs (ter Stege *et al.* 2014).

The delivering and receiving of high velocity blows appears to be the current best indicator for correlation of whether or not a sport will have an increased risk of injury (Bledsoe *et al.* 2006). Martial arts that include striking have been documented to have a higher risk and incidence of injury over those that use grappling alone (Kazemi and Pieter 2004; Zetaruk *et al.* 2005). This is especially true in MMA where incidence of musculoskeletal injury is high. Due to the physical nature of MMA, practicing the sport is a high-risk activity for injury, this is consistent with a study from 2001 to 2004 documenting injuries in all sanctioned professional MMA competitions in Nevada (USA), with athletes participating in competitions sustaining more than one injury per fight on average (Bledsoe et al 2006). According to Ngai, Levy and Hsu (2008), musculoskeletal injuries in MMA athletes are near inevitable, with the risk of further injury multiplied should the athlete fight with existing injury.

Athletes who train for MMA competition are typically proficient in skill sets from a number of disciplines, most of whom have a particular field of expertise in which they have previously competed, often at a high level e.g. Judo, Jujitsu, boxing, Kickboxing, muay tai etc (Bledsoe 2009). This necessitates that the MMA fighter be well conditioned in order to minimize the risk of injury in varying situations. The training and preparation for MMA competition, which is taught even to amateurs, should include cross-training that covers the fields of cardiovascular exercise, skills and techniques, as well as strength and weight training (Bledsoe 2009; Dooley 2013). MMA fighters that neglect conditioning, especially in spinal musculature, are at greater risk for injury overall (Amtmann 2004), which is compounded by the increased risk of injury as existing MMA fighters age (Zetaruk *et al.* 2005).

The evidence of the high incidence of injury in MMA players is clear in international literature (Kazemi and Pieter 2004; Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; Rainey 2009; Scoggin *et al.* 2010) however there is limited information regarding the prevalence of specific injuries and the risk factors thereof, especially in a South African context. It is therefore essential to examine demographic information, training details, level of expertise and history of injury, among other factors, when assessing the epidemiology of the injuries in a population with as broad a spectrum as that of MMA.

1.3. AIMS AND OBJECTIVES

The aim of this study was to determine the prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area.

Objectives:

The first objective was to determine the demographic profile of MMA athletes in the greater Durban area.

The second objective was to determine the prevalence of musculoskeletal injuries amongst MMA athletes in the greater Durban area.

The third objective was to determine the risk factors for injury of MMA athletes in the greater Durban area.

1.4. HYPOTHESES

1. MMA athletes display a high prevalence of musculoskeletal injuries
2. There is a strong correlation of specific risk factors to the development of particular musculoskeletal injuries in MMA athletes.

1.5. NULL HYPOTHESES

1. MMA athletes do not display a noteworthy prevalence of musculoskeletal injuries.

2. There is no correlation between specific risk factors and the indication of development of particular musculoskeletal injuries in MMA athletes.

1.6. RATIONALE AND BENEFITS OF THE STUDY

MMA is a complex discipline, where injuries are often contracted even in conditioned athletes (Scoggin et al 2010, Ngai and Levy 2008).There is consensus among experts in the field, that there is a lack of understanding surrounding injuries and their risk factors in MMA, including injury prevention, contraction and return-to-play, with authors calling for more studies to facilitate further understanding of this phenomenon (Dooley 2013, Rainey 2009, Woodward 2009, Bledsoe et al 2006).

This study seeks to contribute to the understanding of injuries in MMA and their risk factors in adult MMA fighters in the greater Durban area. An awareness and understanding of high-prevalence injuries and their associated risk factors may allow for trainers to adapt training strategies to minimize chances of injury contraction. This information may also be valuable to chiropractors and other healthcare providers in understanding the aetiology and aggravating factors of particular injuries and thus enable the healthcare practitioner to provide treatment that is not just generic to the condition present, but rather provide management and advice that is appropriate to the situation and conducive to resolution of the condition and minimal unnecessary interruption of activity.

1.7. STRENGTHS OF THE STUDY

This study provides detailed information on various aspects of MMA injuries. Studies that are similar in nature but conducted in varying sample populations may have results that vary significantly. For this reason, findings reported by each participant regarding their unique situations in terms of history, activity and conditions that were potential predisposing factors for injury were assessed and complied into a biographic profile. This provides significant insight into the sample population and provides a starting point for understanding the origin of and potential for injury development.

Injuries and their prevalence are presented in numerous ways. In addition to classifying injuries in terms of the affected area, injuries were also classified according to type and mechanism. This provides a depth to the results that can be applied to many and varying forms of injury investigations. In addition to this nature of reporting, information was collected that reflected injuries sustained up to a year preceding the date of data collection. These injuries were classified as either current or previous injuries. This provides further insight into the results of the prevalence assessment in terms of whether the fighters were injured, uninjured, or those who recently had injuries but that had since been resolved. The system of multi-classification and the specificity of reporting regarding the state of injury provides a detailed and dynamic report that may be relevant in widespread practical and academic applications.

Having the availability of a biographic profile and a dynamic prevalence report, a widespread range of relationships could be investigated in order to determine significant risk factors for injury. Relationships were investigated across biographic, training and injury fields, providing a set of risk factors that is applicable to MMA fighters in their personal, recreational and fighting lifestyles.

1.8. LIMITATIONS OF THE STUDY

While the scope of the study included identifying risk factors for injuries within MMA, factors external or unrelated to MMA may be have been causes of or predisposing factors to injuries. While the identification and role of these particular risk factors is beyond the scope of the study, there is some control over these extraneous variables as they were included rudamentally in the demographics section of the questionnaire.

For logistical reasons, the study was limited to MMA athletes training at gyms located in the greater Durban area. This was advantageous, as the majority of MMA gyms in Kwa-Zulu Natal are located in the greater Durban area. While the entire population of eligible candidates was invited to participate, the number of respondents was limited which in some cases affect the potential to identify trends buy generating results of borderline significance. Authenticity of data relied on participants being open and honest in their responses.

Recruitment of participants was largely reliant on the individual gym owners as recruitment was conducted at the various MMA gyms in Durban, which was only done if the gym owner agreed in writing to allow the study to be conducted at their respective venues.

While every effort was made to ensure that both fit and injured participants at each gym had advanced notice of the day of data collection and were encouraged by their respective gym owners to attend, only one visit at each gym/venue was allocated for data collection. Although it was controlled to a large degree, there was a potential scenario of individuals who were eligible to participate in the study not being present and not contributing to the pool of data.

The data collected represented injuries sustained in a 12 month period. This was done in an attempt to avoid the risk of memory decay, but the potential scenario of an injured MMA athlete who is unable to differentiate whether the injury occurred during MMA-related activities or in an unrelated circumstance is a limiting factor.

In this study, injuries have been classified and discussed according to the area, type and mechanism of the injury as well as the number of days missed from training as a result of injury, however, grading of injuries is outside the scope of this study.

1.9. OUTLINE OF CHAPTERS

This chapter provided an introduction and background to the study in order to explain its context and setting. The study's aims and objectives, hypotheses, rationale, benefits, strengths and limitations are also described. Chapter Two provides a review of literature covering the subject of martial arts and its associated fields that are specific to the research question. Chapter Three discusses the methodology and includes materials and methods utilized in the study. Chapter Four presents the results and discussion of the data following its analysis in the context of the related literature. Chapter Five concludes the study and offers recommendations for future studies in similar fields of research.

2. LITERATURE REVIEW

2.1. HISTORY AND BACKGROUND TO THE MARTIAL ARTS

There are many forms and adaptations of martial arts that have evolved over various time periods and are being practiced around the world today. The diverse nature of the martial arts is represented in the modern practice of technique sets that include but are not limited to punching, kicking, throwing, force redirecting, strangulations, joint locks, blocking and evading (Mitchell 1990; Stepan 2002; Warr 2004; Pranin 2006). Some of the more popular forms in which these techniques are exemplified are Aikido, Judo, Karate, Kung Fu and Taekwondo (Mitchell 1990; Lantz 2002; Stepan 2002; Yamashita *et al.* 2005).

The afore-mentioned martial arts that enjoy world-wide popularity originate from the Far East. Aikido, Judo and Karate all originated from Japan, with Judo being founded in 1882 and both Aikido and Karate being formalized in the 1920's (Stepan 2002; Yamashita *et al.* 2005; Pranin 2006; Kordi *et al.* 2009). Kung Fu has in roots in China, with styles being formalized in the fifth and sixth centuries (Warr 2004; Gwin 2011). Taekwondo is a Korean martial art that is recognised to be formally started in 1955 (Hornsey 2002; Stepan 2002) .

The origins of combining methods and techniques from varying fighting styles can be traced back to ancient Greece, in the activity of Pancrase, where participants competed in games that combined Wrestling and boxing (Kordi *et al.* 2009; Rainey 2009). In more modern times the art of Brazilian Jiu-Jitsu was developed by the Gracie family and popularized mixing fighting techniques to overcome any single martial art form (Bledsoe 2009). This marked the birth of the Ultimate Fighting Championship (UFC) which is the top league that fighters with combined and different backgrounds can compete in no-holds-barred combat and the basis of mixed martial arts (MMA) (Bledsoe *et al.* 2006; *World Book Encyclopedia* 2009; Kordi *et al.* 2009; Rainey 2009; Woodward 2009).

Individuals or groups may have very different motivations for participating in and practicing a martial art which extends beyond the scope of competitive fighting. These motivations may be to achieve personal goals or to take advantage of one of the many benefits that participation in the martial arts can offer its practitioner. Aside from the obvious ability to defend oneself in dangerous situations (Gidycz *et al.* 2006; Nower 2007; Orchowski, Gidycz and Raffle 2008), benefits that are applicable to all individuals that participate in martial arts include balance improvements with a decreased risk of falling (Pons van Dijk *et al.* 2013), psychological upliftment as well as improvements in self-esteem and self-regulation (Li *et al.* 2002).

In addition to the benefits enjoyed by all who participate in martial arts, particular (vulnerable) groups of individuals have been identified to have additional specific benefits. Improvements in self-reliance and quality of interpersonal relationships as well as decreased depression, PTSD hypersensitivity and behavioural avoidance patterns are significant benefits to female victims of sexual assault (David, Simpson and Cotton 2006). Significant benefits of physical self-appreciation (bodily empowerment) in terms of body function and capability (Paul 2015) and a decreased risk of falling (Weerdesteyn *et al.* 2008) are also of further benefit to women specifically. Elderly practitioners have improvements in strength (Brudnak, Dundero and Van Hecke 2002), balance, as well as in quality and velocity of walking, resulting in further decreased risk of falls (Cromwell *et al.* 2007). Child-specific programs have shown marked improvements in behaviour and academic performance (Rajan 2015), intelligence (Conant *et al.* 2008), self-regulation and classroom conduct (Lakes and Hoyt 2004) as well as in social interactions and memory recall (Lakes and Hoyt 2004; Conant *et al.* 2008; Rajan 2015).

Individuals that have varying degrees of movement restrictions, especially in cases of multiple sclerosis enjoy increased mobility from martial arts programs (Woodward 2009). Patients with medical disorders that participate in martial arts have been shown to have therapeutic benefits. Patients with heart disease have reductions in blood pressure, stroke patients have a decreased risk of falling, and breast cancer survivors benefit from improved general welfare as a result of participation in the martial arts which is usually determined on a case to case basis (Rajan 2015).

Due to reasons that range from the ambition to participate in elite competition to reaping the physical, functional or psychological benefits, popularity and participation in martial arts is growing. This growth demands the attention of athletes in regards to the activities that they will be participating in, as well as the risks associated with their involvement.

2.2. MIXED MARTIAL ARTS COMPETITION

Mixed martial arts is exactly what the name suggests, a collection of moves from various martial arts and fighting styles employed by fighters who compete in unrehearsed competition (Ngai, Levy and Hsu 2008; Rainey 2009; Woodward 2009). In contrast to the highly regulated competition rules of disciplined martial arts, MMA fighting is governed only by fundamental and limited rule sets, which is necessitated by the diverse nature of the activity (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008).

In attempts to increase safety and shed the stigma of ‘blood-sport’, the UFC saw fit to introduce the “Unified Rules of Mixed Martial Arts”, to be implemented globally (Rainey 2009; McClain *et al.* 2014; UFC 2015). These rules apply to both professional and amateur league fights. According to these rules, two athletes fight in a ring or cage while being presided over by a referee. Fighters compete against other fighters in the same weight division, which varies according to weight ranges. According to UFC (2015), internationally recognised weight divisions consist of flyweight (<57kg), bantamweight (57 – 61kg), featherweight (62 – 66kg), lightweight (66 – 70kg), welterweight (71 – 77kg), middleweight (78 – 84kg), light heavyweight (84 – 93kg), heavyweight 93 – 120kg) and super heavyweight (>120kg).

Fights last three rounds in a non-title match and five rounds in a title match, with each round not exceeding five minutes. Fighters must compete using a mouthpiece, padded gloves, a groin protector for males and a chest protector for females. The winner of the match is determined by knockout, technical knockout (referee stoppage), submission, judge’s decision, or by disqualification. Fighters do not need to adhere to any particular method of striking or grappling, as long as they do not contravene the rules of the match or commit any fouls. A list of banned actions or fouls adapted from the unified rules as per UFC (2015) is displayed in figure 2.1 below:

Table 2.1: Fouls and banned actions in MMA competition

Head butting
Gouging of the eye
Spitting at or biting an opponent
Hair pulling or fish hooking
Attacks to the groin
Finger insertion into orifices, cuts or lacerations of the opponent
Manipulation of small joints
Using the point of the elbow to strike downwards
Strikes to the back of the head or spine
Attacking the kidney with a heel strike
Strikes to the throat or grabbing of the trachea
Skin twisting, clawing or pinching
Grabbing the collar bone
Kicking or kneeing the head of an opponent on the ground
Stomping an opponent on the ground
Holding onto the fence or onto the opponent's shorts or gloves
Use of abusive language in the cage/ring
Any unsportsmanlike action that injures an opponent
Attacking an opponent during the break period between rounds
Attacking an opponent that is being tended to by the referee
Attacking an opponent once the fight is deemed over
Purposely avoiding contact with an opponent, exhibiting timidity, dropping the mouthpiece intentionally or pretending to be injured
Throwing opponent out of ring/fighting area
Blatant disregard of the referee and/or their instructions
Throwing or spiking an opponent onto his head or neck
Any interference by corner personnel
The application of a foreign substance to the body or hair for advantage

Contravention of the rules by committing one or more fouls results in the halting of the fight by the referee and ordering the return of the fighters to a neutral starting position. Depending on the contravention, the offending fighter may be warned, have a point deducted from their score or may be disqualified (UFC 2015).

2.3. INJURIES IN MIXED MARTIAL ARTS

Due to the relatively recent formalization and regulation of MMA through the birth of the UFC in 1993, studies that have examined injuries in MMA as a specific discipline are limited (UFC 2015). MMA studies that report on injury findings which will be discussed in this review have made use of different methods for the reporting of injury incidence. The first method is the reporting of injury incidence according to the percentage of injured fighters within a study's total sample or the average number of injuries per fighter. This method is typically used in studies with cross-sectional methodology. The other method is by reporting on injuries as a rate per athlete exposures, commonly as a figure designating injuries per 100 or 1000 athlete exposures. One athlete exposure is where an athlete is exposed to risk of injury by participating in one bout (Ngai, Levy and Hsu 2008). For purposes of rate reporting, one bout therefore constitutes two injury exposures (Scoggin *et al.* 2010). This method of reporting is typically utilized in studies that either prospectively follow a cohort of fighters through a series of events or as a retrospective analysis of fight data e.g. analysing records of a past event or series of separate events.

The presentation of injury incidence or prevalence within a population as a rate per athlete exposures provides a reference that can be easily compared to those of other studies. Regardless of whether information is presented as percentages within a population or as rate per athlete exposures, the information may be presented for multiple fields. These fields may include any of but are not limited to: location/area, type and mechanism of injury, basis for match stoppage and background fighting style.

2.3.1. Incidence and Prevalence of Injuries

Bledsoe *et al.* (2006) conducted a retrospective analysis of injuries sustained in all 171 professional MMA fights in Nevada, USA from September 2001 to December 2004, in which 220 different male fighters were involved. Injury data was descriptive of injuries that were sustained during the fights as acquired from the reports of ringside physicians, although no information was available for injuries that the athletes may have had before the start of the fight(s). Of the 171 matches fought, 40% ended with at least one of the fighters having sustained an injury for which assistance was sought. This resulted in 96 injuries to 78 of the 220 fighters and an overall rate of 2.86 injuries per 1000 athlete exposures.

With only a 17% difference, the rate reported by Bledsoe *et al.* (2006) is very similar to that recorded by Ngai, Levy and Hsu (2008) who reported 2.36 injuries per 1000 athlete exposures. This is to be expected, as both studies were retrospective analyses of injury trends of professional male fights that took place in the state of Nevada. It is even more surprising to note that the chronological period that the two studies reviewed overlapped, with the study by Ngai, Levy and Hsu (2008) reviewing the period between March 2002 to September 2007 (same study population). This means that 47% of the total time analysed by both studies utilized exactly the same population, resulting in approximately half of the data being duplicated.

Due to the retrospective nature of the studies, it is possible that the authors were unaware of this at the time of their respective studies. As a result of this 34 month overlap, the remaining 53% of the time (7 months before overlap as well as 34 months after overlap) exhibited a difference in injury rates of only 17% when compared to the overlapped time. This indicates that the injury rates of professional MMA fighters in Nevada, USA over a seven year period from September 2001 to September 2007 are very consistent.

Rainey (2009) conducted a study investigating injury prevalence in 55 professional and amateur, male and female MMA fighters from eight of 24 MMA gyms in the Midwest region (12 states) of the USA. Rainey (2009) assessed the injury prevalence through use of a questionnaire that required injury information from the participants backdating a period of 12 months prior to the date of data collection. Analysis of the self-report questionnaire yielded an average rate of 3.76 injuries per fighter. This figure was also an exact median value between the highest subgroup rate of 6.2 injuries per fighter in the 30 to 33 years age group and the lowest subgroup rate of 2.4 injuries per fighter in the 18 to 21 years age group.

McClain *et al.* (2014) compiled an injury profile of male and female professional and amateur MMA fighters that competed in a total of 711 bouts in selected MMA matches in the states of Kansas and Missouri, USA between 2008 and 2012. The study utilized the reports that were completed by the same physician for all 711 bouts in order to compile the injury profile. There were a total of 121 different participants (110 male and 11 female), which McClain *et al.* (2014) presents as an injury rate of 8.5% of fight participations. When converted, this can also be expressed as a rate of 0.85 injuries per 1000 athlete exposures.

This rate of 0.85 injuries per 1000 athlete exposures is exceptionally low when compared to the results presented by Bledsoe *et al.* (2006) and Ngai, Levy and Hsu (2008) who reported a rate of 2.86 and 2.36 injuries per 1000 athlete exposures respectively. The injury rate can also be expressed as being less than one injury per fighter. This is also very low when compared to the results of Rainey (2009), who reported an average rate of 3.76 injuries per fighter in the Midwest region at the same chronological period as McClain *et al.* (2014). Kansas and Missouri are two of the 12 states that compromise the Midwest region of USA, which suggests that either the results provided by McClain *et al.* (2014) are questionable due to the methodology of capturing data at only specific MMA matches, or that the higher injury rate seen by Rainey (2009) is indicative of much higher injury rates in the other constituent states of the Midwest region of the USA.

2.3.2. Area of Injury

In a combination activity where the injury rate has been shown to reach a rate as high as 6.8 injuries per athlete (Rainey 2009), one would expect the nature of the injuries to be diverse, affecting a wide range of locations on the body. This is not the case according to Bledsoe *et al.* (2006), who reported that of injuries spread throughout body regions, those to the head constituted almost half (48%) of all injuries sustained by professional athletes in his questionnaire study of fighters in the Midwest region of the USA. According the review of fight and injury records, Rainey (2009) also reported that the head was the most affected of all areas, comprising of 38% of all injuries, with the highest rate of the head's constituent areas affected being the nose, followed by the eye and ear. The review conducted by Ngai, Levy and Hsu (2008) also revealed that the head was the most affect region. Due to some of the injuries not having an anatomical site recorded, the percentages for area affected only reach a combined total of 50%. This resulted in 15% of injuries being reported to the head. This is a low rate when compared to Rainey (2009) and Bledsoe *et al.* (2006), but it remains the most prevalent of all the injuries reported.

Two of the studies reported that the region following the head in terms of being most commonly injured was the upper limb Bledsoe *et al.* (2006); Ngai, Levy and Hsu (2008), with Rainey (2009) noticing that the frequency of lower limb injuries was marginally higher than that of the upper limb. Bledsoe *et al.* (2006) reported the most prevalent of the upper limb's constituent areas to be the hand followed by the shoulder, whereas Ngai, Levy and Hsu (2008) reported the shoulder followed by the fingers to be most prevalent contributors. Individual areas of injury were not reported by Rainey (2009).

While these results reflect only those obtained from MMA, the trend of the greatest proportions of injury being to the head followed by the limbs are consistent with the majority of studies that were conducted in other martial arts disciplines. The exception appeared in studies of injuries in Brazilian Jiu-Jitsu, where Kreiswirth, Myer and Rauh (2014) and Scoggin *et al.* (2014) stated that the elbow and knee were most commonly effected.

2.3.3. Type of Injury

Being an activity that includes techniques from multiple martial arts backgrounds, gripping, throwing, strangling, timed moving, force redirecting, joint locks, punching, kicking and blocking are just some of the manoeuvres that are commonly observed in MMA (Lantz 2002; Douris *et al.* 2004; Boguszewski and Boguszewska 2009; Kazemi *et al.* 2009). It is therefore not surprising to find reports of many varying injury types as opposed to only considering contusion-related injuries from repeated high velocity and high amplitude strikes.

From the results of the questionnaire, Rainey (2009) reported eight major injury types that were experienced and reported by the study population. These types included, concussions, contusions, dislocations, fractures, joint sprains, lacerations & abrasions, muscle strains, and as well as a miscellaneous category. The most common injury types identified by Rainey (2009) were contusions (29%) and joint sprains (24%). The works of McClain *et al.* (2014) and Scoggin *et al.* (2010) reported findings of injury types to a lesser extent than that of Rainey (2009).

Scoggin *et al.* (2010) followed a cohort of 179 professional MMA fighters over a seven year period from 1999 to 2006 in 12 separate recognised events in Hawaii. Scoggin *et al.* (2010) reports findings of injury types to a lesser extent than that of Rainey (2009), with the most common injury types sustained by the 179 fighters being lacerations and abrasions (51%) and concussions (20%). This pattern was also found by McClain *et al.* (2014), who identified the same trends in the review of 711 bouts, with lacerations and abrasions (38%) and concussions (28%) being the most common injury types.

While it is difficult to note generalizable trends based on the findings of only three studies, the high rates of lacerations and abrasions and concussions cannot be ignored McClain *et al.* (2014); Scoggin *et al.* (2014). When compared to similar studies in other martial arts, contusions, joint sprains and muscle strains seems to make common appearances as the leading injury types in Taekwondo (Feehan and Waller 1995; Kazemi *et al.* 2009), Karate (Arriaza and Leyes 2005; Destombe *et al.* 2006; Arriaza *et al.* 2009) and Judo (James and Pieter 2003).

2.3.4. Mechanism of Injury

In studies done on disciplined martial arts, mechanisms of injury have been reported as specific exposures, such as being thrown, delivering a throw, impact with opponent and impact onto surface as seen in Judo (James and Pieter 2003) as well as offensive kick, defensive kick, offensive punch, defensive punch and falling as seen in Taekwondo (Kazemi and Pieter 2004).

Studies conducted in MMA lack the degree of detail concerning descriptions of injury mechanisms as compared to studies of disciplined arts. Ngai, Levy and Hsu (2008) reported on a total of 1270 injuries from a retrospective analyses of injury trends of professional male fights that took place in the state of Nevada. Mechanisms of match-ending scenarios were quantified in terms of percentages of the total injury count. The case of one the fighters being disqualified for committing a serious or series of injury-causing fouls accounted for 0.8% of all injury mechanisms. Stopping of the fight by a physician due to compromised medical safety was 1.6%, knockouts (KO) were 3.3%, technical knockouts (TKO) were 33.7% and the mechanism by which the most injuries occurred was submission manoeuvres at 35.4%.

Bledsoe *et al.* (2006) also reported match-ending scenarios quantified in terms of percentages of the total injury count, which followed similar trends to that of Ngai, Levy and Hsu (2008). Bledsoe *et al.* (2006) reported that 1.8% of all injuries were from a serious of injury-causing foul, 2.3% were due to due to chokes, 6.4% were due to knockouts, 30.4% were due to joint lock and fatigue submissions, and the most common mechanism of injury that resulted in match-ending scenario was the TKO, i.e. when the fight is stopped by the referee because one of the fighters is unable to continue as a result of injury.

Buse (2006) conducted a retrospective review of 1284 male MMA fighters competing in 642 televised matches in the USA and Japan in order to determine the reason for match stoppage over a ten year period from 1993 to 2003. It was reported that stoppage of a fight due to head trauma occurred in 28.3% of all cases of match stoppage (which could be classified as KO, TKO or physician stoppage). The most way in which this occurred was due to a definable single punch (16.8% of all match-stoppages), a barrage of strikes (5.9%) and knee strikes (2.2%). The same analysis was done for matches stopped due to musculoskeletal stress, which accounted for 14.5% of all match stoppages. The most common reasons for this were elbow lock (9.3%), ankle lock (2.0%) and shoulder lock (1.7%). All percentages were of the total number of matches stopped.

2.4. RISK FACTORS FOR INJURIES

Risk factors can vary in nature from being an unexplained or unprecedented circumstance to being a situation or behaviour that is known to have a direct negative influence on the variable McClain *et al.* (2014); (Scoggin *et al.* 2014). The latter is seen in MMA, as it has been shown that participation in MMA commonly results in injury contraction and that various aspects participation in contact sports, especially MMA, can increase the risk of hazardous outcomes (Buse 2006); Ngai, Levy and Hsu (2008). This can vary largely and may be due to an overtly hazardous circumstance such as participating in an MMA match or may be due to small details regarding the preference of fighting styles (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; Rainey 2009).

Martial arts is a wide classification that refers to fighting disciplines that differ in style and application. There are two broad categories that martial art disciplines can discussed in terms of. These are striking, in which emphasis is placed on force transmission through the limbs, and grappling, in which is close quarters contact is emphasized (Buse and Santana 2008; Woodward 2009; Brito *et al.* 2012).

2.4.1. Risk Factors Associated With Grappling

Although risk factors are generalised to a particular population, risks may vary between groups of individuals within those populations, such as the risks that apply to children as opposed to adults. This is seen in the work of Salanne *et al.* (2010), who assessed the epidemiology and distribution of Judo injuries in children. This study was conducted over a two year period where 173 children between the ages of eight and fifteen were included into the study by presenting to French paediatric emergency departments after sustaining injury from participating in Judo. Apart from the type and location of the injury, information collected included the participant's sex, age, weight, and geographic origin. The study asserted that Judo accidents in children differ from those identified in adults. High injury incidence and Chi-square testing were methods used to determine that significant risk factors for injury in children who participate in Judo and other grappling sports include overweight body types, pre-competition body weight loss of greater than five percent, increasing age, greater experience in Judo and male gender (Salanne *et al.* 2010).

The results of the study by Salanne *et al.* (2010) are to be expected in the given population and can be accepted as valid results, however, the power of the study is unknown. This is due to the lack of mention of uptake rates and percentage of the total population of injured children that presented to the hospitals where the study was conducted. This results in an uncertainty of the statistical effect that the results carry, which may possibly call into question the efficacy of results obtained by high incidence patterns. While this uncertainty exists, a thirteen year paediatric martial arts injury study conducted by Yard *et al.* (2007) that compared injury rates in 128 400 children presenting to emergency departments shared virtually the same study design as that of Salanne *et al.* (2010). While Yard *et al.* (2007) reported on the differences in injury patterns as opposed to risk factors, the methodological procedure of having data collected at multiple hospitals simultaneously may have been a limitation in terms of having uptake rates noted and should not result in the information being deemed unsound.

Apart from risk factors identified specifically in child Judokas, Souza *et al.* (2006) conducted a study assessing the injuries of 93 adult Judokas taking part in the Sao Paulo State Championships through a referred morbidity inquiry (RMI). A RMI is a questionnaire that is designed to retrieve injury-based information according to the speciality of the athlete(s) (Pastre *et al.* 2005). Based on the responses of the participants, risk factors for injury were determined. The action with the greatest resultant risk of injury was the situation of throwing an opponent Souza *et al.* (2006). The risk of injury in the controlling an opponent to throw them was also recognized in the work of Shadgan (2010), who conducted an injury survey at the 2008 Beijing Olympic Games based on ringside physician reports of injuries occurring through all bouts in the total population of 343 wrestlers. Shadgan (2010) reported that the risk of injury is highest in a standing contact and takedown position, which is a scenario equivalent to that of a Judo throw in terms of contact and forces applied (Yamashita *et al.* 2005). Notwithstanding the methodological differences of a questionnaire versus real-time physician reports, both studies emphasise the same risk factor founded on contact forces produced, enforcing the efficacy of the particular situation as risk factor for injury.

Due to the similarity in nature of close-quarters contact and force manipulation, Wrestling has many risk factors that are common and applicable to all grappling sports. A study conducted by Yard (2008) compared the epidemiology of injuries in wrestlers at 74 high schools and 15 colleges. Injury rates were not reported in percentages but rather as figures per 1000 athlete exposures, where an athlete exposure is defined as one athlete participating in one Wrestling bout where they are exposed to the possibility of being injured (James and Pieter 2003; Yard 2008). A 95 percent confidence interval was utilized as a measure of statistical significance, however the risk associations were not calculated using chi-square tests, but rather demonstrated by injury proportion ratios (IPR's) also known as rate ratios (RR's), which were considered to show a risk relationship if the value exceeded 1.00. The results of this IPR testing revealed several risk factors for injury. Any takedown manoeuvre presented significant risk for injury was the most common mechanism by which wrestlers contracted injuries. Risk of injury was noted to be higher in college Wrestling as opposed to that of high school in terms of overall risk, as well as in risk of skin infections, lacerations and cartilage injuries. It was also shown that risk of injury is higher in a practice situation as compared to matches in both college and high schools and the risk of laceration as observed in high schools was also greater in practices as opposed to matches (Yard 2008).

The study by Yard (2008) mentioned only the number of institutions that participated in the study with no mention of the number of participants. This could call into question the study's power, but the participation is evident in the 201878 athlete exposures, resulting in no need to question the efficacy of the results of the study.

Agel *et al.* (2007) conducted a 16 year surveillance study of injuries in college wrestlers that included 6969 participants spread throughout 286 colleges. While this study spanned a significantly longer period and included far more participants, the study design is virtually identical to that of Yard (2008), especially in the presentation of data, as both studies report injuries as rates per 1000 athlete exposures and utilize IPR's as the statistical indicator of risk association. The risks identified included takedowns, which enforces the results of the study by Yard (2008). Other results indicated that participation in matches as opposed to practice carried nine times the risk of concussion, seven times the risk of internal knee injury and five times the risk of injury to ankle ligaments (Agel *et al.* 2007).

Kordi *et al.* (2012) conducted a twelve-month prospective study where 495 male Iranian wrestlers were followed in terms of participation and injury in order to assess the incidence, nature and causes of fractures and dislocations in Wrestling. Results were expressed in rates per 1000 athlete exposures and risk factors were determined using RR analysis. This study showed that the risk of sustaining a fracture or dislocation is greatly increased if there is a previous history of such injury, and the risk increases proportionately as age and Wrestling experience increases (Kordi *et al.* 2012). This shows that although it is expected that different groups of individuals within a discipline may have differing risk factors, these risk factors are consistent with those observed in chid Judokas (Salanne *et al.* 2010; Kordi *et al.* 2012).

The above demonstrates that some risk factors are applicable to practitioners across similar activities (grappling martial arts), as well as across age groups from developing children to adults. Another risk factor that can be assumed to be generalizable across all contact sports is that stated by Kordi *et al.* (2011) who assessed indirect catastrophic injuries in Iranian wrestlers through retrospective case series. Kordi *et al.* (2011) emphasized that increasing age was the best indicator for risk of development of indirect catastrophic injuries, which was most often caused by coronary heart disease.

Care must be taken however, in the generalization of risk factors, as some risks are clearly specific to the activity in question. This is seen in Wrestling in implications for injury through interaction of Wrestling shoes and competition surfaces (Newton *et al.* 2002). Herein lies the potential danger of overt generalization of risk factors, as it could be said that because wrestlers have a high risk of knee and ankle injury (Newton *et al.* 2002), the same can be said about other grappling arts, which is not the case for this this specific risk factor. The study by Newton *et al.* (2002) assessed the degree of friction between various Wrestling shoes on the two different competition surfaces in wet/dry conditions, with the result of usage of Wrestling shoes increasing the risk of torsional injuries to the lower limb, especially in dry conditions.

James and Pieter (2003) conducted a cross-sectional study in which 116 British Judo athletes (70 male and 46 female) at a national competition described their injuries using a check-off injury collection form after being diagnosed by a tournament physician. Data was presented as rates per 1000 athlete exposures, where significance was established using a 95 percent confidence interval. Statistical testing was used to determine the differences in injury rates between men and women (Mann-Whitney U test) as well as the differences in injury rates between body regions (Kruskal-Wallis test). The findings of the study regarding risk factors are explicatory of constituents of grappling, such as delivering a throw (throwing an opponent), receiving a throw (being thrown) and falling (James and Pieter 2003). While statistical differentiation tests were employed in this study, no statistical testing was utilized to determine the significance of the risk factors for injury. The risk was extrapolated from the high-incidence measures evident in the results. With the absence of statistical testing, these risk factors cannot be relied upon as being scientifically accurate, however, the high incidence of injury resulting from these actions cannot be ignored, and is informative about the most common mechanisms through which injury was sustained, thus being of value to the athlete.

In a study by Bledsoe *et al.* (2006), the incidence of injury in professional MMA fighters was established. This was conducted in the state of Nevada, where all fight records in a three year period were reviewed, which included 220 fighters who contributed to 171 fights. Once collated, the results showed that of the five possible match-ending scenarios, the submission (aka tap-out) was the second most common way in which fights were ended, surpassed only by referee stoppage (TKO). Submissions are commonly elicited through the application of a joint lock, strangulation or choke (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008). Scoggin *et al.* (2014) conducted a review of medical records generated from eight state-wide BBJ competitions in Hawaii, USA held between 2005 and 2011. Analysis of the medical records revealed that ten out of 14 incidences of elbow injuries occurred while having an arm-bar applied. This result supports finding of (James and Pieter 2003) where it is stated that in Judo and among the martial arts that include arm-bars, that joint sprains are a relatively common injury type.

In summary, risk factors for injury that are applicable to practitioners of grappling martial arts are high in the cases of increasing age (Salanne *et al.* 2010; Kordi *et al.* 2011; Kordi *et al.* 2012), increasing experience in grappling arts (Salanne *et al.* 2010; Kordi *et al.* 2012), participation in grappling arts beyond high school (Yard 2008), having a history of grappling-related injuries (Kordi *et al.* 2012), executing a throw or takedown as well as having a throw or takedown performed on oneself (James and Pieter 2003; Agel *et al.* 2007; Yard 2008), and having a joint lock applied (James and Pieter 2003; Scoggin *et al.* 2014). Risk of injury for concussion, knee and ankle injury is increased in competition/match scenarios (Agel *et al.* 2007). Risk factors shown to be specific to children are pre-competition body weight loss of greater than five percent and being male (Salanne *et al.* 2010). A risk factor for knee and ankle injury that is specific to wrestlers is the use of Wrestling shoes, especially on a dry surface (Newton *et al.* 2002).

2.4.2. Risk Factors Associated With Striking

The deliverance of strikes may vary in different competition martial arts in terms of velocity, part of the body used to make contact, zones of impact and directional forces, but all share the damage-producing potential that results in risk of injury. This is expressed by Zazryn, McCrory and Cameron (2008) who asserts that acute injuries sustained in professional boxing are similar in aetiology and rate to those of other combat sports involving striking, enabling these arts to be considered together for purposes of injury and risk analyses.

The epidemiology of injuries and risk factors in the form of a retrospective cohort was carried out by Altarriba-Bartes *et al.* (2014), across two Olympic periods, where 22 male and 26 female elite athletes of the Spanish national Taekwondo team were studied. Although a significant relationship was found between age and risk of injury contraction, the risk was specific to age groups with genders i.e. 23 to 24 years in males ($p = 0.005$) and 17 to 18 years in females (p = 0.003), with the consequence of this risk factor not being able to be deemed either as greater nor lesser with increasing age, but rather specific to the afore-mentioned age groups. A low body weight was found to be a significant risk factor for injury in males, with relative increments weight resulting in lesser risk (p = 0.04). In a different circumstance, weight in females was considered to be a risk factor in the middle weight categories, which consisted of the 49–57 kg and the 57–67 kg divisions (p = 0.01).

Zazryn, McCrory and Cameron (2009) followed a cohort of 545 professional boxers in 907 matches in the state of Victoria, Australia over an 8.5 year period. The purpose of this retrospective cohort study was to ascertain the injury rates and risk factors for injury within the study population. Data was collected from an organization-controlled database that kept records of all professional boxing matches occurring in the state of Victoria. The analysis of the risk factors were limited due to the field-structure of the information that was captured in the database. This resulted in fight-specific risk factors being limited to basic match-statistics. Zazryn, McCrory and Cameron (2009) reported that boxers with existing injuries sustained from strike impact were significantly more likely to lose their matches as compared to uninjured boxers (p = 0.03), with the additional likelihood of strike-injured boxers being unable to reach the end of the prescribed number of rounds (p = 0.019). Following participation in each match, a boxer's risk of injury from striking consistently increased (p = 0.011). This effect, when coupled with the injury risk associated with increasing age (p = 0.011), limits the viable length of careers in professional boxing.

In a study investigating injury rates in the Shotokan style of Karate, Critchley, Mannion and Meredith (1999) assessed the injuries sustained in three consecutive British Shotokan Karate championships which consisted of 1770 bouts. All participants were required to wear mouth and groin/chest guards (dependant on gender), however no padded protective gear was permitted for head and limbs. From analysis of the 160 injuries sustained over the three championships, Critchley, Mannion and Meredith (1999) asserted that the use of protective padding does not decrease the risk of injury to the areas beneath the so-called protective wear, rather the risk of injury can be increased through use of such gear by alluding the wearer with a false sense of security. Moreover, reduction of risk of injury can be seen in strict application of the competition rules by referees. The latter is supported by Kazemi and Pieter (2004), who conducted a prospective study of injuries at a Canadian national Taekwondo championships and states that competitions rules are a major determining factor of injury in the martial arts.

More than a decade after the statement by Critchley, Mannion and Meredith (1999) that risk of injury can be increased through use of protective equipment, this was put to the test by Gupta (2011), who's study involved the observation of 15 elite Taekwondo athletes performing a series of three roundhouse kicks on a heavy-core model thorax that was fitted with an accelerometer that recorded data. Each of the three kicks performed by the participants involved the application of varying degrees of protection for the model. The first kick was performed directly onto the model without any protection. The second kick was performed on the same model that was fitted with a hogu (Taekwondo chest protector). The third kick was performed on the model that was fitted with the hogu as well as the athlete being required to wear a foot instep pad. The decreases in the amplitude of the forces produced were significant with each degree of protection i.e. no protection ($p = 0.04$), hogu only ($p = 0.03$) and hogu plus instep pad ($p = 0.02$). The results of this study oppose the assertion of Critchley, Mannion and Meredith (1999), and by virtue of the scientific controlled measures and statistical testing, are considered more reliable results.

In addition to the observation by Gupta (2011) that padding is a determining factor of the resultant force generated by a roundhouse kick onto an opponent, Falco *et al.* (2009) performed a similar study that assessed the impact force and execution time of a roundhouse kick. The study consisted of 31 Taekwondo athletes that were required to perform a total six roundhouse kicks onto a target. Athletes performed two kicks at three distances that increased incrementally. The results of statistical testing revealed that there was a significant relationship between the impact force of the kick and the distance from which it was performed ($p < 0.01$). That is to say that the greatest force can be generated from a roundhouse kick that is the farthest distance from an opponent while still being in range. It was also found that in novice athletes, the athlete's body weight was proportional to the impact force of the kick ($p < 0.01$).

Bolander, Neto and Bir (2009) also conducted a study on the force produced by martial arts strikes, specifically punch and palm strikes and the relative effects of height and distance on their application. The participants consisted of 13 experienced Kung Fu practitioners who were required to strike a target fitted with a load cell and accelerometer. The actions were recorded using high-speed video. A (Kung Fu style) punch was identified as a strike with the metacarpal phalangeal (MCP) joints, where the metacarpals are parallel to the ground, and a palm strike was identified as imparting a force with the hypothenar eminence of the hand. Arm acceleration was the same in both strikes, however the palm strike was able to produce a significantly greater force ($p < 0.05$). The relationship between the force generated by the strike and the height at which it was delivered was represented by an Eta score of 0.43, which is indicative of a larger than typical strength relationship (Morgan *et al.* 2004). The height of the strike (head vs chest strike) was reported to be significantly greater for strikes delivered at chest-level. In the same manner that distance affected the force of the roundhouse kick as described by Falco *et al.* (2009), the force of both the punch and palm the strikes ($p < 0.001$) and the acceleration of the arm ($p < 0.001$) were the greatest at the farthest distance from the target while still being in range.

As seen in the works of (Bolander, Neto and Bir 2009; Falco *et al.* 2009; Gupta 2011), martial arts strikes have been shown to be able to generate significant amounts of force. This is a concern when the primary target for a strike is the head, as is the case of boxing and boxing. This is concern is quantified by Buse and Wood (2006) who identified the causes of match-ending scenarios in 148 military and civilian kickboxers. A premature ending to a match is the occasion when a fight is stopped either by the referee, ringside physician or voluntarily by the fighter. Traumatic brain injury (TBI) was described as a transient loss of consciousness or state of delirious defencelessness to a match-ending extent. TBI as a result of strikes to the head was identified as the single greatest cause of premature match endings, and has a higher incidence than all other match-ending injuries combined (Buse and Wood 2006).

Zetaruk *et al.* (2000) conducted a questionnaire-based study on Shotokan Karate athletes training in Boston, Massachusetts in order to identify injury trends, risk factors and best-practice safety recommendations. The sample consisted of 114 athletes, yielding a 74% response rate. Those Karatea older than 18 years were at significantly higher risk of injury as opposed to those younger than 18 years of age ($p < 0.001$). Risk was also associated with the number of training hours spent weekly, with the greatest risk of injury being with those who train more than three hours per week ($p < 0.05$). The risk of injuries seemed to increase proportionately with each rank (belt colour) gained until the level of brown belt was reached, where a plateau was reached in terms of injury risk ($p < 0.0001$).

Lystad (2015) conducted a 15 year retrospective cohort study on 581 amateur and professional fighters (406 male and 75 female) from 57 events in Nevada, USA from 2000 to 2014 to establish the incidence, pattern and risk factors of injuries in kickboxers. Statistical analysis revealed that risk factors were significant in terms of fighters that compete at a professional circuit as opposed to amateur ($p = 0.046$) with a greater risk in athletes that lost their matches ($p = 0.045$) and a far greater risk in individuals who lost by knockout (KO) ($p = 0.026$). It was noted in the methodology that the statistical model used to determine these risk factors did not include exposure time when determining that risk of injury was higher in professional athletes. Although this may present an implication, it would be expected that professionals would have a greater total exposure time than most amateurs, giving little reason to question the viability of the results.

In summary, overall risk factors in terms of association with striking include increasing age (Zetaruk *et al.* 2000; Zazryn, McCrory and Cameron 2009), fighting on a professional/elite circuit (Lystad 2015) as well as an increase in injury risk with every match fought as that level (Zazryn, McCrory and Cameron 2009). History of injuries sustained from striking (Zazryn, McCrory and Cameron 2009), participation without any protective equipment (Gupta 2011), being struck by a roundhouse kick, straight punch or palm strike from a far distance (Bolander, Neto and Bir 2009; Falco *et al.* 2009), being hit by a palm-strike (Bolander, Neto and Bir 2009) and being punched or palm-struck in the chest (Bolander, Neto and Bir 2009) all increase the risk of injury development. The receiving of strikes to the head presents a high risk of sustaining traumatic brain injury (Buse and Wood 2006). Athletes that lose their matches and moreover those who lose by knockout are at high risk of injury (Lystad 2015). Bodyweight in novices (Falco *et al.* 2009), advances in rank (belt colour) until brown belt (Zetaruk *et al.* 2000) and referees that do not strictly enforce competition rules (Critchley, Mannion and Meredith 1999) are all factors that increase the risk of injury in striking martial artists.

2.4.3. Risk Factors Related to Influences Outside of Fighting Styles

2.4.3.1. Hand Dominance

It is expected that favouring ones dominant side while fighting would result in a greater potential velocity and force production when striking. In a review conducted by Harris (2010), it was demonstrated that in fighting sports, the left hand dominant fighter is at a distinct advantage when facing a right hand dominant fighter. This is due to frequency dependence, i.e. due to the exposure of left-handers to right-handers and vice versa, giving that right handedness is far more common than left handedness.

While Harris (2010) demonstrated that left handers seem to have a competitive advantage in fighting sports, Aggleton, Kentridge and Neave (1993) ascertained the relationship between longevity and hand dominance through a retrospective analysis on a cohort of elite British cricket players. After examining the lifespans of the 2580 right and 585 left handed male cricketers, it was found that being left handed was greatly associated with a decrease in longevity and a higher likelihood of accidental death or death during activities related to warfare ($p = 0.006$).

This finding is consistent with that of Zverev and Adeloye (2001), who investigated the prevalence of left handedness in patients with traumatic brain injury. Zverev and Adeloye (2001) conducted a case control study in 163 patients presenting with head injury. If full Glasgow coma scale (GCS) score and absence of upper limb injuries was established, hand dominance was then established through grip strength tests and a short questionnaire. As a result of chi-square testing, fighting, sporting activities and transportation accidents were the three activities shown to be of significantly greater risk of head injury in left handed individuals. Left handedness has therefore been shown to be risk factor for head injury in left handed individuals when engaging in contact and confrontational situations (Zverev and Adeloye 2001).

Notwithstanding the natural benefit of frequency dependence that left handed fighters can enjoy, left handedness appears to be a risk factor for development of morbidity and even mortality in combat-related activities.

2.4.3.2. Falling and Orthopaedic Injury

Falling has been shown to be a common mechanism of injury in many martial arts. This can be expected in grappling arts but also includes those technique sets where accidental falls are involved, such as in striking arts. The following are descriptions and accounts of these claims.

In a nine year longitudinal retrospective study of Taekwondo injuries, Kazemi *et al.* (2009) analysed 532 injury reports from 58 competitions in Ontario, Canada, and found that 4% of all injuries were attributed to falling as the mechanism of injury. In a study of similar design, Arriaza *et al.* (2009) analysed injuries from 2762 Karate matches over three consecutive World Karate Championships over a six year period and found that of the injuries reported on, 10% were sustained from falling. With Taekwondo and Karate being striking martial arts where fighting on the ground is not permitted, it can be surmised that incidences of falling are due to losses in balance in the scenario of delivering, receiving or evading a strike.

In martial arts where falling is almost essential for match victory, falling is expected and can be said to be more probable. This is exampled is grappling martial arts, as is seen in the work of James and Pieter (2003) where 116 British Judo competitors participated in a UK national competition, with data being collected on athletes who sustained injuries. The rate of injuries that occurred due to falling were averaged between men and women and accounted for 20% of injuries. Scoggin *et al.* (2014) states that a common manner in which injury is sustained from a fall is by falling on an outstretched hand (FOOSH injury). Kreiswirth, Myer and Rauh (2014) states that falling injuries occur regularly from being the victim of a takedown technique, which was the most common injury mechanism in the 2009 World Jiu-Jitsu No-Gi championship where injuries were reported by 62 of the 951 competitors.

A study by McPherson and Pickett (2010) reported on the results of a 14 year data collection program (1993 to 2006) that collected information on all martial arts injuries (striking and grappling) across all ages in Canadian Hospitals. Although this information was collected from injury sufferers from any number of martial arts, it cannot be ignored that from the 920 reports collected, a combined mechanism category of falling and jumping accounted for 33% of all injury cases.

The account of FOOSH injuries by Scoggin *et al.* (2014) stimulates enquiry into the extent and potential injury that can result from a loaded gravitational force onto a closed kinematic circuit as seen when the wrist or elbow contacts the ground. Scoggin *et al.* (2014) also stated that the majority of orthopaedic injuries sustained in Brazilian Jiu-Jitsu athletes were ligamentous in nature, many of which were from a collection of active and typically quick movements, such movements observed in falls and arm-bars. These orthopaedic injuries may be limited to joint injury, as Zetaruk *et al.* (2005) observed that there was no difference in the rates of fractures sustained between participants of five different martial arts. The martial arts that were included in this one year retrospective cohort study consisted of 263 athletes across the disciplines of Karate, Taekwondo, Aikido, Kung Fu and Tai Chi.

2.4.3.3. Gender

MMA would appear to be an activity dominated by males, but there is conflicting evidence in literature to support risk of injury ratios in one gender over the other in varying martial arts. Comparisons are made between the following works:

Feehan and Waller (1995) conducted a questionnaire-based study at a major Taekwondo competition in New Zealand. Before taking part in the competition, participants between the ages of 16 and 45 completed a self-report questionnaire on injuries they had sustained from

Taekwondo spanning twelve months prior to the report. No differences in gender were established as a risk factor. Kazemi *et al.* (2009) conducted a nine year longitudinal retrospective study of Taekwondo injuries obtained from 532 injury reports from 58 competitions in Ontario, Canada. Injuries sustained were also reported as being equal among males and females.

Lystad, Pollard and Graham (2009) conducted a meta-analysis of 14 prospective cohort studies reflecting incidence of injuries in competition Taekwondo. The data in these studies was pooled for the purpose of regression analysis. It was ascertained that gender was not a significant variable when considering risk factors for injury. The conclusion of this meta-analysis was synonymous with the work of Zetaruk *et al.* (2005), who conducted an injury survey across five martial arts style in retrospective cohort analysis for a one year period. The sample consisted of 263 martial artists, 114 from Karate, 49 from Taekwondo, 47 from Aikido, 39 from Kung Fu and 14 from Tai Chi. Despite sex being a predictor variable, gender differences were not significant in terms of risk for injury.

Arriaza and Leyes (2005) conducted a prospective study of injuries from three consecutive World Karate Championships over a six year period that assessed injuries that resulted from 2837 matches. This study was conducted again by Arriaza *et al.* (2009) in the following three consecutive World Karate Championships after a set of competition rule changes were implemented. Having a negligibly lower match volume than the predecessor study, 2762 matches were assessed. Both studies showed that no difference existed between the risk of injury from males to females. This pattern was also evident in the work of Destombe *et al.* (2006), who conducted a questionnaire-based study in 186 Karate athletes in Brest, France that assessed the injuries sustained in the 12 month period prior to the injury reporting. Incidence of injuries in males and females were similar within their respective groups, resulting in there being no difference in risk dependant on gender.

(Salanne *et al.* 2010) assessed the epidemiology and distribution of Judo injuries in children. This study was conducted over a two year period where 173 children between the ages of eight and fifteen were included into the study by presenting to French paediatric emergency departments after sustaining injury from participating in Judo. Of the injuries to the upper limb, 78% were sustained by males, demonstrating the higher risk of injury (p = <0.0001). Risk of fractures was also greater in males (p = 0.04). Overall, gender was shown to be a factor that predisposed male children to a higher risk of injury then females. McPherson and Pickett (2010) reported on the results of a 14 year data collection program (1993 to 2006) specific to martial arts injuries in Canadian Hospitals. Information was captured for any martial art-related injury across all ages from minors to elderly practitioners and yielded 920 reports. The results were in accordance with that of (Salanne *et al.* 2010), as males were shown to be at higher risk of injury than females (p = 0.01).

Rainey (2009) conducted a questionnaire-based study among 55 professional MMA fighters from the ages of 18 to 39 in the Midwest region of the USA. Notwithstanding a male dominated sample (94.5% male vs 5.5% female), average injury rates differed dramatically where males averaged 3.9 injuries per subject and females averaging only 2.3 injuries per subject, however, the relationship was not deemed statistically significant, with the p-value exceeding 0.05. McClain *et al.* (2014) conducted a cross-sectional analysis of ringside injuries as diagnosed by a physician in 711 MMA competitions fights in the states of Kansas and Missouri. The main outcome measures were the rate of injuries per fight and whether or not injuries required referral to emergency departments. A rate of 8.5% of fight participations resulted in injury, although injury rates were consistent in male and female athletes.

Overall, there is conflicting evidence in literature regarding the role of gender as a risk factor. There are martial art studies that have identified a higher risk of injury in males over females (McPherson and Pickett 2010; Salanne *et al.* 2010), however, the split is dominated by evidence in studies that have identified no difference in risk of injury dependant of gender (Feehan and Waller 1995; Arriaza and Leyes 2005; Zetaruk *et al.* 2005; Destombe *et al.* 2006; Arriaza *et al.* 2009; Kazemi *et al.* 2009; Lystad, Pollard and Graham 2009; Rainey 2009; McClain *et al.* 2014).

2.4.3.4. Smoking and Alcohol

Lisha and Sussman (2010) conducted a meta-analysis of 34 studies conducted between 1982 and 2008 that evaluated the smoking and alcohol consumption habits in high school and college students between the ages of 13 and 24 years. Concerning smoking, 15 of the 34 studies assessed the relationship between sports participation and cigarette smoking patterns. Of these studies, 14 demonstrated an inverse relationship and showed that participation in sports served as a protective factor against smoking. One study could not determine a significant relationship between sports participation and smoking. Regarding alcohol, 29 of the 34 studies assessed the relationship between sports participation and alcohol consumption. The majority (22) of these studies demonstrated a positive proportional relationship between participation in sports and alcohol consumption as compared to those who were not active in sports. These findings are supported by a systematic review of risk behaviour according to

Diehl *et al.* (2012) who noted a trend of less smoking and higher alcohol consumption in young adult athletes.

These patterns were further noticed by Hessami *et al.* (2012) who showed that out of 738 professional Iranian athletes spanning ten different sports, only 24.6% of the participants had experienced cigarette smoking with a low rate of 9% that were current smokers. Spanoudaki *et al.* (2005) conducted a study among Greek young adult athletes, where 10.4% of 1003 participants were current smokers who smoked an average of 13.6 cigarettes per day. 9.1% of the male participants and 12.4% of the female participants reported to currently smoke at the time of the study. Higher rates of smoking was observed in the participants of six particular sports, one of these being Kickboxing.

2.4.3.5. Stretching

Andersen (2005) conducted a meta-analysis of six randomized and partially randomized controlled trials that analysed the effects of stretching in athletes. It was noted that if these physically active individuals stretched before and after physical activity, a marginal decrease in muscle soreness (2%) was noted in a 72 hour window after activity. In the light of only a 5% reduction in risk of injury, stretching protocols were found to have no significant value to athletes in terms of overall risk reduction (Andersen 2005). This is consistent with the work of Herbert and Gabriel (2002) and Thacker *et al.* (2004), who have shown that there is no significant benefit from stretching either before or after exercising in term of reduction of injury risk. Tisal (2000) noted that stretching in training was a source of back pain in martial artists due to faulty positioning.

In addition to the effects of stretching on muscle soreness and injury prevention, an experiment to test the effect of static stretching on the strength performance of Jiu-Jitsu athletes was carried out by Costa *et al.* (2009), who recruited 20 Jiu-Jitsu athletes (age 24.1±1.8 years) which were split into two groups. One group that would perform the strength test immediately without the stretching intervention and repeat the process a week later with the added stretching intervention. The intervention group performed a stretching protocol prior to the bench press which consisted of three static stretches, done three times each, each held for 20 seconds.

The control group performed one repetition maximum of a horizontal bench press without stretching. The results showed that the groups that performed the stretches had an 8.75% decrease in strength as opposed to the control groups, showing that the stretching regimen performed before the bench press significantly decreased the strength ability of the athletes (Costa *et al.* 2009).

While the study by Costa *et al.* (2009) shows a clear result, there are several factors that call into question the efficacy of the study design that warrant discussion. Using only 20 participants to perform an experiment can leave room for extraneous variables to impact the results, however this was protected against by using the entire study population as both the intervention and control groups at alternating times. This may have in fact safeguarded the results against additional variables that could have been introduced if two completely separate groups of individuals were used. The study protocol called for cessation of any form of training between the assessments (seven days) in to prevent interfering of any activity in the test results. While I was controlled for to a large degree, the possibility of injury due to an unrelated factor existed. Overall, there are pros and cons of the study design, but none of these should have had a significant effect of the validity of the results.

2.4.3.6. Rapid Weight-Loss

A study by Brito *et al.* (2012) was conducted to ascertain the nature and extent of rapid weight loss methods in participants of Judo, Jujitsu, Karate and Taekwondo, who attempt to lose weight in order to make their target categories. Questionnaires were distributed to 580 participants between the ages of 20 to 30 in Minas Gerais, Brazil. It was found that 60% of the athletes in the study reported to be using increased energy expenditure as a method of rapid weight loss. Strikers (Karate and Taekwondo participants) were noted to start using rapid weight loss methods in as early as adolescence. Half of the sample made use plastic/ insulated clothing or saunas with only 26% of all rapid weight loss program users receiving advice from a nutritionist or dietician.

The frequency of utilization of these methods has been shown to be detrimental to the health of the users, especially in those who are young (adolescents) and those who use saunas, insulated clothing and diuretics (Brito *et al.* 2012). This injudicious practice of rapid weight loss may be compounded by opportunities for rapid gain directly after the rapid loss, as is in the case of preparation for weigh-ins for MMA fights, where the weight check is conducted 24 hours before the match takes place (Kordi *et al.* 2009).

2.4.3.7. Conditioning

Participation by elite athletes in martial arts at highly competitive levels has been documented to be very physically demanding, especially in the case of Judo (Artioli *et al.* 2009) and forms of Kung Fu (Almansba *et al.* 2010). A lack of conditioning has been shown to be detrimental to those who participate in these activities, especially in terms of flexibility, body fat percentage, isometric strength and anaerobic power of the limbs, deficits of which can lead to injury (Franchini *et al.* 2005; Andreato *et al.* 2012).

Athletes have many choices when considering methods or programs to participate in that can increase their conditioning levels. One such activity is CrossFit, which is a relatively new high intensity training (HIT) program, also known as an extreme conditioning program (ECP) (Smith *et al.* 2013). A consensus paper based on a consortium of experts was held to determine the definition, guidelines, implementation and considerations of ECP's (Bergeron *et al.* 2011). Positive and negative characteristics of the programs were identified, with a result showing that that ECP's are effective in improving maximal aerobic fitness and optimum body composition, which is confirmed in a study by (Smith *et al.* 2013) who evaluated the cardiovascular fitness, efficacy of oxygen transport, body composition and body fat percentage in 43 participants before and after a ten week CrossFit-based ECP. Notwithstanding these benefits, Bergeron *et al.* (2011) ascertained that a large risk of musculoskeletal injury is associated with participation in these programs, particularly in the case of novice participants. This may be due to the extreme nature of the program, as it has been shown to exceed the standards for safely and appropriately developing muscular fitness (Bergeron *et al.* 2011). Low back pain was also found to be common in cases of repetitive exercise in martial artists and was attributed particularly to their training Tisal (2000).

2.5. CONCLUSION

MMA has provided the opportunity for athletes of different martial arts backgrounds to compete in a form of combat where strategies other than brute strength can be employed to win a match. This participation has led to fighters being subjected to exposures that may be unusual or unexpected, often resulting in a broad spectrum of injuries.

Injuries in MMA have been outlined and discussed in terms of incidence and prevalence, area, type and mechanism, which have described the extent to which these aspects are identified in literature. The injury rates have been shown to differ between studies, but the rate remains relatively consistent, with no studies presenting an injury rate close to zero across any competitive martial art. Risk factors for injury have been identified throughout various forms of martial arts and contact sports. These factors have been discussed in terms of the risk they present to athletes as well as whether or not they can be generalised to martial artists across all disciplines. These risk factors include those that relate directly to the background fighting style of an athlete, namely, striking and grappling as well as those factors that are unrelated to differences in styles, which are more widely applicable. Knowledge of these influences should inform those who participate in martial arts of the potential risks involved, as well as being valuable to those who monitor the participation and performance of fighting athletes.

3. METHODOLOGY

3.1. STUDY DESIGN

The design used in this study was a prospective, analytical, quantitative survey.

The questionnaire contained sections for demographic details, training regimen details, and the participant's injuries that were sustained while practicing or competing in MMA activities in a 12 month period prior to the date of data collection.

3.2. STUDY POPULATION

The population consisted of adult fighters above the age of 18 that had been participating in MMA for at least six months and training at least once weekly at an accredited MMA gym in the greater Durban area.

The target population was approached at each of the participating gyms. At the time of the study, there were 17 functioning, accredited MMA gyms in the Greater Durban area.

3.3. AREA OF STUDY

The study was limited to MMA fighters training at accredited gyms that were located in the Greater Durban area. For the purposes of obtaining specific and definable constituent areas, the geographic area and borders of the eThekwini municipality was intended to be used. This presented the problem of two MMA gyms that were located in the Ballito area within the Dolphin Coast region, which would have been the first northern region outside of the boundaries of this study, and the last accredited MMA gym(s) for a further 129km (Google Maps 2015). The Ballito-based gyms are classified as KZN constituent gyms, meaning that participation of these gym's members in any provincial MMA activities take place with the other MMA gyms in KZN, almost all of which are located in the greater Durban area, demonstrating the important link between these gyms. Due to this nature of participation of the Ballito-based gyms and their fighters in Durban-based MMA activities, the omission of these gyms could have proven detrimental to the study. For this purpose, the area of the study was deemed to be any region that was located within a 50km radius of Durban city centre. Over 80% of this area was comprised of the eThekwini district, also including very small parts of iLembe (KwaDukuza), Umgungundlovu and Ugu districts (Ulwazi Programme 2015).

EThekwini consists of 2291km^2 of land, with its coastline spanning more than 100kms from Tongaat at the Northern boundary to Umkomass in the South and extends more than 50kms inland from the Indian Ocean to Cato Ridge in the West (Ethekwini municipality 2015a, 2015b; Google Maps 2015). In contrast to the geographical composition of the eThekwini district, the area within the 50km radius from Durban city centre (Greater Durban area) consists of 3929km^2 of land, spanning 100km from the Dolphin Coast (North) to Luthuli (South), and 50km inland (West) to Inchanga (Google Maps 2015).

3.4. SAMPLING

3.4.1. Sample Size

At the time of the study, there were 17 functional, accredited MMA gyms in the greater Durban area out of a total of 19 gyms located in the province of Kwa-Zulu Natal. Prior to data collection the exact number of MMA fighters in the greater Durban area was unknown as registration with a governing body was not necessary unless they were entered into a league fighting circuit. Based on telephonic conversations with numerous gym owners, a figure of 120 fighters was estimated as the eligible population for this study. This figure was arrived at considering that only those who qualified to participate in the study (those that met the inclusion criteria) were considered as constituents of the total study population.

At the conclusion of data collection, the total number of MMA fighters in the greater Durban area that were eligible to participate in the study was 116. GPower version 3.1.9.2 was used to perform statistical power calculations that showed that in order to achieve a significant (medium to large) statistical effect, a sample size of 80% of the total population was required (Faul *et al.* 2009). Considering that the size of the population was relatively small and that the sample size percentage was relatively high, a maximum response rate (100% of the eligible population) was attempted.

3.4.2. Permissions

Once ethical clearance for the study had been granted by the Durban University of Technology Institutional Research Ethics Committee (DUT IREC) (Appendix F), gatekeepers of the MMA associations and the MMA gyms were contacted. The chairman of Mixed Martial Arts KwaZulu-Natal (MMA KZN) was contacted and notified of the study, who then provided information pertaining to the number and location of accredited MMA gyms in the greater Durban area as well as particulars of their owners. The president of Mixed Martial Arts South Africa (MMA SA) was approached who subsequently granted gatekeeper permission for the study to be conducted at MMA SA accredited gyms (Appendix B). The researcher then approached the owners of all of the Durban-based MMA gyms telephonically for permission to conduct the study on their premises in order to invite their members to participate in the study. The gym owners signed written confirmation of permission (Appendix C) once the researcher arrived at the venue prior to interaction with any potential participants. Those that met the inclusion criteria for the study were given letters of information and informed consent (Appendix D) that were required to be read and completed before further participation.

3.4.3. Recruitment/ Advertising

All of the 17 functioning, accredited gyms in the Greater Durban area were approached through the respective gym owners to obtain permission for the gyms to be used as venues for data collection. There were no gym owners that refused the invitation to participate in the study or withhold permission for the usage of their venue(s). One of the 17 gym's owners could not be reached telephonically nor by repeated email requests, therefore due to the unavailability and lack of response from the gym owner in question, that gym could not be visited for data collection. Although the fighters at the gym in question were not able to be sampled, the gym remained an accredited, functioning gym within the study area. An average of the number of eligible participants at each of the participating gyms was taken and used as the estimated number of fighters at the non-participating gym. This was done to establish a workable total number of MMA fighters in the Greater Durban area.

A suitable date and time for data collection at each of the gyms was established telephonically with the gym owners. While only one visit was allocated per gym/venue, the gym owners co-operated with the researcher by giving their fighters advanced notice of the study and requested that all of their members, both fit and injured fighters, be present on the day allocated for data collection. Final recruitment of participants was done on-site at the gyms when the gym owners introduced the researcher, thus requiring no further advertising.

3.4.4. Allocation

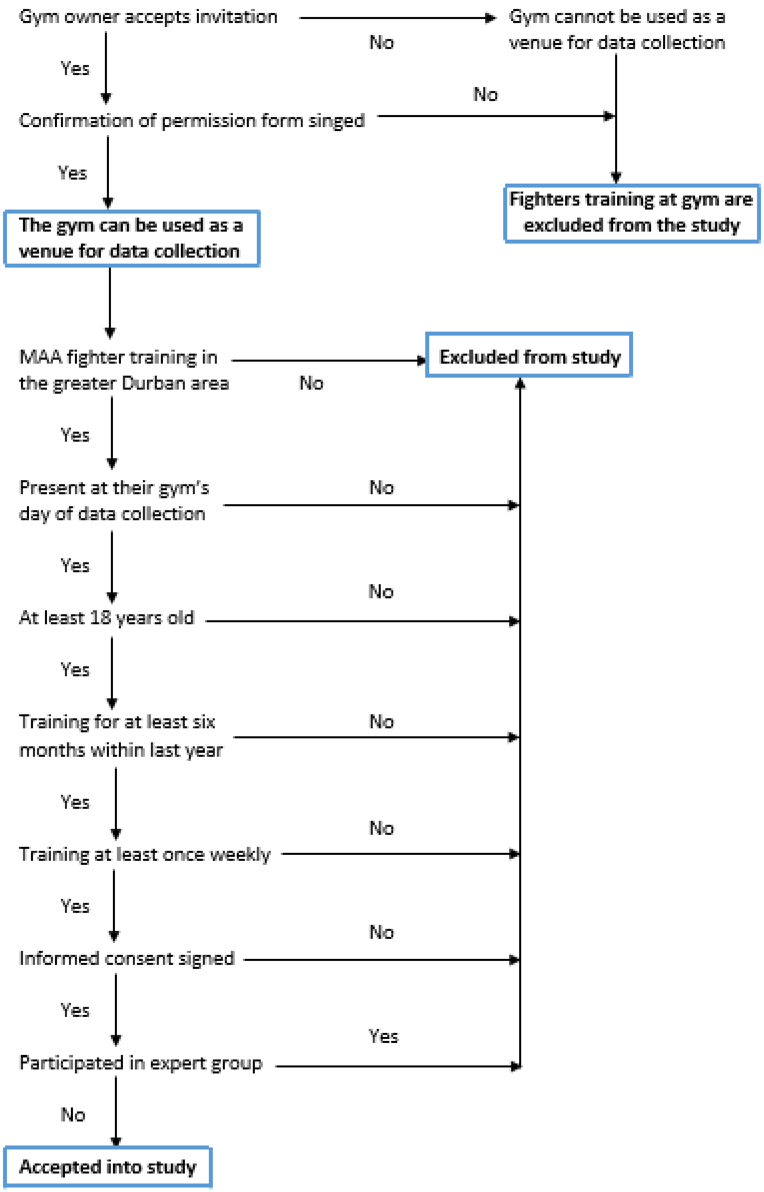
All participants were given identical questionnaires to complete. No grouping was necessary in the data collection stage of the study, as the entire population group was being investigated. Sub-grouping only occurred during data analysis.

3.4.5. Sampling Procedure

The data collection took place at the training location of each of the MMA gyms in the greater Durban area. When on site at each of the gyms, the researcher briefly addressed the potential participants, providing information about the study, the questionnaire (Appendix E) and how to answer it as well as answering questions and invited them to participate in the study. Those that met the inclusion criteria for the study were given letters of information and informed consent (Appendix D) to read and complete. Once participants handed in a completed informed consent form, they were given a questionnaire (Appendix E) to complete as well as a clipboard and pen to use. The questionnaire (Appendix E) was anonymous and did not require any identifying information and was completed by the participants in a self-report manner in the presence of the researcher. The length of time it took for an individual to complete the questionnaire varied according to the number of injuries that needed to be reported on. The average time taken for the completion of a questionnaire was approximately five minutes.

The steps for inclusion of a gym and subsequently its fighters into the study are reflected in figure 3.1 below.

Figure 3.1: Flow diagram for procedure for inclusion of participants into study



3.4.6. Questionnaire Evaluation

Once the data collection had been completed, the questionnaires (Appendix E) were analysed by the researcher and were deemed either usable or spoiled. Spoiled questionnaires were set aside from the usable ones and were not electronically captured.

Questionnaires were deemed spoiled if:

1. Significant data was missing.

Questionnaires with missing data were not automatically deemed spoiled and excluded from the pool of usable data. Data contained in incomplete questionnaires was still utilized provided that the missing data did not exceed 15% of the mandatory sections of the questionnaire (Brazier *et al.* 1992; Griffith *et al.* 1999; Subar *et al.* 2001). The questionnaire consisted of 26 compulsory questions. Questionnaires with missing data of greater than 15% (four questions) of the mandatory sections were deemed spoiled and the data they contained was not used.

Questions with answers that were undiscernible were ignored and the data they contained was deemed missing. In cases of questions that required a single choice where more than one answer was marked, the inappropriately answered question was ignored and deemed missing.

2. Answers indicated that the respondent was not eligible to participate in the study.

   In cases where the information provided by the respondent indicated that they in fact did not meet the inclusion criteria, even after the briefing, the questionnaire was deemed spoiled and was not electronically captured. The answers to the questions that provided this information were Questions: A1 (Age), B1 (Length of time actively doing MMA) and B2 (Number of training sessions per week).

All spoiled questionnaires were kept for records purposes, but were not electronically captured, resulting in the data they contained not contributing to the pool of usable data. While questionnaires that were deemed spoiled due to insufficient completion were not captured, they still contributed to the study's uptake and response rates. In contrast to this, questionnaires that were deemed spoiled due to the respondents not being eligible for the study, did not contribute to uptake and response rates, as this was contributed to only by the target population.

3.5. SAMPLE CHARACTERISTICS

In pursuit of reliable data, the research participants had to meet particular criteria in order to qualify to participate in the study.

3.5.1. Inclusion Criteria

In order to qualify to take part in the study, the following criteria needed to be met:

- Individuals must have been participating in MMA for at least six months in total within a twelve month period prior to the date of data collection.
- Participants must have been training at least once per week during that six month period.
- Participants must have attended and trained at an MMA gym in the greater Durban area.
- Participants were required to be 18 years of age or older.

3.5.2. Exclusion Criteria

Potential participants were excluded from the study if any of the following criteria was applicable to them:

- Any person that participated in the expert group.
- Any person that did not meet the inclusion criteria.
- Any person that declined the invitation to participate in the study.
- Any person who failed to or refused to sign informed consent.

3.5.3. Expert group

Following ethical clearance for the study to be conducted from the DUT IREC (Appendix F), an expert group was convened to critically assess the questionnaire in terms of face validity and content validity**.** The following information regarding the expert group can be viewed in the appendices indicated:

The motive and process for the expert group:	Appendix G
The pre expert group questionnaire:	Appendix H
The changes to the questionnaire suggested by the expert group:	Appendix I
The post expert group questionnaire:	Appendix E

3.6. QUESTIONNAIRE DEVELOPMENT

The questionnaire (Appendix E) was created in order to assess the prevalence of and role of risk factors for injuries in MMA fighters and consisted of three sections, namely demographics/participant information (Section A), training (Section B) and injuries (Section C).

3.6.1. Section A

Section A covered demographics and participant information and was created by making use of standard demographic questions as well as incorporating some questions that the researcher considered appropriate and necessary. There were 15 questions in total in Section A, which covered basic demographics, hand dominance and usage, occupation, injuries sustained from any activities outside of MMA, surgical history, smoking and alcohol consumption. These questions were tools in extracting information pertinent to the study and information that could assist in decreasing the potential of inaccurate information and extraneous variables.

3.6.2. Section B

Section B covered the participants' training habits that were specific to MMA activities. This section consisted of eight questions through which the participants could describe their training regimen and what form of activities and techniques were covered, as well as describing the usual conditions of their training.

3.6.3. Section C

Section C of the questionnaire covered injury-reporting and required the participants to describe their injuries by completing fields in a table format. The design of this section was based on a component of a questionnaire by Kazemi and Pieter (2004), who gave permission for the component to be used in the development of the questionnaire used in this study (Appendix M). Rather than repeat a page-long injury inquiry five times (a page per injury), it was decided to utilize this table design which recorded details of all five injuries on one page, as it is noted by Mouton (1996) and (Kelley *et al.* 2003) that long or repetitive questions can result in loss of interest, inaccurate responses and poor quality data.

All injuries reported on must have been sustained though MMA activities. There were six required fields that identified and described the specific injury, each with examples. The participant could enter information for up to five different injuries. The participant completed the table by entering the most appropriate answer into the relevant field from a list of possibilities found on the questionnaire. The fields to be completed consisted of: Injured area, side, type, days out, activity and mechanism (see Appendix E) .Section C was divided into two categories, namely, current and previous injuries, with the same table contained in both sections.

3.6.3.1. Current Injuries

Participants were required to describe (up to five of) their most significant current injuries (if any) sustained though MMA activities. This section was for injuries that the participant was currently suffering from.

3.6.3.2. Previous Injuries

Participants were required to describe (up to five of) their most significant previous injuries (if any) sustained though MMA activities. Previous injuries were limited to injuries sustained within the 12 month period prior to the date of data collection. This time-specific criterion was implemented in order to minimize the effect of memory decay, which shows that an increased length in time is indirectly proportional to data quality and reliability (Jenkins *et al.* 2002).

3.7. STATISTICAL METHODOLOGY

Once the usable data had been identified, it was captured electronically by the researcher and coded for statistical analysis. The data was analysed with SPSS version 23.0. The results obtained from the questionnaires is presented in Chapter Four. The results will present the descriptive statistics in the form of graphs, cross tabulations and other figures for the qualitative data that was collected.

The relationships and the strength thereof between categorical variables were analysed using Chi squared methodology and measured by Fischer's Exact Test (Exact Significance 2-sided) to obtain the p-value, Spearman's Correlation (Value) to obtain the correlation value and Spearman's Correlation (Exact Significance) to obtain the correlation p-value (see Appendix J) (Bahr and Holme 2003). Relationships are considered significant by using a 95% confidence interval. Correlation values range -1 to 1 (0 = neutral / no correlation) to show the strength and nature of proportion of the correlation between the variables.

Relationships between nominal variables, or that of nominal variables against categorical variables are measured by Eta scores, which are interpreted using effect size and are considered to show significant relationship strength from a value of 0.24, where ≥0.24 = medium or typical; ≥0.37 = larger than typical; >0.045 = much larger than typical. (Morgan *et al.* 2004).

4. RESULTS AND DISCUSSION

4.1. INTRODUCTION

The research instrument consisted of 26 items, with a level of measurement at a nominal or an ordinal level. The questionnaire was divided into 3 sections (A, B and C) which measured various themes as illustrated below:

Section	Topic
A	Biographical Data: Fighter Profile
B	Biographical Data: Training Profile
C	Injuries

4.2. BIOGRAPHICAL DATA: FIGHTER AND TRAINING PROFILES

The results presented in this section are representative of the data obtained from Section A of the questionnaire.

4.2.1. Fighter Profile

This section measured the nominal and ordinal values captured in Section A of the questionnaire.

4.2.2. Sample Size and Response Rate

In order to achieve a significant (medium to large) statistical effect, 80% of the total population of 116 MMA fighters in the greater Durban area was required (Faul *et al.* 2009). In total, 109 questionnaires were despatched and 105 were returned, rendering a 91% response rate. This is comparable with a study by Destombe *et al.* (2006) who assessed the responses of 186 out of 206 Karate athletes in France, obtaining a response rate of 90%. While the sample size of this study is smaller that of Destombe *et al.* (2006), the response rate is representative of the whole population of MMA fighters in the greater Durban area.

Studies that assess populations of a limited number may often have small sample sizes. While the response rate is greater, the sample size of this study is comparable to that of local sports injury studies that investigated various populations by means of a questionnaire in the province of KwaZulu-Natal, as seen in the work of Coetzee (2013), who assessed 71% of active amateur and semi-professional triathletes, with a sample size of 57 participants, and that of Archary (2008), who assessed 70% of league amateur indoor and outdoor soccer players, with a sample size of 126 participants.

A high percentage sample size (above 70%) is often necessary in smaller populations in order to achieve a significant statistical effect, as the potential for error exists when using a smaller number of participants (with e.g. 30% sample size) even if that number is representative of the total population (Faul *et al.* 2009).

This section summarises the biographical characteristics of the respondents in terms of demographics, lifestyle and history. The number of participants was proportionally drawn from 16 clubs (MMA gyms). The frequency spread of the numbers participating is shown in the table below.

Table 4.1: Distribution of percentage of participants described by club (*N*=105)

Club	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Percent	5,7	8,6	9,5	1,0	18,1	4,8	9,5	6,7	4,8	3,8	3,8	6,7	5,7	2,9	2,9	5,7

The mean number of participants per club was 7, with the smallest club allocation being 1 and the largest being 19. There was no baseline available for comparison in other studies in regards to distribution by club.

4.2.3. Fighter Characteristics

Details of the particulars that contribute to the characteristics of the profile of the MMA fighters is shown in table 4.2 below.

Table 4.2: Percentage distribution of gender, age, height, weight, ethnicity, hand dominance and occupational activity of participants (*N* = 105)

Gender	Percent	
Female	16.2	
Male	83.8	
Age	**Percent**	
	Female	**Male**
18 - < 20	0	4.8
20 - < 30	7.6	39.0
30 - < 40	4.8	31.4
40 - < 50	1.9	6.7
50 - < 60	1.9	1.9
Height	**Percent**	
Minimum	1.5	
Maximum	1.9	
Mean	1.7	
Weight	**Percent**	
Minimum	53	
Maximum	138	
Mean	79.9	
Ethnicity	**Percent**	
African	6.7	
Asian	1.9	
Coloured	14.4	
Indian	14.4	
White	62.5	
Hand Dominance	**Percent**	
Right	83	
Left	8	
Ambidextrous	9	
Favour dominant Hand	**Percent**	
Right	81	
Left	77.8	
Occupational Activity	**Percent**	
	Total	**Injured within group**
Bending	1	0
Constant movement	17.3	11.1
Driving	7.7	0
Manual labour	4.8	0
Sitting	46.2	6.5
Standing	12.5	0
Walking	10.6	9.4

Overall, the ratio of females to males is approximately 1:5 (16.2% : 83.3%). The youngest participant was 18 and the oldest was 52 years old, with a mean age of 30 years. These findings were similar to trends observed in international studies that assessed martial artists and their injuries. Feehan and Waller (1995) assessed Taekwondo injuries in New Zealand, where the male to female ratio was approximately 5:1 (81% : 18%) respectively. With similar figures, an investigation of injuries in participants at Muay Thai clubs around the United Kingdom and the Netherlands showed a male to female ratio of 6:1 (82% : 13%) (Gartland, Malik and Lovell 2001). Destombe *et al.* (2006) observed a lesser spilt when assessing injuries in French Karate athletes where the male to female ratio was approximately 3:1 (76% : 24%) respectively. The male to female ratios observed in these studies range from 3:1 to 6:1, placing this study's gender ratio in close to the mean and within the trends as seen by these studies.

All of the participants in the age category of 18 to 20 were male, followed by a 1:5 ratio of females (16.3%) to males (83.7%) in the age category of 20 to 30 years, a 1:7 ratio between females (13.2%) and males (86.8%) in the age category of 30 to 40 years, a 1 : 4 ratio of females (22.2%) to males (77.8%) in the age category of 40 to 50 years, and an equal split of females (50%) to male (50%) in the age category of 50 to 60 years.

Males in the age category of 18 to 20 years, contributed to of 4.8% the total number of males. Almost half of the total number of females (47.1%) and the total number of males (46.6%) were between the ages of 20 to 30 years. Of the remaining total number of participants, 29.4% and 37.5% of the total number of females and males respectively were in the age category of 30 to 40 years, similarly, 11.8% and 8% of the total number of females and males respectively were in the age category of 40 to 50 years, and 11.8% and 2.3% of the total number of females and males respectively were in the age category in 50 to 60 years.

While these results form near a mean value of those observed in other studies (as abovementioned), numerous studies conducted in various states of the USA and Japan investigated injuries at MMA competitions where there was no female participation at all (Bledsoe *et al.* 2006; Buse 2006; Ngai, Levy and Hsu 2008; Scoggin *et al.* 2014). It is unclear whether the nature of the male-only participation seen in these studies is due to negligible numbers of female MMA participants at the events in question or due to the nature of the study design(s).

For the purpose of local comparison, the South African study by du Preez (2013) was of limited use, providing only the details on age groups according to competitive age categories. Of the total population, 35% of participants constituted the 14-16 years category (mean=15.33, std.dev=0.63), 20% of participants constituted the 17-19 years category (mean=17.75, std.dev=1.14) and 45% of participants constituted the 20+ years category (mean=23.0, std.dev=5.16). This does however, demonstrate the large percentage of individuals over the age of 20 that are actively participating in martial arts in a South African context, which is reflective of the results of this study. This pattern of greater involvement in the adult years (20 - <30) in the martial arts may be due to a stigma of violence that many parents may want to discourage their children from, especially raising their children in a country with a history of violence, with the result of many individuals starting participation in a martial art once they have begun an independent and self-sufficient lifestyle.

Age values for injury-based studies in the martial arts vary in international literature, with the average minimum age value at 14.2 years (min=6, max=19), the average maximum age value at 48.8 (min=44, max=53), the average mean age at 31.5 (min=19.6, max=29.2) and the average standard deviation at 5.07 (min=4.7, max=5.7) (Feehan and Waller 1995; Gartland, Malik and Lovell 2001; Bledsoe *et al.* 2006; Buse 2006; Destombe *et al.* 2006). This study has similar mean, extreme and standard deviation values and ranges as that of the international literature, which may suggest a better integration of martial arts into society as an accepted practice in more developed countries.

Of the 105 participants who completed the questionnaire, 97 entered data for height, and 101 entered data for weight. The distributions for the age and weight are not normally distributed ($p = 0.002$ and $p = 0.005$ respectively), this is also observed with the large standard deviations for these variables (age = 7.9 and weight = 15.5). The height variable is normally distributed ($p = 0.2$) and has a small standard deviation (0.1).

The height of the participants in this study is in correlation with Buse (2006) who observed that the participants of a ten year review of mixed martial arts competitions had a mean height value of 1.80m, with a minimum value of 1.6m, a maximum value of 2.1m and a standard deviation of 0.1m. This suggests standard adult height variances, without incidences of individuals that are very short e.g. in the case of achondroplastic dwarfism, or very tall, as is in the case of gigantism, who may, for medical reasons decide not to participate in martial arts.

The weight of the participants in this study is lower than average when compared to the findings of international studies where the values for weight were available, with the average minimum weight is 62kg (min=60.0, max=63.6), the average maximum weight being 219.55kg (min=166.4, max=272.7) and the average mean weight at 92kg (min=87.6, max=96.4). The mean weight of the participants of this study is 13% lower than that of the participants of the studies above by Bledsoe *et al.* (2006) and Buse (2006). This variation is expected with differing body types of the participants of the different studies, as Bledsoe *et al.* (2006) and Buse (2006) included professional MMA athletes only, who can be expected to be conditioned and more muscularly defined than the average participant in this study.

The trend of ethnic distribution as found in this study was also identified by Feehan and Waller (1995), who showed that of the population MMA fighters in New Zealand, the majority were European (83%), with 8% Chinese, 4% Maori and 4% Pacific Islander. This distribution pattern may be linked to the participants' socio-economic and financial status, which may include distance from areas of residence to MMA gyms, whether or not a participant has friends that able to attend the same training sessions, and the ability to afford training fees. The findings of this study are on par with that of Feehan and Waller (1995) in terms of all demographic markers that were identified in the study (ethnicity, gender and age).

It is noted that in fighting sports, the left hand dominant fighter is at a distinct advantage when facing a right hand dominant fighter due to the exposure of left-handers to right-handers and vice versa, giving that right handedness is far more common than left handedness (Zverev and Adeloye 2001; Harris 2010). This concept can also be applied to the population of left hand dominant MMA fighters, as 8% of this study's population were left-handed, with a further 9% being ambidextrous.

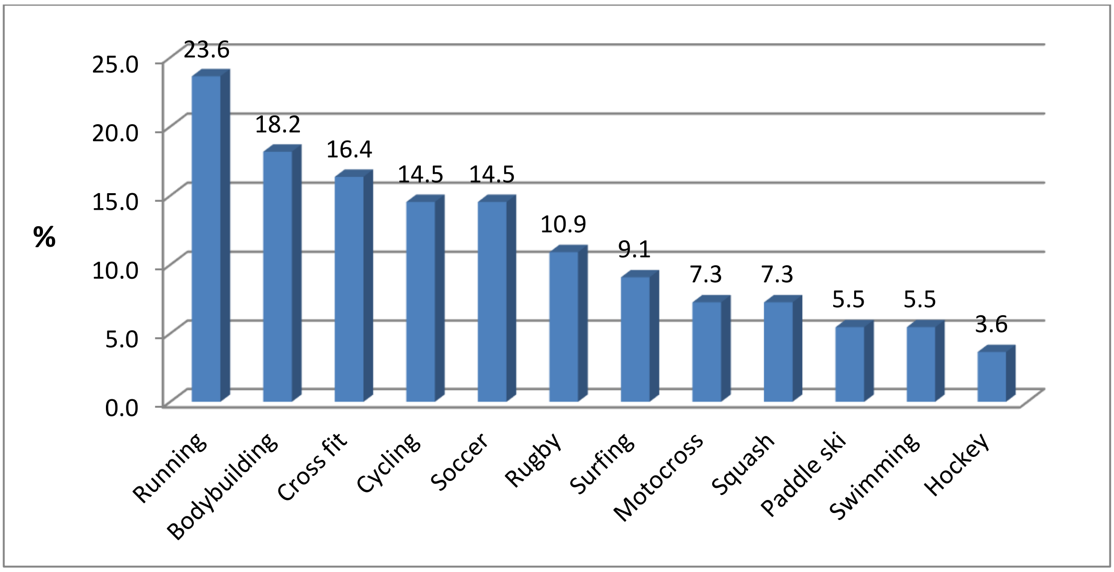
Hand dominance is a strong indicator for the side of injury that will be sustained in a fighting situations (Beaton, Williams and Moseley 1994), suggesting favouring of the dominant hand in both right handed and left handed individuals. This is consistent with the results of this study, as there was a negligible difference in percentage between those right handed fighters who favoured their right hand as opposed to their left. While studies have demonstrated the natural advantage that left-handers have over right handers in oppositional contact sports (Harris 2010), a contrast of greater longevity and lower risk of head injury is enjoyed by right handed athletes over their left handed counterparts (Aggleton, Kentridge and Neave 1993; Zverev and Adeloye 2001). This evidence suggests that fighters who favour neither their left nor right hands (ambidextrous individuals) may enjoy a degree of advantage over fighters that prefer fighting with one side as well as enjoying a lesser risk of head injury.

It is noted that the risk of low back injury is increased when spinal flexion manoeuvres are performed after periods of sitting that exceed one hour (Beach *et al.* 2005). The occupations of 46.2% of the participants in this study consisted mostly of sitting. These findings of occupational activity and risk of injury thereof cannot be compared to the populations of similar studies, as studies in the area of injuries in the martial arts lack details concerning the occupational and home life of participants. This information is available as a reference and starting point for future studies that will investigate these variables and their connections further.

4.2.3.1. Activities Outside of MMA

In addition to participation in MMA, potential existed for participants to have contracted injuries through participation in additional sports, through occupational activities and though means outside of MMA, work or sports.

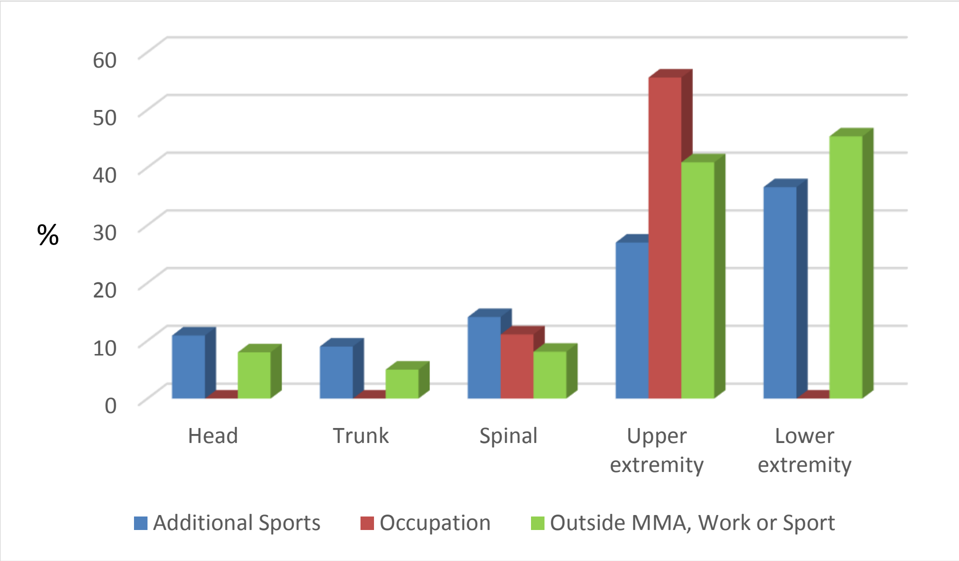
Figure 4.1: Bar graph representing sports most commonly done in additional to MMA (%)



Of the total number of participants (N = 105), 52.4% engaged in sports additional to their participation in MMA. Multiple responses by participants were allowed in cases of participation in multiple sports. Of the participants who did play other sports (n = 55), 54.5% indicated that they had been injured (28.6% of the total sample).

Participation in multiple sports concurrently is a factor that may have a strong contribution (positively or negatively) to the risk of injury contraction. The effect of other sports on the reduction or compounding of specific risks of injury from participation in the martial arts is largely unknown. Exception is seen in general risk of injury, such as the benefit of further cardiovascular conditioning or flexibility may be enjoyed as a result of participation in additional sports (Laursen and Jenkins 2002; Wisløff *et al.* 2007). The findings of this study regarding the percentage of participants who are actively involved in sports additional to MMA have no existing standard to be compared against. Participation in sports additional to MMA can be due to personality and activity preferences that differ between fighters, or due to parental or peer motivation (Seabra *et al.* 2008). Fighters who wish to or do compete in competition also recognise the need for conditioning which often cannot be fully incorporated into their MMA training, but can be supplemented by participation in additional sports e.g. running, bodybuilding, etc.

Figure 4.2: Bar graph representing injuries sustained outside of MMA by region (%)



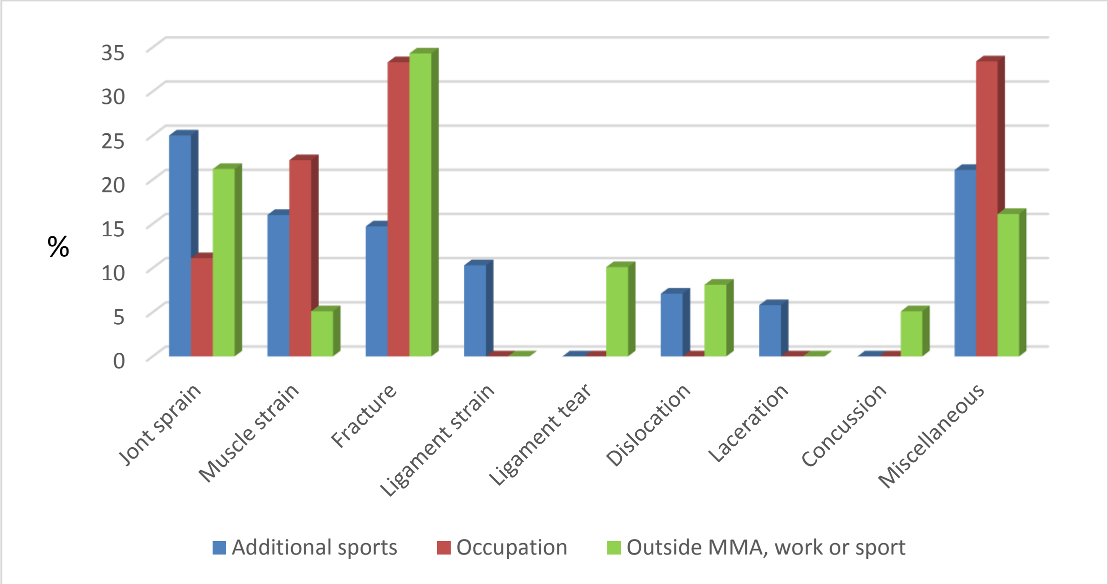
The figure above represents the type and area of the injuries sustained from participation in sports additional to MMA, occupational injuries and though means outside of MMA, work or sports.

In injuries due to participation in additional sports (*n* = 55), the most common injuries were skull and facial bone (each at 4%) in the head region, ribs (6.4%) in the trunk, low back (12.8%) in the spinal region, shoulder (16.1%) in the upper extremity, and knee (12.8%) followed by ankle (10.9%) in the lower extremity. Injuries to the right side of the body (41.1%) were more common than those to the left (33.4%). The remainder (25.5%) of injuries were reported to be areas without side specifications e.g. neck.

In injuries due to occupational activity (*n* = 9), the most common injuries were low back (11.1%) in the spinal region, shoulder (33.3%) followed by wrist and fingers (each at 11.1%) in the upper extremity. There were no injuries reported on the left side of the body, as opposed to the majority of injuries being on the right side of the body (55.6%). Injuries without side specifications e.g. low back were at 11.1%, with the remaining 32.3% of injuries being unaccounted for in terms of side due to some participants failing to complete all fields regarding occupational injuries.

In injuries that occurred outside of MMA, work or sport (*n* = 40), the most common injuries were skull (4%) in the head region, ribs (4%) in the trunk, low back (8.1%) in the spinal region, shoulder (9.1%) followed by upper arm (7.1%) in the upper extremity, and knee (28.3%) followed by ankle (11.1%) in the lower extremity. Injuries to the left side of the body (49.5%) were more common than those to the right side of the body (28.2%). The remainder (22.3%) of injuries were reported to be areas without side specifications e.g. facial bone.

Figure 4.3: Bar graph representing injuries sustained outside of MMA by type (%)



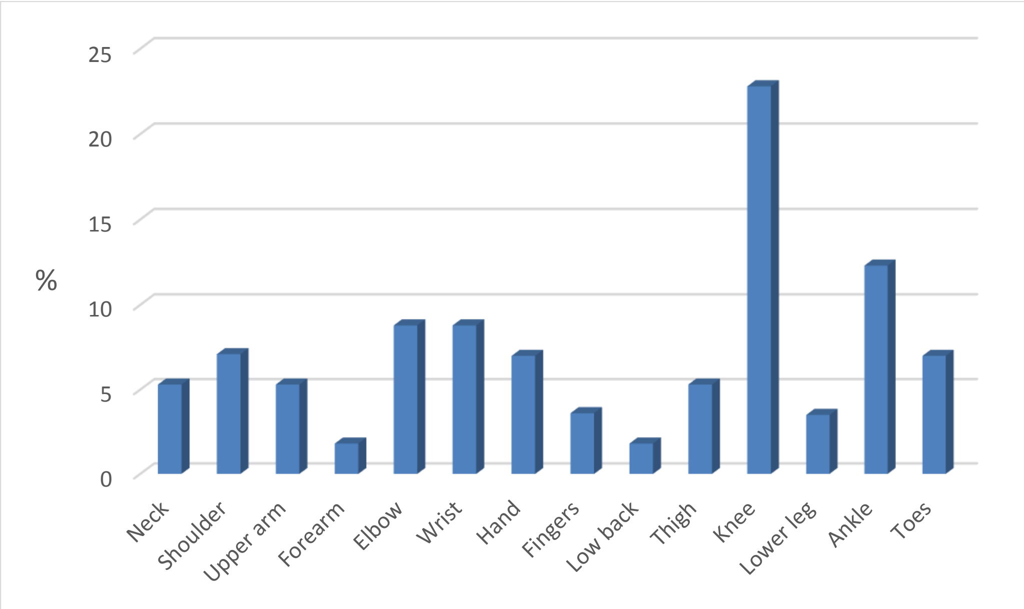
*Miscellaneous: Indicates categories of injuries that were less than 5% individually or not specified

For injuries due to participation in sports in addition to MMA, the predominant types of injury when considered together were joint sprains (25%), muscle strains (16%) fractures (14.7%) and ligament strains (10.3%). In injuries due to occupational activity, the predominant types of injury were fracture (33.3%), muscle strain (22.2%) and joint sprain (11.1%). In the case of injuries that occurred outside of MMA, work or sport, the predominant types of injury were fractures (34.3%), joint sprains (21.2%), ligament tears (10.1%) and dislocations (8.1%).

The majority of studies that report on findings of injuries in the martial arts are observational in nature, taking place at a particular event or set of events, with the methodology almost always consisting of descriptive analysis of the injuries that presented due to participation in competition, but fail to investigate the precipitating factors of the injury (Feehan and Waller

1995; Critchley, Mannion and Meredith 1999; Gartland, Malik and Lovell 2001; James and Pieter 2003; Arriaza and Leyes 2005; Bledsoe *et al.* 2006; Buse 2006; Ngai, Levy and Hsu 2008; Arriaza *et al.* 2009; Kazemi *et al.* 2009; Scoggin *et al.* 2010; du Preez 2013; McClain *et al.* 2014; Scoggin *et al.* 2014). Knowledge of injuries that are present in an individual that are unrelated to their MMA participation may be valuable in terms of identifying risk factors for injury within MMA

Figure 4.4: Bar graph representing areas of musculoskeletal surgery having been done (*n* = 31)



There was an almost even distribution of surgeries between left and right sides (43.9% and 49.4% respectively). The remaining 12.2% of surgeries were attributed to areas without side specifications e.g. neck surgery.

Table 4.3: Types of musculoskeletal surgery performed (%)

Surgery	Joint reconstruction	Ligament repair	Fracture repair	Stability plate or pin	Surgical relocation	Tendon repair	Cartilage resection Not sure	DIP amputation; Infection removal
Percent	21.1	19.3	19.3	15.8	8.8	5.3	3.5	1.8

*DIP = Distal interphalangeal joint

In a similar circumstance to that described in injuries sustained outside of MMA, work or sport, there is a paucity in the description of precipitating factors of injuries in studies similar in nature to this study. This yields a largely incomparable set of findings but could yet contribute to the understanding of the prevalence and risk factors of injuries. Notwithstanding the lack of a wide range of comparative factors, 29.5% of this study's population had undergone surgery, which is a percentage very closely comparable to that of an international survey investigating upper extremity injuries in martial arts participants, where 30% of the population required surgery (after participating in competition), ranging from one to five surgical interventions per case (Diesselhorst *et al.* 2013). The area and type of surgery were not recorded.

The high rates of surgeries required on the left followed by right knee can be understood by observing the manner in which MMA fighters conduct themselves in fights, being willing to sacrifice a safe but tactically disadvantageous landing for the tactical advantage which can result in inappropriate and harmful landings, causing unnecessary repetitive stress on joints. This may also result if fighters attempt to remain in an upright position by kneeling on one or both knees after losing balance from a standing position.

4.2.3.2. Smoking and Alcohol

Participants reported on their smoking habits, which indicated that 45.7% of participants (n = 48) admitted to having a history of smoking, with 20.4% still being current smokers and 79.6% being ex-smokers. The mean period of smoking was 7 years (std.dev = 5.4) and the mean number of cigarettes smoked daily was 11.5 (std.dev = 6.9).

Of the participants who had a smoking history, 42.9% smoked for a period of 1 – 5 years, 37.1% smoked for 6 – 10 years, 11.4% smoked for 11 – 15 years and 8.6% smoked for 16 – 20 years, with no reports of smoking for longer than 20 years. Of same population of current and ex-smokers, 28.1% indicated that the average number of cigarettes smoked daily was 1 – 5, while 31.2% smoked 6 – 10 cigarettes daily and 40.6% smoked 11- 20 cigarettes daily, with no reports of smoking more than 20 cigarettes daily.

Knowledge of precipitating factors for injury in martial artists remains limited. Studies have shown the prevalence of smoking and alcohol use in populations of athletes from varying countries. It was noted in two systematic reviews that there is a trend of less smoking but higher alcohol consumption in young adult athletes when compared to their sedentary counterparts. (Lisha and Sussman 2010); Diehl *et al.* (2012)

Hessami *et al.* (2012) showed that out of 738 professional Iranian athletes spanning ten different sports, 24.6% of the participants had experienced cigarette smoking with 9% that were current smokers. Spanoudaki *et al.* (2005) conducted a study among Greek young adult athletes, where 10.4% of 1003 participants were current smokers who smoked an average of 13.6 cigarettes per day. 9.1% of the male participants and 12.4% of the female participants reported to currently smoke at the time of the study. Higher rates of smoking was observed in the participants of six particular sports, one of these being Kickboxing, a martial art.

In regards to smoking, this study's findings of current smokers are in almost exact accordance with that of Hessami *et al.* (2012) and Spanoudaki *et al.* (2005), with a current smoking rate of 9.5% of the participants. The finding by Hessami *et al.* (2012) is exceeded by that of this study, with 36.2% of participants having experienced cigarette smoking in their lives. In regards to those who did smoke, the findings by Spanoudaki *et al.* (2005) were marginally higher than those in this study, where the reported average period that the participants smoked for was 7.2 years and smoking an average of 11.5 cigarettes daily. The trend of a larger portion of athletic individuals being non-smokers may be linked to a degree of natural euphoria and stimulation after exercising that non-athletes may seek from nicotine in cigarettes.

Of the total number of participants, 46.7% consumed alcohol on a weekly basis (n = 49), with 23.8% consuming 1 – 2 tots weekly, 11.4% consuming 3 – 5 tots weekly, 5.7% consuming 6 – 9 tots weekly, 4.8% consuming 10 – 14 tots weekly. Although only 2.9% of participants admitted to consuming more than 14 tots per week, the volumes consumed were significantly higher than the rest of the population of drinkers, with one participant admitting to consuming 120 tots of alcohol per week. These extreme values resulted in a large standard deviation of 12.3.

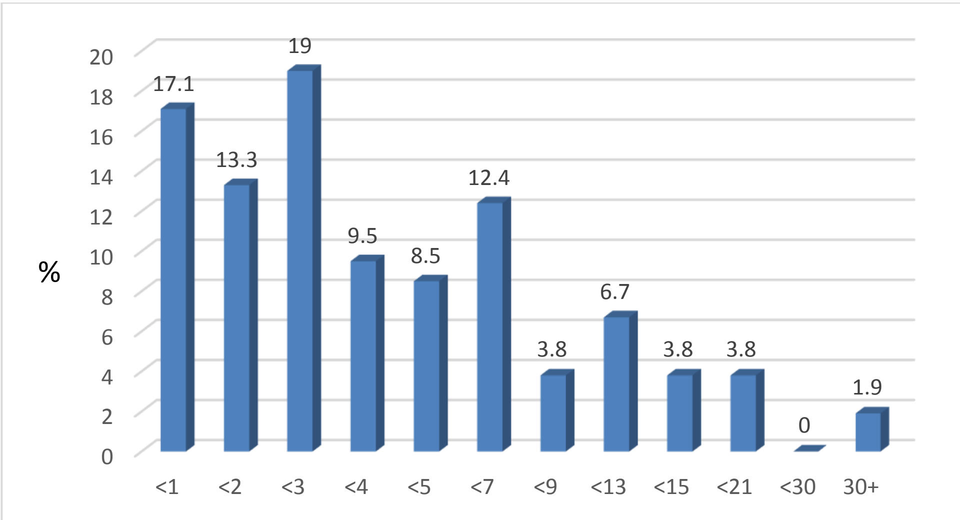
In regards to alcohol consumption, a study of 215 students at each of 127 American colleges by Wechsler *et al.* (1997) found that in males, binge drinking occurred in 61% of participants who were heavily involved in athletics, in 55% of participants who were partly involved in athletics and in 43% who did not participate in athletics, further suggesting that sport involvement is an indicator for higher alcohol consumption than those who are not involved in sports. This is in contrast to the findings of this study, where the majority of MMA fighters (53%) were non-drinkers, consuming a relatively low average of 3.3 tots of alcohol per week. There is however, some correspondence in that of the category pertaining to weekly alcohol consumption greater than 14 tots (highest category by volume), where the values are 20, 30 and 120 tots of alcohol weekly respectively, which may be due to binge drinking.

Fewer patterns of high-volume drinking are noted in this study and could be due to the most dense population group being 20 - <30 followed by 30 - <40, which excludes the adolescent fighters, the likes of which were the subjects of the study by Wechsler *et al.* (1997) where high volume alcohol consumption was noted.

4.2.4. Training Profile

The results presented in this section are representative of the data obtained from Section B of the questionnaire.

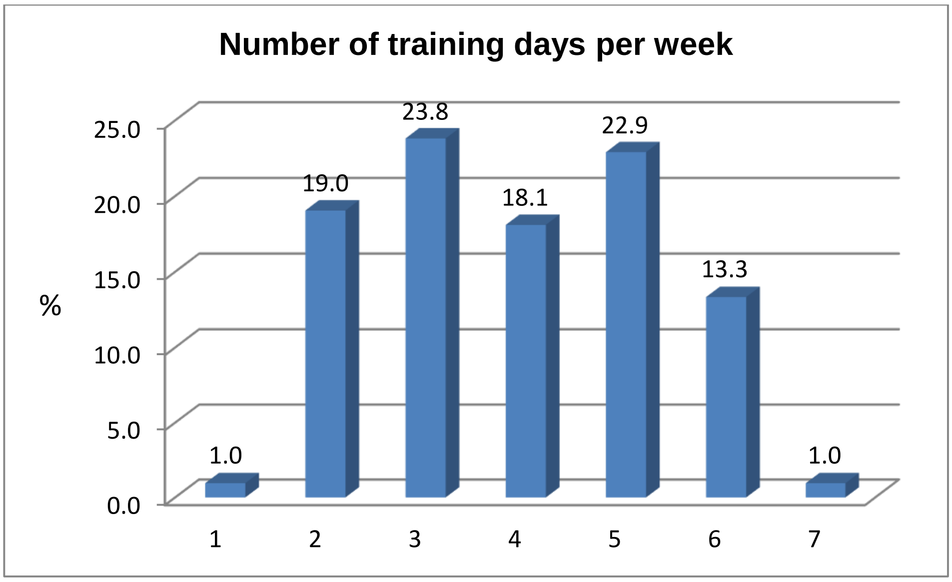
Figure 4.5: Bar graph representing period actively doing MMA (years)



More than half (59%) of the population had been actively participating in MMA for less than 4 years, with a further 21% of the population having actively participated for between 5 to 7 years. The final 20% of the population was spread between active involvement from 7 to 30+ years, where only 1.9% of which reported to have been actively doing MMA from between 21 and 30+ years.

Studies conducted in populations that are active in and at risk of injury in the martial arts have presented varying findings in terms of training profiles. A study by Rainey (2009) shows a peak in the total time spent participating in the martial arts being less than a year (47.3% of the study population), whereas the average time spent participating in fighting sports as found by Destombe *et al.* (2006) is 5.8 years, with Gartland, Malik and Lovell (2001) reporting an average participation period of eight years. While none of these studies portrays the trend noted in this study, these diverse findings are a good representation of the spread of experience found in the participants, where 1-4 years' experience is representative of 59% of the population, with 21% representation in the 5-7 years' experience category. Reasons for the relatively short period of active involvement in MMA may be due to the nature and high physical demands of the sport, with moderate to serious injuries being enough to dissuade fighters from further participation in MMA.

Figure 4.6: Bar graph representing number of training days per week (%)



The figure above shows that 98% of the participants practice between 2 and 6 times per week, with the highest population of fighters (23.8%) training 3 times per week, closely followed by 22.9% of whom train 5 times per week. Numbers of those who train 2, 4 and 6 days a week are 19%, 18.1% and 13.3% respectively. The minority of fighters (2%) reported to train once (1%) and 7 times (1%) weekly respectively.

More than half (50.5%) of the study population participate in one training session on any given training day, followed by 35.5% of participants training twice a day. The remaining 14.3% of participants reported to do multiple sessions daily, which consisted of 10.5% training between 3 and 4 times daily, with the remaining 3% of participants training 5 time (1%), 6 times (1%) and 7 times (1%) times daily respectively. Duration of a single training session was reported to range from 60 minutes (1 hour) to 150 minutes (2.5 hours). More than half (50.5%) of the participants train for 60 minutes (1 hour), followed by 20% training for 120 minutes (2 hours), 19% training for 90 minutes (1.5 hours) and 8.6% training for 150 minutes (2.5 hours). 2% of the participants trained for 75 minutes, which is the only training time to not be a multiple 30 minutes.

According to the findings of various studies, the time spent training per week varies, as Rainey (2009) shows a peak incidence (36% of the study population) of training for 12 or more hours/week, with Destombe *et al.* (2006) reporting an average of 3.1 hours/week with findings from Zetaruk *et al.* (2005) who noted 5.4 hours/week. This demonstrates the large variation in different study populations in varying sets of circumstances.

Instead of presenting time spent in training as hours per week, this study presents training details in terms of number of training sessions per week (peak incidence of 3 and 5), number of training sessions on a training day (peak incidence of 1) and duration of training sessions (peak incidence of 60 minutes).

Comparisons and similarities have been drawn between the techniques used in MMA competitions that originate from particular styles, with emphasis on the type of technique, which fall broadly into either striking or grappling. This is observed in the works of:

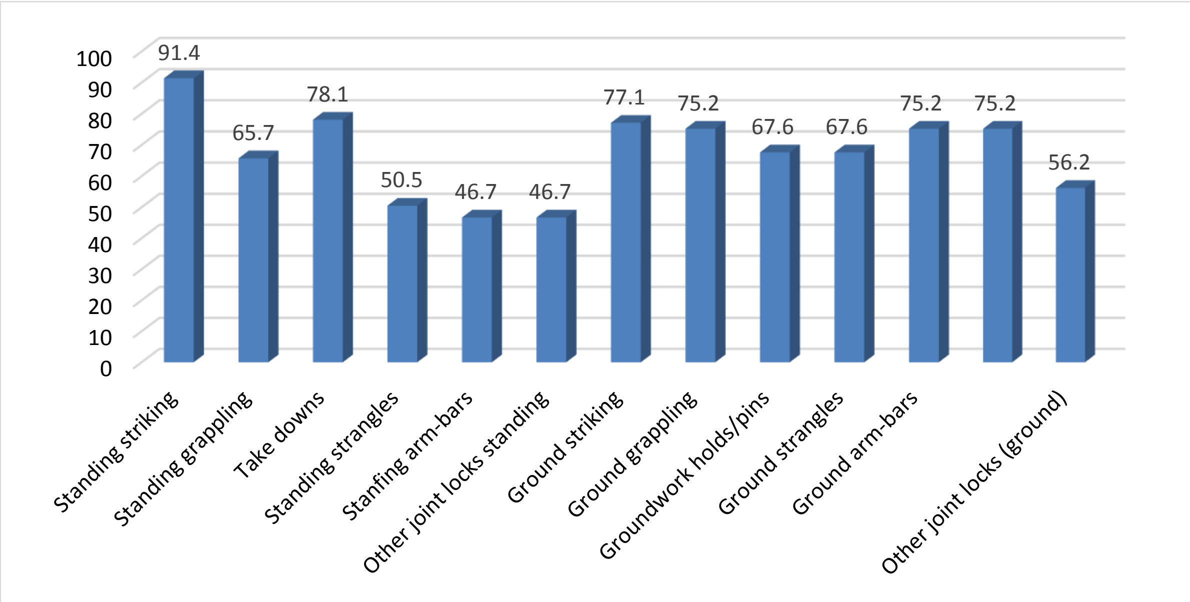
Zetaruk *et al.* (2005) compared injuries in five martial art styles (Karate, Tae Kwon Do, Aikido, Kung Fu and Tai Chi. Rainey (2009) assessed injuries in MMA fighters, where the most common background form was Wrestling (grappling), flowed by Jiu-Jitsu (grappling) and freestyle Kickboxing (striking). Buse (2006) reviewed televised MMA competitions in the USA and Japan over ten years, noted the proportions of background fighting styles, namely Jiu-Jitsu (22.2%), Wrestling (20.3%), Submission fighting (16.2%) and Kickboxing (12.9%) to mention the major contributors. Diesselhorst *et al.* (2013) surveyed MMA fighters internationally for upper extremity injuries, found that in answer to the question of what martial art the participant did, ‘multiple’ was most common response (38%), followed by Karate (28%) and Tae Kwon Do (22%).

The wide variance in the background type of martial arts can be due to multiple factors, such as the preference of the instructor, the ability/inability of the fighter to execute certain skills and the interest of the fighter in naturally defensive or aggressive martial art forms, to mention a few. In comparison to the studies that note the basic art forms, and by extension, the basic technique sets adopted by the participants, this study describes the general and specific activities that the participants took part in during their MMA training sessions.

There were five categories reported on in respect to general activities covered in MMA training. Due to the nature of the question, respondents marked all of the general activities that were covered in their MMA training sessions (repeat measures were allowed), necessitating percentage values being presented per activity. No one category was indicated by the entire sample. The activity done by most of the participants was cardio/fitness (95.2%), followed by technique (87.6%), sparring (81.9%), strength training (72.4%), with the activity least done being flexibility (48.6%). It is important to note that participants or groups (clubs) of participants may have included various combinations of these activities in their training.

The diverse nature of the perceived teaching and practicing of MMA is evident within this study population. The wide-spread nature of general activities can be attributed to time limitations of training sessions, where covering all of the desirable conditioning strategies may not be feasible.

Figure 4.7: Bar graph representing specific activities Included in MMA training (%)



In a similar manner to that of general activities, specific activities were reported on by participants by marking all of the fields (specific activities) that were covered in their MMA training sessions (repeat measures were allowed) with percentage values being displayed per activity. As with general activities (cardio, flexibility etc), no one category was indicated by the entire sample. It is noted that arm-bars (standing or on the ground) are joint locks that are applied to the elbow, with the category of other joint locks referring to a joint lock of any extremity joint in the body other than that of elbows and usually with the exception of fingers and toes. It is noted that although standing striking is done by most of the participants (95.2%), 4.8% of the participants reported not doing standing striking, which is an interesting observation in MMA fighters.

Again it is noted that no single specific activity was practiced/included into the training sessions of 100% of the MMA fighter population. This may be as a result of preferences of the instructor or of the participant, or as a result of the participant being unwilling or unable to participate in a given specific activity.

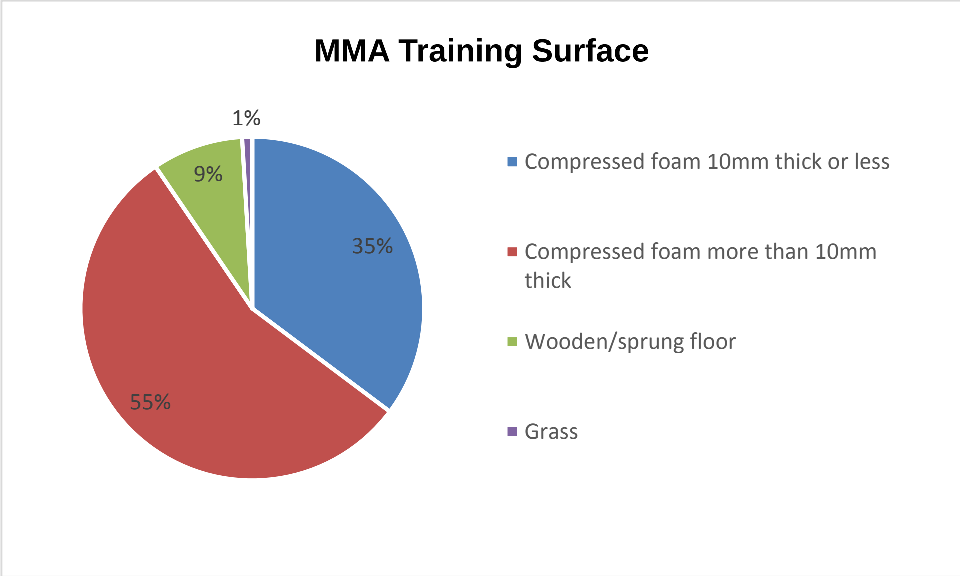
The conditions under which MMA is done may have varying degrees of influence on the fighters and the way in which they practice. This can include training supervision and environment.

Accredited coaches (coaches recognised by the MMA governing body) that supervised MMA training sessions were reported by 84% of the participants. Coaches that lacked accreditation were reported as training supervisors by 2% of the population. It was reported by 10% of the population that rather than having their training supervised by a coach, this function was performed by another fighter, with the remaining 4% not knowing the credentials of the person who supervised their training.

Due to the paucity of descriptions in studies that investigate injuries in MMA athletes, there is no reference standard for comparison of training conditions, as was investigated in this study.

Supervision by accredited instructors in MMA training would be assumed to be a contributing factor to the prevention of injuries. It would also be assumed that if an individual were to take up MMA that they would seek a club run by an accredited instructor. This study shows that this is not the case. While this has not been widely discussed in literature as a risk factor for injury, it can be presumed that training under ill-equipped individuals may present its own set of risks.

Figure 4.8: Pie chart representing MMA training surfaces (%)



The majority of the participants reported to train on a compressed foam surface more than 10mm thick, which is the most protective of the known training surfaces. Despite data collection being conducted at gyms that happened to be indoors, 1% indicated that they usually trained on grass. While this may be the usual surface that is trained on, the participant in question may train less often at an indoor MMA gym. Training environments for MMA have also been under-represented in literature. This may be due to the large variance of the background art of a given MMA club, as some martial arts may require highly padded flooring, whereas others may not. Given the diverse nature of MMA, this may be considered to be a risk factor for injury.

There was an almost equal split of participants that competed in MMA competitions (49.5%) as opposed to those who do not (50.5%). Of the fighters that did participate in MMA competitions, 65% competed in the Amateur circuit (*n*=34), which formed 32.4% of the total sample. The remaining 35% of the fighters that participated in MMA competitions competed as professionals (*n*=18), which formed 17.1% of the total sample.

4.2.5. Summary of Biographical Profile

A pattern emerged in the biographical profiling results, categorizing most of the participants as male, between the ages of 20 to 30 years, White/Caucasian, and right handed. Most of the participants were in occupations that involved sitting for the greatest time period and were largely uninjured by work activities. Half of the participants actively engaged in one or more sports other than MMA, of which the most common was running, with half of those who did engage in other sports having sustained an injury from participation in those sports. Most participants had not been injured outside of MMA, work or sport, neither had they had a history of surgery, with most being non-smokers (including ex-smokers) and non-drinkers.

The majority of the participants had been doing MMA for less than four years, training for 60 minutes per day on a compressed foam surface (more than 10mm thick), three to five days per week which is supervised by an accredited coach. Half of the participants had competed in MMA competitions, with the majority competing in an amateur circuit.

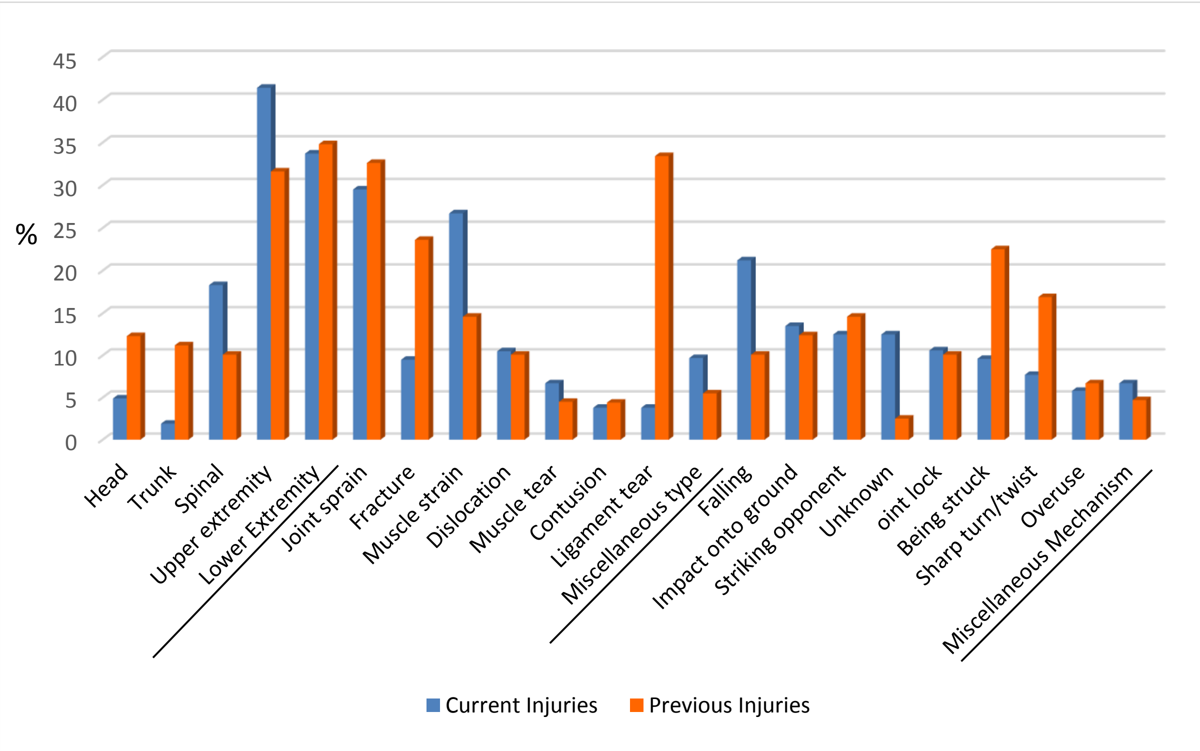
4.3. PREVALENCE OF MUSCULOSKELETAL INJURIES

This section investigates the point period of injuries of the respondents. The results presented in this section are representative of the data obtained from Section c of the questionnaire.

4.3.1. Components of Prevalence Assessment

The following results are representative of both current and previous injuries. Current injuries are defined as injuries that the participants reported to be suffering from at the time of data collection. Previous injuries are representative of the injuries that the participants reported to have suffered from within a period of 12 months prior to the date of data collection that had since been resolved. Participants completed four fields pertaining to their injuries, namely, area (e.g. shoulder), type (e.g. joint sprain), mechanism (e.g. falling) and number days missed from training as a result of injury. While participants were able to complete numerous (up to 10) injury reports, there were equal amounts of current and previous injury reports (*n* = 104 for both categories).

Figure 4.9: Graph representing prevalence of MMA Injuries in terms of area, type and mechanism (%)



*Miscellaneous: Indicates categories of injuries that were less than 5% individually or not specified

For current injuries, the most common area of injury in the head region was skull (1.9%), ribs (1.9%) in the trunk region, low back for the spine (11.5%), shoulder (18.3%) followed by elbow (7.7%) in the upper extremity, with knee (13.5%) followed by ankle (4.8%) in the lower extremity. The most common type of injury was joint sprain (29.5%) followed by muscle strain (26.7%) and dislocation (10.5%). The most common mechanism by which participants contracted injuries was by falling (21.2%), followed by impact onto ground (13.5%).

For previous injuries, the most common area of injury in the head region was eye (4.8%) followed by nose (3.4%); ribs (10.1%) in the trunk region, neck and low back for the spine (4.5% each), shoulder (12.6%) followed by elbow and wrist (6.7% each) in the upper extremity, with knee (15.7%) followed by ankle (7.9%) in the lower extremity. The most common type of injury was ligament tear (33.4%) followed by joint sprain (32.6%) and fracture (23.6%). The most common mechanism by which participants contracted injuries was by being struck (22.5%), followed by sharp turn/twist (16.9%) and striking opponent (14.6%).

When considering injuries as a whole (current and previous injuries together), the head region constituted 8.6% of all injuries. Similarly, the overall values for all (current and previous) injuries in other regions were 6.5% for trunk, 14.2% for spinal, 36.5% for upper extremity and 34.3 for lower extremity. When considered as single areas, the most common sites of injury were shoulder (30.9%) knee (29.2%) and elbow (14.4%), with the most common injury types being joint sprain (31.1%), muscle strain (20.7%) and ligament tear (18.6%). The most common injury mechanisms were being struck (16.1%), falling (15.7%) and striking an opponent (13.6%). It is also noted that participants were unsure of the mechanism of their injuries in 12.5% of the current injury reports and 2.5% of the previous injury reports, resulting in a mean value of 7.5% of injuries with mechanisms unknown.

Injury results according to area of injury were reflected in 21 studies of a similar nature that will be used for comparative purposes below (see Appendix A).

Just under half of these studies showed that the area most frequently injured was the head region, with figures ranging from 30% to 86% of the respective study's injury reports (Critchley, Mannion and Meredith 1999; James and Pieter 2003; Arriaza and Leyes 2005; Bledsoe *et al.* 2006; Arriaza *et al.* 2009; Rainey 2009; Zazryn, McCrory and Cameron 2009; Shadgan 2010; Lystad 2015). In other studies, the head region was not the most reported area of injury but still remained a relatively high statistic in three studies who showed figures of 10% (Feehan and Waller 1995), 18% (Zetaruk *et al.* 2005), 19 % (Kazemi *et al.* 2009) and 28% (Kazemi and

Pieter 2004) respectively. Five studies did not report on head injuries specifically. (Yard *et al.* 2007; Salanne *et al.* 2010; Kordi *et al.* 2012; Kreiswirth, Myer and Rauh 2014; Scoggin *et al.* 2014). The percentage of head injuries in this study is low when taking the results of these other studies into consideration.

Nine studies showed results for injuries sustained to the trunk/torso. Most of the studies' results were between 1 and 11% (Feehan and Waller 1995; Critchley, Mannion and Meredith 1999; Arriaza and Leyes 2005; Souza *et al.* 2006; Agel *et al.* 2007; Rainey 2009; Zazryn, McCrory and Cameron 2009; Lystad 2015), with one study showing a figure of 24% of the total reported injuries being to the trunk/torso (Zetaruk *et al.* 2005).The findings of this study correlate well to that of most of the other studies regarding injuries to the trunk/torso.

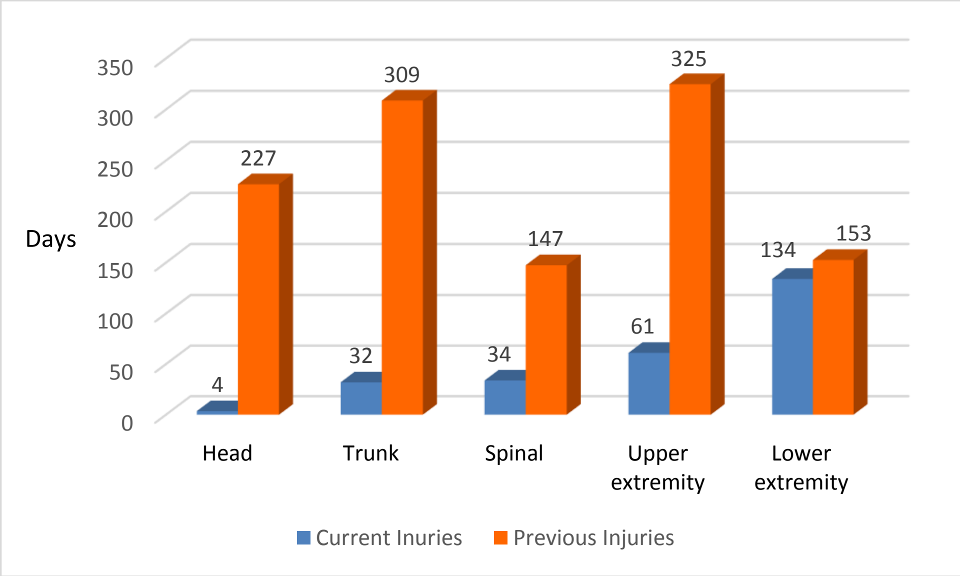
Twenty of the studies (all but one), showed results for injuries sustained to the limbs/extremities, with percentages ranging from 3% to 67% for upper limb with a mean value of 29% and ranging from 6% to 55% (mean = 29%) in the lower limb. One study presented a single figure of 38% for injuries to the limbs (Arriaza *et al.* 2009), which for analytical purposes was split so each field could be represented. The findings of this study are within the ranges found by other authors as mentioned above, being slightly higher than average for both upper limb and lower limb injuries.

The variance between studies with regards to injury percentages can be considered large, but this can be expected when comparing studies than span multiple disciplines across grappling and striking and in mixed martial arts. Further contributing to the large variance is the environment and level of competition that the participants of the relative studies were involved in. All of these factors may predispose different groups to varying injuries.

Injuries presented in terms of injury type were reflected in 20 studies across the martial arts, including MMA (see appendix A). These studies presented results in terms of the most common injury types. The mean values across the 20 studies that presented results for injury type in terms of the most common were contusions (19%), lacerations (16%), joint sprains (12%) muscle sprains (10%) concussion (7%), fracture (6%) and dislocations (2%). The results of this study are in stark contrast to those of the above mentioned, as contusions and lacerations ranked low compared to the high numbers of muscle and joint-complex related injuries. This pattern of results is more commonly observed in grappling arts than in striking, due to the nature of exposure of the discipline groups (joint locks and submissions versus striking and knockouts). The high possibility of re-injury cannot be ignored. This is demonstrated in the case of joint sprains, with 29.5% having reported a current joint injury, where 32.6% had reported previously having that injury. This pattern of high previous-to-current injury percentage is evident for many injury types in this study, including muscle strain, muscle tear, dislocation and contusion.

The days missed from training as a result of injury vary greatly between anatomical regions as well as between injuries that have been resolved (previous injuries) and injuries that are still influencing the participants (current injuries).

Figure 4.10: Graph representing mean number of days missed from training as a result of injury according to region (%)



For current injuries, the head region consisted of four anatomical areas, two of which had a value of zero (eye and mouth), and two of which had values of 7 days each (nose and skull). The trunk consisted of ribs only, while the spinal region was split (unevenly) into neck (5 days), midback (zero days) and low back (28 days). The upper extremity region consisted of six areas with fairly widespread values, namely, wrist and upper arm (zero days each), fingers (3 days), shoulder (13 days), hand (15 days) and elbow (31 days), whereas the lower extremity region had the largest variance over its six anatomical areas, with foot and thigh (1 and 2 days respectively), hip and toes (5 days each), ankle (15 days), knee (19 days) and lower leg (87 days). The total collective number of days missed from training due to current injuries was 274 days, with a mean value of 13 days per injured area.

For previous injuries, the four areas that contributed to the head region were mouth (zero days), nose and skull (60 and 61 days respectively) and eye (106 days). The trunk was made up of two categories, namely ribs (39 days) and collar bone (270 days) which had the single highest value for days missed. The spinal region consisted of the neck (40 days), midback (14 days) and low back (93 days). The upper extremity consisted of hand (3 days) wrist (21 days), elbow (30 days), fingers (40 days), shoulder (48 days) and forearm (183 days). With a narrower spectrum of days than the upper limb, the lower limb region consists of hip (zero days), lower leg (7 days), toes (11 days), foot (14 days), thigh (22 days), ankle (44 days) and knee (55 days). The total collective number of days missed from training due to current injuries was 1160 days, with a mean value of 53 days per injured area, which is four times as much as that of the current injuries section.

Some of the figures reflected above can be expected. This is evident in the case of injury to the collar bone, as it can be expected that 270 days away from training is most likely due to fracture and subsequent healing and rehabilitation. However, it cannot said that the days missed from training are indicative of the type or severity of the injury, as the anatomical location of the injury (as in the case of the collar bone) can dictate the rest period required. The location, type and severity of a particular injury each have the potential under varying circumstances to affect the functionality of the affected part and as well as the rest period required before returning to activity in the martial arts.

4.3.2. Summary of Prevalence of Musculoskeletal Injuries

The section of the study in which current injuries were assessed revealed the following: The most common area injured was shoulder, followed by knee. The most common type of injury was joint sprain, followed by muscle strain. The most common mechanism of injury was falling, followed by impact onto ground. The number of days missed from training ranged from zero to 86.8 and was the highest in injuries of the lower leg, followed by ribs and elbow. The section of the study in which previous injuries were assessed revealed the following: The most common area injured was knee, followed by shoulder. The most common type of injury was joint sprain, followed by fracture. The most common mechanism of injury was being struck, followed by sharp turn/twist. The number of days missed from training ranged from zero to 270, and was the highest in injuries of the collar bone, forearm and eye.

4.4. RISK FACTORS FOR INJURY

In this section, the relationships between variables are investigated using Chi squared methodology. Relationships between variables were tested in order to determine the role of these factors in the risk of injury for MMA fighters. The results are presented and discussed herein.

4.4.1. MMA Injury Relationships

For the sake of relationship investigations, the variable 'MMA injuries' is a score total of current and previous injuries that the participants reported on in Section C of the questionnaire. This was done by totalling scores according to the region/area reported in each case of injury for current injuries and previous injuries respectively. These totals were combined to obtain a grand total score, which is the variable 'MMA injuries'.

4.4.1.1. Risk of Generalized Injuries in MMA

Table 4.4: Statistical significance of variables in relation to MMA injuries (set one)

Variable	*P* - value	Correlation coefficient
Gender	0.071	0.212
Favour dominant hand	0.011	0,243
CrossFit	0.007	-0.312
Flexibility	0.019	0,240
Falling	0.006	0,254

The relationships presented in table 4.4 are all significant, with the exception of gender as a risk factor injuries in MMA. While no relationship exists, a correlation between the incidence of MMA injuries and the number of males and females that participate in MMA respectively. Simply stated, as the number within a gender group of MMA fighters increase, so do the incidence of MMA injuries in that group. The percentage of injured females was 64.7% (n = 11) and those inured among the group of males was 86.4% (n = 76). Of the significant relationships presented in table 4.4, all variables present a significant risk for the development of injuries in MMA fighters, with the exception of participation in CrossFit as an additional sport. CrossFit has an inverse correlation to the incidence of MMA injuries, resulting in the participation in CrossFit by participants to be a significant protective factor against injuries in

MMA. The ratio of uninjured MMA fighters that did do CrossFit to those who did not was approximately 4 : 1 (55.6% : 13.5%).

There is a disparity of evidence in studies examining risk factors for injury, with some having noticed a higher risk of injury in males over females (Feehan and Waller 1995; Arriaza and Leyes 2005; Arriaza *et al.* 2009; Rainey 2009; McPherson and Pickett 2010) as opposed to those that have identified no difference in risk of injury depending on gender (Zetaruk *et al.* 2005; Destombe *et al.* 2006; Kazemi *et al.* 2009; Lystad, Pollard and Graham 2009; McClain *et al.* 2014). This study's findings conform with the latter, demonstrating no significant relationship between risk of injury and gender.

Similar injury rates across gender groups can be understood by the very small number of females that participate in MMA, often making it necessary for females to train with males in order to experience practicing with varying opponents. This could suggest why the females in this population do not enjoy a lower rate of injury compared to males as in the cases above, making it possible that training across an individual's gender group may predispose them to a greater risk of injury.

A higher risk of injury is also present in fighters who favour their dominant hand while fighting as opposed to the practice of using both of their sides equally and irrespective of dominance. This is applicable during practicing as well as serious fighting, where the fighter makes use of the non-dominant side as and when opportunity to do so arises.

There was very little literature on the subject of hand dominance and injury risk in the martial arts, save for the work of Neto *et al.* (2012) where it was expressed that strikes delivered from the dominant hand are 50% stronger and 11% faster than that of the non-dominant hand. While the increased magnitude and velocity of these strikes is likely due to improvement from consistent practice with the dominant side, these findings may suggest a higher risk of injury in the dominant hand due to a greater force and velocity ratio than the non-dominant hand. This force generation exposes the 'striking' hand to repetitive stress as opposed to distributing the impact load by striking with both hands. It is also likely that fighters who favour their dominant hand receive more injuries on one side of the body, as fighters who favour one side may typically assume a standard fighting stance that will allow for greater tactical advantage for striking, but may predispose one side of the body to repetitive strikes from the opponent.

With this study showing that participation in CrossFit by MMA athletes significantly decreases the risk of contracting injuries in MMA, it is unexpected to observe that in the evaluation of the

‘CrossFit’ extreme conditioning program (ECP), the parameters of the sport violate the standards for safely and appropriately developing muscular fitness (Bergeron *et al.* 2011). Notwithstanding this evidence, it cannot be ignored that the program has shown to improve maximal aerobic fitness and body composition (Smith *et al.* 2013).

It is noted by Laursen and Jenkins (2002) and Wisløff *et al.* (2007) that athletes that already train in high intensity disciplines can further their cardiovascular performance significantly through high-intensity interval training, as is seen in sports such as CrossFit. It can be postulated that the similar nature of movements experienced during CrossFit training (high intensity and high velocity) and those in MMA is what offers the protective/conditioning factor against injuries sustained while performing these movements. This effect can be coupled with the benefit received from cardiovascular conditioning in addition to that received in MMA training.

In contrast to the evidence of CrossFit providing protection against MMA injuries, studies have shown that there is no significant benefit from stretching either before or after exercising in terms of reduction of injury risk (Herbert and Gabriel 2002; Thacker *et al.* 2004; Andersen 2005). Tisal (2000) noted that stretching in training was a source of back pain in martial artists due to faulty positioning. This finding is further confirmed by this study, where it was found that not only did stretching provide no significant benefit to athletes, but rather significantly increased the risk of injury in those who did do flexibility training within their MMA training sessions as opposed to those who did not.

While the nature and cause of the increased risk with flexibility training could not be assessed, it is likely that injuries that result from these techniques arise from inappropriate stretching techniques and application being employed by the participants or endorsed by the instructors. This could suggest that incorrect stretching techniques or protocols that are discouraged e.g. ballistic stretching could be being done as opposed to making use of protocols that add benefit to the specific activity being done (martial arts) and increase functional stretching ability such as proprioceptive neuromuscular facilitation (Haff 2006).

Falling is inevitable in the martial arts and have been shown to be a common mechanism of injury (Kazemi *et al.* 2009; Scoggin *et al.* 2010). This common phenomenon includes those technique sets where accidental falls are involved such as in striking arts, as well as those where the presence of falls can be necessary to win a match e.g. Judo techniques (James and Pieter 2003; McPherson and Pickett 2010). This is confirmed by this study, finding that falling as a mechanism of injury is a significant risk factor for injuries in MMA. Considering that falling occurs in almost every Judo match and that there are less injuries on average than in Karate and Taekwondo (James and Pieter 2003), it is predictable that athletes who participate in martial arts that focus on practicing safe and correct falling techniques are at less risk of injury contraction through falling (Salanne *et al.* 2010) in contrast to those who fall without having practiced it sufficiently, which puts these individuals at significant risk of injury from falling (Dvorak *et al.* 2000; Robert *et al.* 2000).

Table 4.5: Statistical significance of variables in relation to MMA injuries (set two)

Variable	*P* - value	Correlation coefficient
Standing grappling	0.055	0,204
Ground grappling	0.068	0,207
Groundwork holds/pins	0.028	0,225
Ground strangles	0.028	0,225
Ground arm bars	0.014	0,266

In reference to the relationships presented in table 4.5, standing grapping and ground grappling are outside of the range of significance. As in the earlier case of gender as a variable, there is a correlation between grappling (standing and ground respectively) and the incidence of MMA injures.

Considering the relationship between MMA injuries and those whose training included standing grappling, both, the relationship and the correlation values are of just outside of the range of statistical significance with for this study's sample population. This relationship can be further explored in similar groups with a greater total population size. As in the earlier case of gender as a variable, in absence of relationship significance there is a correlation between ground grappling and the incidence of MMA injuries. With the exception of grappling (standing and ground), the other relationships presented in table 4.5 present significant risk of injury to those who practice them.

James and Pieter (2003) noted that injury rates of elite athletes in Judo, a grappling art, are generally lower compared to those that competed in Karate and Taekwondo. This is supported by McPherson and Pickett (2010) who noted that while Judo does not have the lowest injury rates of the martial arts, the injury rates of Karate and Taekwondo (striking arts) are higher. In the light of these findings that demonstrate a mid-way point for injury prevalence in grappling arts, it is not surprising that the relationship between risk of injury and standing grappling in this study is of borderline significance. If further studies of this nature are conducted, participants from multiple regions of South Africa can be included to increase the total number of research subjects, which may then allow closer analysis of this relationship and the acceptance/rejection of standing grappling as a significant risk factor for injury in MMA.

The incidence of injuries increasing proportionately to the practicing of ground grappling is to be expected, as martial artists with a background in a sport such as Brazilian Jiu-Jitsu (a ground grappling art), experience a lower injury rate than those of most other martial arts but have a high prevalence of elbow and knee injuries (Kreiswirth, Myer and Rauh 2014; Scoggin *et al.* 2014). The commonly injured areas of elbow and knee may be at higher risk of injury due to the repetitive trauma of movement on the ground.

Martial arts such as Brazilian Jiu-Jitsu, Judo and MMA involve fighting on the ground regularly and allow for a fighter to win a match by submitting an opponent through a strangle or choke (as one possible method), predisposing participants of these arts to a risk of injury (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; McPherson and Pickett 2010; Scoggin *et al.* 2010; Kreiswirth, Myer and Rauh 2014; McClain *et al.* 2014). In pursuit of match victory by means of strangulation or joint lock on the ground as in Brazilian Jiu-Jitsu, many movements of body can be strenuous (Kreiswirth, Myer and Rauh 2014), and it is reasonable to assume that an activity where movement off of ones feet (on hands, elbows, knees, buttocks and head) is involved, the body can be put at risk of injury. The action of having a strangle applied may have risk associated through unintentional neck torsion or pressure, but the events preceding the strangle (fighting for positions where strangles can be applied from etc) could be where a large portion of the risk lies.

As is the case with ground strangles as a risk factor for injury, ground arm-bars put participants at risk of generalised injury in a similar fashion, as joint locks are the most common methods by which a fighter can win a match in Brazilian Jiu-Jitsu, where many movements of body on the ground can be strenuous (Kreiswirth, Myer and Rauh 2014). Being one of the ways in which a match can be won (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; McPherson and Pickett 2010; Scoggin *et al.* 2010; Kreiswirth, Myer and Rauh 2014; McClain *et al.* 2014), practicing this technique set repeatedly has been shown in this study to be a significant risk factor for injury.

4.4.1.2. Risk of Injury by Mechanism

Table 4.6: Statistical significance of MMA activities in relation to mechanisms of injury

MMA activity	Mechanism of injury	*P* - value	Correlation coefficient
Standing striking	Falling	0.033	-0.228
Take downs	Ground impact	0.006	0.265
Other joint locks standing	Joint lock	0.037	0.211
Surgery: Fracture repair	Striking opponent	0.028	0.248
Surgery: Ligament repair	Sharp turn/twist	0.015	0.272

In reference to the relationships presented in table 4.6, all of the relationships are significant and have direct correlations between the variables, categorising the MMA activity as a significant risk factor for injury through its associated mechanism, with the exception of that between standing striking as a component of MMA training sessions and falling as a mechanism of injury, which have a significant inverse correlation. This inverse correlation classifies the practice of standing striking as a protective factor against injury through falling.

This is to say that the more that standing striking is practiced in training, the less the fighter is at risk of being injured from falling. This finding roughly follows a trend as observed by authors who noted lower injury rates due to falling as a mechanism of injury in martial arts that involve varying degrees of standing striking. This is depicted as 4% injured by falling in Taekwondo (Kazemi *et al.* 2009) and 10% injured from falling in Karate (Arriaza *et al.* 2009) as opposed to 10% of injuries sustained from falling in Judo (James and Pieter 2003). This can be understood in terms of the more time spent doing standing striking results in less time to practice other activities that may put the fighter at risk of falling, thus acting as a protective factor when viewed in isolation.

In some sports, take downs and falling are grouped together in terms of mechanism of injury. An example of this is when a fighter is injured during a take down by falling on an outstretched hand (FOOSH injury), as commonly seen in Brazilian Jiu-Jitsu (Kreiswirth, Myer and Rauh 2014; Scoggin *et al.* 2014). Again, injuries from falling and from impact onto the ground can be due to inadequate exposure to falling as a practiced technique, which could explain the high risk associated with these manoeuvres.

The incidence of fighters from any martial art that apply standing joint locks (other than that applied to the elbow) is almost non-existent in literature, with many authors classifying a mechanism of injury merely as a joint lock, without specification as to whether it was applied while standing or on the ground. Those who reported to practice standing joint locks (other than to the elbow), may be doing the techniques correctly, but it is possible that due to the uncommon nature of these techniques that they could be practicing them incorrectly. It is also possible that the phrase 'other joint locks standing' could be misunderstood by some participants. Nevertheless, there is a greater risk of injury to those who practice this technique set as opposed to those who do not.

The speed at which standing movements are done is faster in general than those done when on the ground. This may allow joint locks that are applied while standing to be done more aggressively than those applied while on the ground. The aggressive application puts the joint under undue strain and results in high risk of injury, especially if the fighters are largely unfamiliar with the techniques.

In a study by Zetaruk *et al.* (2005) that compared five martial arts that include striking (to varying degrees), namely Karate, Taekwondo, Aikido, Kung Fu and Tai Chi, it was noted that there was no difference in the rates of fractures sustained between styles. This demonstrates and is in accordance with the findings of this study that there is consistent risk between being struck by an opponent and requiring surgery for a fracture sustained from that strike. The deliverance of high velocity and high amplitude blows to a specific body area would be expected to be a far higher risk of fracture than other techniques or mechanisms, such as falling or grappling.

While there is no literature that covers the nature of risk between a sharp turn/twist and requiring surgery for ligament repair, Scoggin *et al.* (2014) noted that the majority of orthopaedic injuries sustained in Brazilian Jiu-Jitsu athletes were ligamentous in nature, many of which were from a collection of active and typically quick movements, such as sweeps, takedowns, arm-bars and passing the guard etc. In accordance with the findings of Scoggin *et al.* (2014), this study found that those who are injured by the mechanism of a sharp turn/twist are at greater risk of requiring surgery for repair of the injury from that mechanism, as opposed to being injured by anther mechanism. Reactions during fighting can often be rapid and reliant on immediate movements without the luxury of forward planning, which could create the possible scenario of a sharp (possibly undesirable) movement that recruits many muscle groups and leaves little more than ligamentous stability of a joint to resist the movement, which can result in injury.

4.4.1.3. Risk of Injury by Anatomical Area

Table 4.7: Statistical significance of MMA activities done in relation to injured areas

MMA activity	Injured area	*P* - value	Correlation coefficient
Standing striking	Knee	0.047	-0.209
Ground arm-bars	Elbow	0.019	0.225
Ground strangles	Neck	0.015	0.237
Standing grappling	Low back	0.051	0.195
Other joint locks (ground)	Low back	0.031	0.214

Table 4.7 presents variables that are related to the risk of injury of a particular anatomical area. Three of the five relationships show significant risk of injury to specific area(s) associated with activities that are practiced in MMA. The practicing of ground strangles is a risk factor for neck injury is just outside the scope of significance. The other exception is in the case of standing striking, where the relationship is inversely proportional. This demonstrates that as standing striking is practiced, the risk of injury to the knee is decreased, qualifying standing striking as a protective factor against knee injuries.

The knee is an area that is at high risk of injury in the martial arts, with 8% of all injuries in a nine year study of Taekwondo injuries being sustained in the knee (Kazemi *et al.* 2009), 11% of injuries in Muay Thai kickboxers being to the knee (Gartland, Malik and Lovell 2001), and Rainey (2009) noticing injury rates of 30% to the lower extremity in MMA fighters. It is surprising therefore to note that the risk associated between knee injuries and whether or not the participant practices standing striking is of an inverse proportion, meaning that the more that standing striking is practiced, the less of a chance there is of contracting injuries to the knee. This may be that by practicing the technique set more frequently, the participant is better equipped to properly execute it and minimize risk of unintentional injury.

The nature of the relationship between the elbow as an area of injury and incidence of ground arm-bars is not surprising, as targeted joint locks are the most common methods by which a fighter can win a match in Brazilian Jiu-Jitsu and a common way of winning a match in MMA (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; McPherson and Pickett 2010; Scoggin *et al.* 2010; Kreiswirth, Myer and Rauh 2014; McClain *et al.* 2014). Being a common route to victory, it would make sense for MMA fighters to practice these techniques often, which would put the athlete at risk for repetitive stress to the elbow joint, and no surprise as to why the more that ground arm-bars are practiced, the greater the risk is for sustaining an elbow injury.

The neck has been noted to be a consistent site of injury in multiple studies due to either strike trauma or through submitting an opponent via a choke or neck joint lock depending on the specific martial art or combination thereof (Feehan and Waller 1995; Gartland, Malik and Lovell 2001; Arriaza and Leyes 2005; Zetaruk *et al.* 2005; Kazemi *et al.* 2009; Lystad, Pollard and Graham 2009; Scoggin *et al.* 2010; Kreiswirth, Myer and Rauh 2014; McClain *et al.* 2014). It is reasonable to assume that activities that put the neck under potential strain, such as strangles, especially on the ground when the surface can act as additional fulcrum for force deliverance can be a significant risk factor for injuries in MMA, as is shown in this study, especially when this activity is repeated in a training setting.

Kazemi *et al.* (2009) noted that 8% of Taekwondo injuries in a nine year study were back injuries. Tisal (2000) found that low back pain was more common in cases of repetitive exercise in martial artists and occurred more in training than competition. These findings give evidence of back pain in the cases of quick and repetitive and stretching movements in general, which can be observed in standing grappling. Although it would be expected for there to be a risk associated with standing grappling and back injuries, the result of this analysis was of borderline significance, requiring further similar studies in population groups of MMA fighters larger than that in the greater Durban area.

The particulars of the relationship between low back as an area of injury and other joint locks on the ground are unclear in terms of whether the risk for injury is due to joint locks being applied to the low back, which would be expected given the high velocity extreme eccentric and tissue stretching movement that can be seen in joint lock manoeuvres (Tisal 2000; Kazemi *et al.* 2009) or from the physical demands of practicing other joint locks. Notwithstanding this uncertainty, significant risk remains associated with practicing this technique set and the chance of low back injury.

4.4.1.4. Risk of Injury by Type

Table 4.8: Statistical significance of MMA activities done in relation to injury types

MMA activity	Injury type	*P* - value	Correlation coefficient
Standing grappling	Muscle tear	0.014	0.234
Ground arm-bars	Joint sprain	0.006	0.268
Ground grappling	Joint sprain	0.035	0.223

The MMA activities presented in table 4.8 are all significantly associated to the risk of development of specific injury types. All of the participants (*n* = 10) who had muscle tears reported practicing standing grappling.

There is no generalised statement in literature regarding potential danger of standing grappling. There are however, findings on the constituents of grappling, such as delivering a throw (throwing an opponent), receiving a throw (being thrown) and falling, as described by James and Pieter (2003) where there is a rate of 14.56 injuries per 1000 athlete exposures when delivering a throw, 9.71 injuries per 100 athletes when receiving a throw and 4.85 injuries per 1000 athlete exposures when falling. It has been shown by this study that those who practice standing grappling are at greater risk of sustaining a muscle tear than those who do not. The use of multiple muscle groups in an attempt to throw an opponent who is resisting the movement could be a scenario in which certain muscles are at a large risk of damage through tearing.

Scoggin *et al.* (2014) noted that at state-wide Brazilian Jiu-Jitsu competitions in Hawaii, ten out of 14 incidences of elbow injuries occurred while having an arm-bar applied. It is also noted that among the martial arts that include arm-bars, that joint sprains are a relatively common type of injury (James and Pieter 2003; Rainey 2009). Joint locks are the most common methods by which a fighter can win a match in Brazilian Jiu-Jitsu and a common way of winning a match in MMA (Bledsoe *et al.* 2006; Ngai, Levy and Hsu 2008; McPherson and Pickett 2010; Scoggin *et al.* 2010; Kreiswirth, Myer and Rauh 2014; McClain *et al.* 2014). Repetitive targeting of and stress to a joint may be the reason why those whose training includes ground arm-bars are at greater risk of a joint sprain injury as opposed to those who do not.

Scoggin *et al.* (2014) noted that the two most common injuries in Brazilian Jiu-Jitsu athletes was the elbow followed by the knee, both of which were commonly injured through grappling-related manoeuvres. This study, in keeping with the above, found that the risk of sustaining a joint sprain is higher in those who practice ground grappling than in those who do not.

4.4.2. Relationships Involving Numerical Variables

The following tables represent the strength of the relationships between nominal variables or nominal and categorical variables respectively, according to their Eta scores (η). Pairs of variables that have significant relationships (medium strength or higher) demonstrate the degree of risk potential that particular relationship carries.

Table 4.9: Eta scores of medium, large and very large strength relationships between variables

Variable 1		Variable 2	η	Strength
MMA Injuries	vs	Days missed from training due to injury	0.241	Medium
Mechanism of injury: Falling	vs	Days Missed from training due to injury	0.322	Medium
Injury Type: Dislocation	vs	Days missed from training due to injury	0.373	Large
Injury Type: Fracture	vs	Days missed from training due to injury	0.395	Large
Period actively doing MMA	vs	Favour dominant hand	0.635	Very large
Injury Type: Muscle tear	vs	Days missed from training due to injury	0.544	Very large
Age	vs	MMA Injuries	0.619	Very large
Weight	vs	MMA Injuries	0.706	Very large
Height	vs	Upper Limb Injuries	0.623	Very large
Height	vs	Lower Limb Injuries	0.615	Very large

According to James and Pieter (2003), the average time loss for the most common injury sustained by athletes was 21 days for males and 7 days for female. This (current) study showed a significant relationship between the presence of injuries and the number of days missed from training as a result of injury, meaning, the more injuries that an individual has is directly proportional to the number of training days they would be likely to miss. This is to be expected, as the healing time of an injury may be lengthened if another (complicating) injury is also present. Having more than one injury, even if unrelated, may extend the individual's time away from training. The severity of the injury may also be a determining factor in regards to necessary healing time and time off of training. In a study by Zetaruk *et al.* (2000), injuries were allocated grades according to number of days missed from training, however, establishing injury grades was outside the scope of this study.

Because falling as an injury mechanism is directly proportional to the risk of extended time missed from training as a result of injury, an individual would be more likely to miss days from training due to an injury if that injury was sustained from falling as opposed to another mechanism. As falling has been shown to be a risk factor for injuries in MMA, it is logical to assume that the more falling is done, the more injuries are likely to be sustained and therefore the greater time away from training is necessary.

An individual is likely to miss more days from training due to injury if the injury is either a fracture, dislocation or muscle tear as opposed to other injury types. Individuals that sustain fractures (especially MMA fighters) usually make use of assistive apparatus, such as a cast applied to the injured area, which in most cases would keep these individuals away from training for the full duration of the healing and presence of the cast, as opposed to returning to training when the pain of the injury is more bearable. In the case of dislocations, the nature of the injury may be complex and have multiple components, as the potential risk of injury to muscle, bone, articular cartilage and joint capsule may require a longer healing period before return-to-activity. In the case of a muscle tear, the fighter may become concerned as strength becomes decreased in the affected muscle. While this is true for most individuals, many MMA fighters may be primarily concerned with strength or deficits thereof, which may result in a voluntarily longer period for healing away from training.

The longer time spent doing MMA indicates a greater likelihood of the fighter favouring the dominant hand. This result is unexpected, as it could be assumed that the longer the period of training is, the more expertise is gained, which could enable the fighter to better use their non-dominant hand. This may not be completely untrue, as a fighter gains more experience, they may be able to tailor moves specific to their own preferences, which may include using the dominant hand and sparing additional effort of using the non-dominant hand.

Age and weight are factors that have an influence on the risk for injury contraction. The older the fighter is, and the more that the fighter weighs puts them at increased risk respectively of sustaining injuries due to participation in MMA. This can be expected, as older fighters may more readily know their physical limitations in terms of ability and healing, and therefore practice in a manner that suits an ageing body, as opposed to the younger generation of fighters that may not yet know or have experienced such limits. The weight of a fighter, like many others risk factors, cannot be considered in isolation, as the higher weight values of the fighters do not necessarily indicate obesity. This may indicate however, that heavier fighters are at higher risk of injury possibly due to moving slower than fighters of a lower weight. This would also predispose fighters to a decreased ability to dodge powerful attacks that often take a longer period to execute as opposed to high velocity manoeuvres.

The height of a fighter has been ascertained to place taller individuals at significantly more of a disadvantage than advantage in terms of likelihood for injury contraction. This is seen in the case of high risk of injury to the upper limb as well as to the lower limb in taller individuals. Simply put, the fighter may be at higher risk of injury if the target area is larger than that of an opponent. The surface area of a smaller opponent may also have a pressure effect on the limb of the larger attacker, depending on the target area.

4.4.3. Summary of Risk Factors for Injury

The following were shown to be significant risk factors for generalized injury in MMA: Favoring the dominant hand while fighting; flexibility training/stretching; doing groundwork holds/pins; doing ground strangles; doing ground arm-bars; falling; increasing age; increasing weight.

Fighters are at greater risk of injury from ground impact when doing take downs, and from a joint lock during standing joint locks (other than to elbow). Similarly, fighters are at greater risk of requiring surgery to repair a fracture when sustaining an injury through striking an opponent, and at greater risk of requiring surgery to repair a ligament tear when sustaining an injury from a sharp turn/twist.

MMA fighters are at high risk of injury: To the elbow when doing ground arm-bars; through a joint sprain when doing ground arm-bars, through a joint sprain when doing ground grappling; to the low back when doing standing grappling; to the low back when doing joint locks on the ground (other than to the elbow); through a muscle tear when doing standing grappling.

Fighters were at greater risk of missing days from training as a result of: Having injuries from participation in MMA; falling (accidental); dislocations; fractures; muscle tears. The longer the period spent actively doing MMA, the more the fighters were shown to favour their dominant hand. The taller the fighter was, the greater the risk was of upper and lower limb injuries.

The only significant protective factor against injuries in MMA as a whole was participation in CrossFit as an additional sport/ conditioning program. Practicing standing striking as a technique set within MMA training sessions reduces the risk of being injured through falling. Practicing standing striking also reduces the risk of sustaining injuries to the knee.

While many of these risk factors have varying avenues of influence and mechanisms by which they can negatively affect MMA fighters, it must be recognised that lack of conditioning or proper training in the specified field(s) can make any activity, general or specific, a risk factor for those who are inappropriately prepared.

4.5. CONCLUSION

The results of this study identified significant risk factors for injury in MMA fighters. Fighters and their coaches will benefit from implementing strategies that reduce the risk of injury contraction, such as:

1. Appropriate cardiovascular warm-up should be done before beginning to practice any techniques or sparring.
2. If flexibility training/stretching is going to be done, the stretches should be carried out in strict according to recognized safe athletic stretching programs. If this information is not available to the coaches and/or fighters, risk of injury can be reduced by omitting stretching.
3. Training in proper falling techniques in a diversified manner is essential to reduce the risk of injury contraction through unintentional falling and ground impact forces.
4. The practicing of techniques and sparring by athletes should be done with both hands/feet and increasing the use of their non-dominant side.
5. Training time should be balanced between different technique sets, with avoiding repetitive exercise of only ground-based techniques.
6. Specificity of techniques should be emphasized in groundwork holds/pins, ground strangles and ground arm-bars, and exercised with a greater emphasis on control as opposed to force.

5. CONCLUSIONS AND RECCOMENDATIONS

5.1. CONCLUSION

In order to draw a significant conclusion, results will be considered in regards to the aims and objectives of the study.

5.1.1. Biographic Profile of MMA Fighters

The pattern that emerged in the results categorized most of the participants as male, between the ages of 20 to 30 years, White/Caucasian, and right handed. Most of the participants were in occupations that involved sitting for the greatest time period and were largely uninjured by work activities. Half of the participants actively engaged in one or more sports other than MMA, of which the most common was running, with half of those who did engage in other sports having sustained an injury from participation in those sports. Most participants had not been injured outside of MMA, work or sport, neither had they had a history of surgery, with most being non-smokers (including ex-smokers) and non-drinkers.

The majority of the participants had been doing MMA for less than four years, training for 60 minutes per day on a compressed foam surface (more than 10mm thick), three to five days per week which is supervised by an accredited coach. Half of the participants had competed in MMA competitions, with the majority competing in an amateur circuit.

5.1.2. Prevalence of Musculoskeletal Injuries

Musculoskeletal injuries have been shown to be very prevalent in MMA fighters. The sample population of 105 MMA fighters generated 208 injury reports, with a perfectly even split of 104 reports of current injuries and 104 reports of previous injuries. This yielded an average rate of approximately 2 injuries per fighter i.e. an average of one current and one previous injury. The most commonly injured areas were the large joints of the body, namely shoulder followed knee, with soft tissue injuries being the most common of all injury types, namely, joint sprains followed by muscle strains. The most common injury mechanisms consisted of situations where a fighter was not in control of the outcome, namely when being struck followed by falling. The number of days missed from training due to injury ranged from zero to 270 (nine months), and were the highest in areas that are commonly made use of and relied on in day to day life, such as the collar bone, forearm and eye.

5.1.3. Risk Factors for Injury

Risk factors were identified in terms of activities or through the application thereof. Risk for generalized injury was noted in the cases of groundwork activities that comprise of holds/pins, ground strangles and ground arm-bars, doing flexibility training/stretching, falling, increasing age, increasing weight and favoring the dominant hand while fighting. It was also noted that the longer the period spent actively doing MMA, the more the fighters were shown to favour their dominant hand. Risk of injury to particular areas or by particular mechanisms was noted when doing specific activities, such as standing joint locks (risk for joint injury) and take downs (risk from ground impact forces). High risk of requiring surgical repair for injuries was noted in cases of injury through striking an opponent (risk from fracture), and in cases of sharp turns/twists (risk from ligament tear).

Risk of injury to particular areas or from particular injury types increased when participating in particular activities such as ground arm bars (risk to elbow and risk from joint sprain), ground grappling (risk from joint sprain), standing grappling (risk to low back and risk from muscle tear) as well as joint locks on the ground other than to the elbow (risk to low back). The risk of missing days from training as a result of injury was increased if the injury was sustained through falling, or through sustaining dislocation, fracture or muscle tear injuries. Risk for injuries to both the upper and lower limb increased proportionately in taller fighters.

The only significant protective factor against injuries in MMA as a whole was participation in CrossFit as an additional sport/ conditioning program. Practicing standing striking as a technique set within MMA training sessions reduces the risk of being injured through falling. Practicing standing striking also reduces the risk of sustaining injuries to the knee

While many of these risk factors have varying avenues of influence and mechanisms by which they can negatively affect MMA fighters, it must be recognised that lack of conditioning or proper training in the specified filed(s) can make any activity, general or specific, a risk factor for those who are inappropriately prepared.

MMA fighters and their coaches will benefit by paying particular attention to the presence of these risk factors due to be being largely preventable and focus on implementing strategies that reduce the risk of injury contraction. Good practice for reducing risk of injury contraction may include strategies such as doing cardiovascular warm up before commencement of training, adhering strictly to guidelines for stretching or reduce risk by omitting stretching completely, dedicating time to practicing proper falling techniques in a diverse situations, practicing techniques and sparring with the dominant and non-dominant sides equally and by focusing on specificity of techniques, especially in groundwork holds/pins, ground strangles and ground arm-bars, which should be exercised with greater control as opposed to force.

5.1.4. Hypotheses

The results that the study has produced allow for the null hypotheses to be rejected and the hypotheses to be fully accepted, which states:

1. MMA athletes display a high prevalence of musculoskeletal injuries.

2. There is a strong correlation of specific risk factors to the development of particular musculoskeletal injuries in MMA athletes.

5.2. RECCOMENDATIONS

Further studies of this nature can be conducted in populations of MMA athletes from multiple regions of South Africa, increasing the total number of research subjects resulting in order to more precisely identify trends in participant responses and in roles of risk factors that were found to have borderline significance. This could be achieved in the form of research that reproduces this study (partially or in full) in MMA communities outside of the province of Kwa-Zulu Natal, also allowing for comparisons to be made between these communities.

A future study can be focused on analysing the risk factors that were identified in this study by determining the reasons why they present significant risk to those who engage in the particular activities. This is particularly true for cases where there is a possibility of incorrect technique being the source of the risk such as stretching, falling etc

The use of a methodology that caters for the assessment of both current and previous injuries lends itself to the potential of further identification and role analysis of specific risk factors for injury. This methodology can be utilised in future research, especially in the case of research in a sport such as MMA where risk of injury contraction is ever-present.

The questionnaire covered a wide field of variables, which made analysing these variables a lengthy and time consuming process. Adapting the questionnaire for future research to focus on a particular section and its responses may allow for more specific analyses in some instances.

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APPENDICES

Appendix A: Summary of literature regarding area, type and mechanism of injury

Section 1: Area of Injury

The following is a summary of findings by various authors regarding the area of injury in various martial arts according to available literature. Figures have been rounded off to the nearest whole number.

Table Displaying Distribution for Area of Injury (%)

Author	Head	Upper limb	Lower limb	Torso	Spinal
Agel *et al.* (2007) (College Wrestling matches, USA)	17	26	40	11	
Arriaza and Leyes (2005) (Karate World Championships)	85	3	6	1	4
Arriaza *et al.* (2009) (Karate World Championships)	66				
Bledsoe *et al.* (2006) (Professional MMA matches, Nevada)	66	19			
Critchley, Mannion and Meredith (1999) (British national Karate championships)	57	19	19	6	
Feehan and Waller (1995) (National Taekwondo Championships, NZ)	10	17	51	6	17
Kazemi and Pieter (2004) (Canadian Taekwondo Championships)	28	7	55		14
Kazemi *et al.* (2009) (Taekwondo competitions, Canada)	19		47		12
Kordi *et al.* (2012) (Wrestling athletes in Iran)	7	67		27	
Kreiswirth, Myer and Rauh (2014) (World Jiu-Jitsu Championships)		35	32		
James and Pieter (2003) (British national Judo competition)	33	28	21		
Lystad (2015) (Kickboxing athletes in Nevada, USA)	30	30	14	3	
Rainey (2009) (MMA fighter history, Midwest, USA)	38	23	30	13	
Salanne *et al.* (2010) (Paediatric Judo athletes in France)		46	25		
Scoggin *et al.* (2014) (Jiu-Jitsu state-wide competitions, Hawaii)		61	36		3
Shadgan (2010) (Wrestlers at Beijing Olympics)	59	25	9		
Souza *et al.* (2006) (Judo championships in Sao Paulo, Brazil)	1	47	49	3	
Yard *et al.* (2007) (Paediatric martial arts injuries, USA)		30	25		
Zazryn, McCrory and Cameron (2009) (Professional boxers in Victoria, Australia)	86	8	1	2	
Zetaruk *et al.* (2005) Comparrison of 5 martial styles, Canada	18	26	32	24	
This (current) study (MMA Athletes in the greater Durban area)	9	37	34	7	14

Section 2: Type of Injury

The following is a summary of findings by various authors regarding the type of injury in various martial arts according to available literature. Figures have been rounded off to the nearest whole number.

Study	Description	Percent
Agel *et al.* (2007)	**Description**	**Percent**
(College Wrestling matches, USA)	Joint sprain	25%
	Ligament sprain	14%
	Muscle strain	13%
	Concussion	5%
	Dislocation	3%
	Infection	3%
	Nerve damage	2%
	Cartilage damage	2%
	Contusion	1%
	Fracture	1%
Arriaza and Leyes (2005)	**Description**	**Percent**
(Karate World Championships)	Contusions	50%
	Epistaxis	16%
	Lacerations	14%
	Abrasion	5%
	Concussions	4%
	Sprains	4%
Arriaza *et al.* (2009)	**Description**	**Percent**
(Karate World Championships)	Contusions	47%
	Epistaxis	20%
	Lacerations	10%
Destombe *et al.* (2006)	**Description**	**Percent**
(Karate athletes in Brest, France)	Hematomas	52%
	Sprains	19%
	Muscle lesions	7%
	Fractures	7%
Feehan and Waller (1995)	**Description**	**Percent**
(National Taekwondo Championships, NZ)	Sprain, strain &soft tissue	82%
	Fracture	7%
	Head injury/concussion 5%	
	Laceration/abrasion	3%
	Dislocation	1%
Kazemi and Pieter (2004)	**Description**	**Percent**
(Canadian National Taekwondo Championships)	Joint sprain	42%
	Contusions	26%
	Lacerations	11%
	Strains	14%
	Concussion	7%
	Abrasions	2%
	Epistaxis	2%
Kazemi *et al.* (2009)	**Description**	**Percent**
(Taekwondo competitions, Canada)	Contusions	36%
	Joint sprains	19%
	Muscle strains	15%
	Fractures	8%
	Joint dysfunction	7%
	Concussion	6%

	Laceration	5%
	Dislocation	1%
	Epistaxis	1%
	Other	5%
Kordi *et al.* (2012)	**Description**	**Percent**
(Wrestling athletes in Iran)	Dislocations	53%
	Fractures	47%
Lystad (2015)	**Description**	**Percent**
(Kickboxing athletes in Nevada, USA)	Lacerations	25%
	Fractures	7%
	Organ injury	1%
	Dislocations	<1%
	Haematomas	<1%
	Joint sprains	<1%
	Nerve injury	<1%
	Tendon injury	<1%
	Not specified	64%
McClain *et al.* (2014)	**Description**	**Percent**
(MMA competitions in Kansas & Missouri)	Lacerations& abrasions	38%
	Altered mental state	28%
	Fractures	17%
	Other types	24%
McPherson and Pickett (2010)	**Description**	**Percent**
(Martial arts injuries presenting at a Canadian hospital)	Fracture	21%
	Sprains & Strains	12%
	Lacerations & abrasions	5%
James and Pieter (2003)	**Description**	**Percent**
(National Judo competition, United Kingdom)	Contusion	26%
	Strain	15%
	Hyperextension	14%
	Laceration	10%
	Sprain	5%
	Abrasion	5%
	Dislocation	5%
	Poked eye	5%
Rainey (2009)	**Description**	**Percent**
(MMA fighter history, Midwest, USA)	Contusion	29%
	Muscle Strain	16%
	Joint Sprain	15%
	Abrasion	10%
	Joint trauma	9%
	Fracture	6%
	Laceration	5%
	Dislocation	3%
	Concussion	2%
	Other	5%
Scoggin *et al.* (2010)	**Description**	**Percent**
(Professional MMA competitions, Hawaii)	Lacerations	51%
	Concussions	20%
	Dislocations	6%
	Contusions	4%
Shadgan (2010)	**Description**	**Percent**

(Wrestlers at Beijing Olympics)	Ligament strain	57%
	Laceration	29%
	Muscle strain	14%
Souza *et al.* (2006)	**Description**	**Percent**
(Judo championships in Sao Paulo, Brazil)	Incision	3%
	Contusion	15%
	Dislocation	18%
	Strain	14%
	Sprain	25%
	Ligament injury	11%
	Fracture	3%
Yard *et al.* (2007)	**Description**	**Percent**
(Paediatric martial arts injuries at emergency departments in the USA)	Sprains and strains	29%
	Contusions and abrasions	28%
	Fractures	25%
Yard (2008)	**Description**	**Percent**
(Wrestlers in high school and college, USA)	Strains and sprains	30%
	Contusions and abrasions	28%
	Fractures	25%
	Lacerations	7%
	Concussions	2%
	Dislocations	2%
	Other	1%
Zazryn, McCrory and Cameron (2009)	**Description**	**Percent**
(Professional boxers in Victoria, Australia)	Laceration	64%
	Concussion	12%
	Fracture	8%
	Contusion	5%
	Abrasion	1%
	Dislocation	1%
	Inflammation	1%
	Strain	1%
	Rupture	1%
	Visual impairment	1%
	Other	6%
Zetaruk *et al.* (2000)	**Description**	**Percent**
(Karate athletes in Boston, Massachusetts)	Sprains and strains	47%
	Contusions	35%
	Lacerations	11%
	Fractures and dislocations	8%
This (current) study	**Description**	**Percent**
(MMA Athletes in the greater Durban area)	Joint sprain	30%
	Muscle strain	27%
	Dislocation	11%
	Fracture	10%
	Muscle tear	7%
	Contusion/bruise	4%
	Ligament tear	4%
	Laceration/bleeding	3%
	Lumbar disc bulge	3%
	Ligament strain	2%
	Headache	1%
	Concussion	1%

Section3: Mechanism of Injury

The following is a summary of findings by various authors regarding the mechanism of injury in various martial arts according to available literature. Figures have been rounded off to the nearest whole number.

Study	Description	Percent
Arriaza and Leyes (2005) (Karate World Championships)	Punches	82%
	Kicks	7%
Arriaza *et al.* (2009) (Karate World Championships)	Punches	67%
	Kicks	16%
	Sweeping/falls	10%
Kazemi and Pieter (2004) (Canadian National Taekwondo Championships)	Receiving a kick	27%
	Delivering a kick	16%
	Simultaneous kicks	2%
	Other	2%
Kazemi *et al.* (2009) (Taekwondo competitions, Canada)	Defensive kick	44%
	Offensive kick	35%
	Falling	4%
	Defensive punch	3%
	Offensive punch	1%
McPherson and Pickett (2010) (Martial arts injuries presenting at a Canadian Hospital)	Fall/throw/jump	33%
	Kick	32%
	Punch	8%
	Weapon	5%
James and Pieter (2003) (National Judo competition, United Kingdom)	Impact onto surface	22%
	Being thrown	17%
	Delivering throw	15%
	Prohibited action	7%
	Groundwork	5%
	Impact with opponent	5%
Souza *et al.* (2006) (Judo championships in Sao Paulo, Brazil)	Striking opponent	60%
	Being struck	27%
	Gripping opponent	6%
	Other	11%
This (current) study (MMA Athletes in the greater Durban area)	Falling	21%
	Impact onto ground	14%
	Striking opponent	13%
	Not sure	13%
	Joint lock	11%
	Being struck	10%
	Sharp turn/twist	8%
	Overuse	6%
	Collision with opponent	4%
	Strangulation	2%
	Gripping opponent	1%

Appendix B: Gatekeeper permission from Mixed Martial Arts South Africa

Contact details: cell: +27 72 363 6244/+27 83 701 2154 Fax: 086 567 8438 E-mail:
bertus.coetzee@icloud.com / mmasouthafrica@yahoo.com
NPO number: 123-408 NPO

To whom it may conern

I, Bertus Coetzee, hereby give you, Duncan Jack permission to conduct your relevant study in the MMA community within South Africa with our affiliated gyms.

[redacted]

Kind Regards
Bertus Coetzee
President
MMA South Africa

Appendix C: Letter of permission from gym owners

<u>CONFIRMATION OF PERMISSION TO CONDUCT RESEARCH</u>

Dear Gym Owner

Thank you for allowing research to be conducted in your gym.

The study to be conducted is:

> The prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area

The questionnaire will take approximately 5 minutes to complete. All information captured will be anonymous and will not in any way be associated back to the participant, you or your gym.

I, ____________________________________ (gym owner) am satisfied with the research arrangements and give permission for the above-mentioned research to be conducted at ____________________________________ (name of gym) at a date and time to be agreed upon by myself and the researchers.

_____________________	_________________	____________________
Name of Gym Owner	Date	Signature

Thank you for your permission and willingness in assisting us to compete our research.

Yours sincerely

Duncan Jack
Researcher

Appendix D: Letter of information and informed consent to potential participants)

<u>LETTER OF INFORMATION</u>

Dear Participant

I would like to welcome you into my study.

<u>Study title:</u>

The prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area

<u>Brief Introduction to the Study:</u>

Due to the nature of MMA, practicing the sport is a high-risk activity for injury. Musculoskeletal injuries in MAA athletes are inevitable, with the risk of further injury multiplied should the athlete fight with existing injury. While there is evidence to support the high incidence of injuries sustained in the practice of MMA, limited information is available on the description and profile of these injuries and their risk factors.

<u>Study Aim</u>:

To determine the role of selected risk factors in the prevalence of musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area.

<u>Study procedure:</u>

The questionnaire contains sections for demographic details, training regimen details, and the participant's injuries that have been sustained while practicing or competing in MMA activities in a 12 month period prior to the date of data collection. Participants will complete the three-part questionnaire after signing informed consent to participate in this study.

<u>Those who may participate in the study:</u>

Those who are eligible to participate in the study are:

- MMA athletes 18 years of age or older.
- Participating in the sport for at least six months in total within a twelve month period prior to the date of data collection.

- Training at least once per week during that six month period.
- Attending and training at an MMA club within the greater Durban area.

Benefits, risks and costs:

This study may contribute to the knowledge and understanding surrounding injuries and their risk factors in MMA athletes. Results of the study will be available in the form of a dissertation in the DUT library. There are no risks involved or costs associated regarding your participation in this study.

Confidentiality:

The questionnaire is anonymous and no personal/identifying information will be recorded. All information that is obtained will be treated as strictly confidential. The usage of the data collected in this study will be used solely as outlined above.

Persons to Contact in the Event of Any Problems or Queries:
Researcher: Mr DA Jack (083 481 3090)
Supervisor: Dr G Haswell MTech: Chiropractic (DUT), B.Com (UND), MCASA (031 563 4451)

Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the
DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

Thank you for participating in research.

Yours sincerely

____

Duncan Jack
BTech: Chiropractic
Researcher

____

Dr G Haswell
MTech: Chiropractic (DUT), B.Com (UND), MCASA
Supervisor

<u>CONSENT</u>

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Duncan Jack, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: IREC 030/15
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my age and injuries will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

______________________	__________	____________________
Full Name of Participant	**Date**	**Signature**

I, Duncan Jack herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Duncan Jack	__________	____________________
Full Name of Researcher	**Date**	**Signature**

Appendix E: Research Tool – Questionnaire (Post Expert Group)

Mixed Martial Arts Injury Questionnaire

Please mark with an 'X' indicating the choice that is the most appropriate to you. For some questions you may mark multiple boxes where indicated (see instructions). Some answers may require you to answer in more detail.

SECTION A: Participant information

(Mark ONE box only per question)

1	Age	years			3	Height	m
2	Gender	Female	Male		4	Weight	kg

5	Ethnicity	African	Asian	Coloured	Indian	White	Other:

6 Which is your dominant hand? Left | Right | Ambidextrous

7 Do you fight favouring your dominant side when possible? Yes | No

8 Which activity do you do the most of in your occupation?

Sitting (at a desk)	Standing	Walking	Driving
Constant movement	Manual Labour	Bending	Other (Specify):

9a Have you ever sustained any work-related injuries? Yes | No

9b If yes to 9a, state the type and area of the injury (can be more than one): ____________

____

10a Are you involved in any sport/activity other than MMA? Yes | No

10b If yes to 10a, please specify (can be more than one): ______________________

____

11a Have you ever sustained any injuries from participation in the above sports/activities? Yes | No

11b If yes to 11a, state the type and area of the injury (can be more than one): ____________

____

12a Have you ever sustained any injuries outside of MMA, work or sport? Yes | No

12b If yes to 12a, state the type and area of the injury (can be more than one): ____________

____

13a Have you ever had musculoskeletal surgery (eg pins, muscle/ligament reattachment, surgical joint relocation, bone graft etc? Yes | No

13b If yes to 13a, please specify (can be more than one, or state if unsure): ____________

____

14a Have you ever smoked cigarettes? Yes | No

14b If yes to 14a, are you a current smoker or ex-smoker? Ex-smoker | Current smoker

14c If yes to 14a, please fill in appropriate numbers: years smoking | cigarettes per day

15 How many tots of alcohol do you consume weekly on average? __________
[1 tot of spirit (30ml) = 1 can of beer (330ml) = 1 glass of wine (250ml)]

SECTION B: Training

Please answer the following questions in regard to your MMA training

1 For how long have you actively been doing MMA? ____________

2 How many DAYS a week do you train MMA? ________days per week

3 How many training sessions do you do on a 'training day'? ________session(s)

4 On average, how long is a typical training session? ____________

5 Which of the following do you do during your weekly MMA training sessions?
(You may mark more than one box)

Cardio/fitness	Flexibility	Strength/resistance eg weights
Technique	Sparring	Other (specify):

6 While practicing technique or sparring, which of the following are included:
(You may mark more than one box)

Standing striking	Standing grappling	Take downs
Standing strangles	Standing arm-bars	Other joint locks (standing)
Ground striking	Ground grappling	Groundwork holds/pins
Ground strangles	Ground arm-bars	Other joint locks (groundwork)

7 By whom is your training usually supervised?
(Mark ONE box only)

Accredited coach	Unaccredited coach	Experienced fighter
Training partner	Unsupervised	Not sure

8 On what type of surface do you usually train MMA? (Mark ONE box only)

Compressed foam/padded surface 10mm thick or less	Wooden/sprung floor
Compressed foam/padded surface more than 10mm thick	Concrete/hard floor
Other (specify):	Grass

9a Have you competed in MMA competitions? | Yes | No |

9b If yes to 9a, what kind of league have you competed in? | Amateur | Professional |

KEY

(To complete the tables on the next page)

FOR REFERENCE ONLY
(Use these options to complete the tables on the next page):

A. Injured area:

Fingers	Shoulder	Lower leg	Mouth
Hand	Ribs	Ankle	Teeth
Wrist	Abdomen	Foot	Ear
Forearm	Hip	Toes	Neck
Elbow	Thigh	Eye	Mid-back
Upper arm	Knee	Nose	Lower back
			Other (be specific)

B. Which side of the body was it? L / R / N/A

C. What type of injury was it?

Muscle strain	Laceration/bleeding	Headache
Muscle tear	Joint sprain	Concussion
Contusion/bruise	Dislocation	
Muscle cramp	Fracture	Other (be specific)

D. How many days in total have you been unable to train (to date) as a result of this injury?

E. During which activity did the injury occur?

Training (TR)	Competition (COMP)

F. How did your injury occur?

Striking opponent	Sharp turn/twist	Other (be specific)
Being struck	Falling	
Collision with opponent	Strangulation	
Impact onto ground	Joint lock	

SECTION C: Injuries

Current **injuries are injuries you have at this point in time.**

Previous **injuries are injuries that have already been resolved, limited to injuries sustained in the last 12 months.**

Select an option from the the key on page 3 for each answer.

1. CURRENT injuries

Do you have any CURRENT injuries? | Yes | No |

If yes, please use the table to describe them (up to 5 most significant). If no, leave this table blank.

	A (Injured area)	B (Side)	C (Type)	D Days 'out'	E Activity	F (Mechanism)
eg	Forearm	R	Contusion	7	TR	Falling
1.						
2.						
3.						
4.						
5.						

2. PREVIOUS injuries

Do you have any previous injuries? | Yes | No |

If yes, please use the table to describe them (up to 5 most significant). If no, leave this table blank.

	A (Injured area)	B (Side)	C (Type)	D Days 'out'	E Activity	F (Mechanism)
eg	Forearm	R	Contusion	7	TR	Falling
1.						
2.						
3.						
4.						
5.						

You have now completed the questionnaire

Appendix F: Ethical Approval from the DUT IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

22 April 2015

IREC Reference Number: **REC 25/15**

Mr D Jack
5 Sunny Circle
Sunningdale
4051

Dear Mr Jack

The prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area

I am pleased to inform you that Full Approval has been granted to your proposal REC 25/15.

The Proposal has been allocated the following Ethical Clearance number **IREC 030/15**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Kindly note that full approval is granted. However, you are required to submit gatekeeper permission letters to the IREC office. Permission letters must be handed to the IREC Administrator by the latest 22 May 2015. Should these letters not be submitted on time, ethics clearance will be withdrawn.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2015 -04- 22
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix G: Motive and purpose for the expert group

The purpose of the expert group was to encourage critical thinking and ideas of its members (Salant and Dillman 1994) in order to ensure that the questionnaire met the aims and objectives of the study and make any additions, changes or deletions that the group felt was necessary to ensure:

1. Face validity – Taking validity of the test by face value by looking at whether the questionnaire seems to measure what it is intended to measure (Benard 2000).
2. Content validity – Assessing whether the content of the questionnaire is considered effective, well rounded enough and represents the entire range of possible concepts the questionnaire should cover (Benard 2000; Grazziano and Raulin 2004).

The process for the study's expert group procedures were in accordance with guidelines from Salant and Dillman (1994); (Mouton 1996); Morgan (1998a, 1998c, 1998b); Seymour (2004). The expert group consisted of members' representative of their particular field(s) of expertise with regards to this study.

The expert group consisted of:

- The researcher
- The researcher's supervisor
- The researcher of the associated study
- Three chiropractic master's students who had experience with questionnaire-based research studies.
- Three martial artists

The researcher's supervisor and the researcher of the associated study were invited to participate in the expert group. The portfolios that did not require particular pre-ordained individuals allowed the researcher to select suitable candidates and invite them to participate in the expert group. It was noted that one individual may fill more than one portfolio if their expertise was considerable in the noted fields. The candidates were contacted telephonically by the researcher and were invited to participate. If the candidate accepted the invitation, they were included into the expert group. If the candidate refused participation, they were excluded from the expert group. It was noted that the martial artists that were invited to be present at the expert group had backgrounds in grappling and striking martial arts, but were not currently training at a sanctioned MMA gym in the greater Durban area. This allowed access of the expertise of these experienced individuals without depleting the pool of candidates eligible to participate in the study.

Once the researcher had a full team of expert group members that had agreed to participate, a date and time for the meeting was agreed upon, a venue was booked and stationary, recording devices and refreshments were arranged

The meeting was convened and chaired by the researcher, all participants were given letters of information and informed consent (Appendix K) as well as a confidentiality statement (Appendix L) that the expert group members were required to read and complete. The researcher explained the aims and objectives of the study and distributed copies of the (pre-expert group) questionnaire (Appendix H), which the expert group members read through individually before starting the discussion. Each question was read aloud by the researcher and then discussed by the group in terms of clarity and purpose and in keeping with the aims and objectives. All questions were discussed in sequential order, giving every member of the expert group opportunity to give their opinions. Changes were made to questions based on group consensus. All changes were recorded and reflected in the post-expert group questionnaire (Appendix E).

Appendix H: Pre Expert Group Questionnaire

Mixed Martial Arts Injury Questionnaire

Please mark with an 'X' indicating the choice that is the most appropriate to you. For some questions you may mark multiple boxes where indicated (see instructions). Some answers may require you to answer in more detail.

SECTION A: Participant information (Mark ONE box only per question)

1	Age	years					
2	Gender	Female	Male				
3	Height	m					
4	Weight	kg					
5	Ethnicity	African	Asian	Coloured	Indian	White	Other:

6 **Which is your dominant hand?** Left | Right | Ambidextrous

7 **Do you fight favouring your dominant side when possible?** Yes | No

8 **What is your occupation?** ______________________________

9a **Have you ever sustained any work related injuries that you would consider to be significant?** Yes | No

9b **If yes to 9a, state the injury (can be more than one):** ______________________________

10a **Are you involved in any sport/activity other than MMA regularly (on a weekly basis)?** Yes | No

10b **If yes to 10a, please specify (can be more than one):** ______________________________

11a **Have you ever sustained any injuries from participation in the above sports/activities that you would consider to be significant?** Yes | No

11b **If yes to 11a, state the injury (can be more than one):** ______________________________

12a **Have you ever sustained any recreational injuries (injuries other than MMA, work or sport) that you would consider to be significant?** Yes | No

12b **If yes to 12a, please specify (can be more than one):** ______________________________

13a **Have you ever had musculoskeletal surgery (eg pins, muscle/ligament reattachment, surgical joint relocation, bone graft etc?** Yes | No

13a **If yes to 13a, please specify (can be more than one):** ______________________________

14 **Do you smoke cigarettes?**

No		
Ex-smoker	years	cigarettes/day
Current smoker	years	cigarettes/day

15 **How much alcohol do you drink weekly on average?** ______ measures of alcohol/week
(1 can of beer (330ml) = 1 glass of wine (250ml) = 1 tot of spirit (30ml) = 1 measure of alcohol)

SECTION B: Training

1 **For how long have you actively been doing MMA?** __________years
(E.g. If you have only been doing MMA for 6 months, please write 0.5 years)

2 **How many DAYS a week do you train MMA?** __________days/week

3 **How many training sessions do you do on a 'training day'?** __________session(s)
(E.g. 1, 2, etc)

4 **On average, how long is a typical training session?** __________hours
(E.g. If training is for 90min, please write 1.5 hours)

5 **Which of the following do you do during your weekly MMA training sessions?**
(You may mark <u>more</u> than one box)

Cardio/fitness	Flexibility	Strength/resistance eg weights
Technique	Sparring	Other (specify):

6 **While practicing technique or sparring, which of the following are included:**
(You may mark <u>more</u> than one box)

Standing striking	Standing grappling	Take downs
Standing strangles	Standing arm-bars	Other joint locks (standing)
Ground striking	Ground grappling	Groundwork holds/pins
Ground strangles	Ground arm-bars	Other joint locks (groundwork)

7 **By whom is your training usually supervised?**
(Mark <u>ONE</u> box only)

Qualified coach	Unqualified coach	Experienced fighter
Training partner	Unsupervised	Not sure

8 **On what type of surface do you usually train MMA?** (Mark <u>ONE</u> box only)

Compressed foam/padded surface 10mm thick or less	Wooden/sprung floor
Compressed foam/padded surface > 10mm thick	Concrete/hard floor
Other (specify):	Grass

SECTION C: Injuries

For CURRENT injuries you have, sustained from MMA (up to 5 most significant), please fill in the table accordingly, using the key below. See overleaf for 'previous injuries'.

Do you have any CURRENT injuries (injuries at this point in time)? Yes | No

If yes, please use the table to describe them. If no, please continue to page 4.

	A (Injured area)	B (Side)	C (Type)	D Days 'out'	E Activity	F (Mechanism)
eg	Forearm	R	Contusion	7	TR	Falling
1.						
2.						
3.						
4.						
5.						

FOR REFERENCE ONLY (Write only on the table above):

A. Injured area:

Fingers	Shoulder	Eye	Head
Hand	Ribs	Teeth	Neck
Wrist	Abdomen	Toes	Mid-back
Forearm	Hip	Foot	Lower back
Elbow	Thigh	Ankle	
Arm	Knee	Lower leg	Other (be specific)

B. Which side of the body was it? **L** **R** **N/A**

C. What type of injury was it?

Muscle strain	Joint sprain	Other (be specific)
Contusion/bruise	Dislocation	
Muscle cramp	Fracture	
Laceration/bleeding	Headache	

D. How many days in total have you missed to date as a result of this injury?

E. During which activity did the injury occur?

Training **TR** Competition **COMP**

F. What was the mechanism of this injury?

Striking opponent	Sharp turn/twist	Other (be specific)
Being struck	Falling	
Collision with opponent	Strangulation	
Impact onto ground	Joint lock	

For <u>PREVIOUS</u> injuries, sustained in the last 12 months (up to 5 most significant), please <u>fill in the table</u> accordingly, using the key below.

Do you have any PREVIOUS injuries (injuries resolved before now)? | Yes | No |

If yes, please use the table to describe them. If no, you have completed the questionnaire.

	A (Injured area)	B (Side)	C (Type)	D Days 'out'	E Activity	F (Mechanism)
eg	Forearm	R	Contusion	7	TR	Falling
1.						
2.						
3.						
4.						
5.						

<u>FOR REFERENCE ONLY (Write only on the table above):</u>

A. Injured area:

Fingers	Shoulder	Eye	Head
Hand	Ribs	Teeth	Neck
Wrist	Abdomen	Toes	Mid-back
Forearm	Hip	Foot	Lower back
Elbow	Thigh	Ankle	
Arm	Knee	Lower leg	Other (be specific)

B. Which side of the body was it? L R N/A

C. What type of injury was it?

Muscle strain	Joint sprain	Other (be specific)
Contusion/bruise	Dislocation	
Muscle cramp	Fracture	
Laceration/bleeding	Headache	

D. How many days in total have you missed to date as a result of this injury?

E. During which activity did the injury occur?

Training **TR** Competition **COMP**

F. What was the mechanism of this injury?

Striking opponent	Sharp turn/twist	Other (be specific)
Being struck	Falling	
Collision with opponent	Strangulation	
Impact onto ground	Joint lock	

Appendix I: Expert group changes to Questionnaire

1. Letter of information: Include the inclusion/exclusion criteria for participants.
2. Include a cover page for the questionnaire, which contains the title and basic instructions for completion.
3. Reposition Q's 3 and 4 on the page to save on space.
4. Section A: Remove Q8 (What is your occupation?) and replace with a question describing the nature of occupational work.
5. Section A Q9a: Delete 'that you would consider to be significant'.
6. Section A Q10a: Delete 'regularly (on a weekly basis)'.
7. Section A Q's 9b, 10b, and 11b: Change the question to say "State the type and area of injury (can be more than one)'.
8. Section A Q12a: Delete the word 'recreational' and remove the brackets.
9. Section A Q13b: Include 'or state if unsure'.
10. Section A Q14: Restructure question into a more user-friendly format. Split the question into pieces.
11. Section A Q15: Restructure question to state 'How many tots of alcohol do you consume…'
12. Section B: Underneath title, state that the questions are specific to MMA training.
13. Section B Q1: Remove the word 'years'.
14. Section B Q1: Remove the instruction in brackets.
15. Section B Q2: Replace the forward slash (/) with the word 'per'.
16. Section B Q3: Remove the instruction in brackets.
17. Section B Q4: Remove the word 'hours'.
18. Section B Q4: Remove the instruction in brackets.
19. Section B Q7: Replace the word 'qualified' with 'accredited'.
20. Section B Q8: Replace the greater than symbol (>) with the words 'greater than'.
21. Section C: Make the headings 'Current' and 'Previous' very big and clear.
22. Section C: Staple the questionnaire in a book format, so pages can be viewed in paired.
23. Section C: Put the tables for Current and Previous injuries on the same page, with the 'key' on a paired page in the booklet, to avoid printing the key out twice.
24. Section C: Change the title of the reference box to 'Use these options to fill in tables on the next page'.

25. Section C Reference box Section A: Change the option ‘Arm’ to ‘Upper arm’.
26. Section C Reference box Section A: Replace the option ‘Head’ with ‘Nose’, ‘Mouth’ and ‘Ear’.
27. Section C Reference box Section C: Change the option ‘fracture’ to ‘fracture/break’.
28. Section C Reference box Section C: Add the options ‘Muscle tear’ and ‘Concussion’ to the list of options.

Appendix J: Statistical Testing For Significant Relationships

MMA Injuries vs Gender

			Injuries		Total
			No	Yes	
Gender	Female	Count	6	11	17
		% within Gender	35,30%	64,70%	100,00%
		% within Injuries	33,30%	12,60%	16,20%
		% of Total	5,70%	10,50%	16,20%
	Male	Count	12	76	88
		% within Gender	13,60%	86,40%	100,00%
		% within Injuries	66,70%	87,40%	83,80%
		% of Total	11,40%	72,40%	83,80%
Total		Count	18	87	105
		% within Gender	17,10%	82,90%	100,00%
		% within Injuries	100,00%	100,00%	100,00%
		% of Total	17,10%	82,90%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	4.705[a]	1	0,03	0,041	0,041	
Continuity Correction[b]	3,304	1	0,069			
Likelihood Ratio	4,034	1	0,045	0,071	0,041	
Fisher's Exact Test				0,071	0,041	
Linear-by-Linear Association	4.660[c]	1	0,031	0,041	0,041	0,032
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.91.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.159.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,212	0,117	2,198	.030[c]	0,041
Ordinal by Ordinal	Spearman Correlation	0,212	0,117	2,198	.030[c]	0,041
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Favour Dominant Hand

			Injuries		Total
			No	Yes	
Favour dominant hand while fighting	Yes	Count	18	62	80
		% within Favour dominant hand while fighting	22,50%	77,50%	100,00%
		% within Injuries	100,00%	73,80%	78,40%
		% of Total	17,60%	60,80%	78,40%
	No	Count	0	22	22
		% within Favour dominant hand while fighting	0,00%	100,00%	100,00%
		% within Injuries	0,00%	26,20%	21,60%
		% of Total	0,00%	21,60%	21,60%
Total		Count	18	84	102
		% within Favour dominant hand while fighting	17,60%	82,40%	100,00%
		% within Injuries	100,00%	100,00%	100,00%
		% of Total	17,60%	82,40%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	6.011[a]	1	0,014	0,022	0,008	
Continuity Correction[b]	4,562	1	0,033			
Likelihood Ratio	9,758	1	0,002	0,008	0,008	
Fisher's Exact Test				0,011	0,008	
Linear-by-Linear Association	5.952[c]	1	0,015	0,022	0,008	0,008
N of Valid Cases	102					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.88.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.440.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,243	0,037	2,502	.014[c]	0,022
Ordinal by Ordinal	Spearman Correlation	0,243	0,037	2,502	.014[c]	0,022
N of Valid Cases		102				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Additional sport: CrossFit

			Injuries		Total
			No	Yes	
CrossFit	No	Count	13	83	96
		% within CrossFit	13,50%	86,50%	100,00%
		% within Injuries	72,20%	95,40%	91,40%
		% of Total	12,40%	79,00%	91,40%
	Yes	Count	5	4	9
		% within CrossFit	55,60%	44,40%	100,00%
		% within Injuries	27,80%	4,60%	8,60%
		% of Total	4,80%	3,80%	8,60%
Total		Count	18	87	105
		% within CrossFit	17,10%	82,90%	100,00%
		% within Injuries	100,00%	100,00%	100,00%
		% of Total	17,10%	82,90%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	10.226[a]	1	0,001	0,007	0,007	
Continuity Correction[b]	7,482	1	0,006			
Likelihood Ratio	7,706	1	0,006	0,007	0,007	
Fisher's Exact Test				0,007	0,007	
Linear-by-Linear Association	10.128[c]	1	0,001	0,007	0,007	0,006
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 1.54.

b. Computed only for a 2x2 table

c. The standardized statistic is -3.183.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	-0,312	0,128	-3,334	.001[c]	0,007
Ordinal by Ordinal	Spearman Correlation	-0,312	0,128	-3,334	.001[c]	0,007
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Flexibility Training

			Injuries		Total
			No	Yes	
Do MMA training sessions include: Flexibility	No	Count	14	40	54
		% within Do MMA training sessions include: Flexibility	25,90%	74,10%	100,00%
		% within Injuries	77,80%	46,00%	51,40%
		% of Total	13,30%	38,10%	51,40%
	Yes	Count	4	47	51
		% within Do MMA training sessions include: Flexibility	7,80%	92,20%	100,00%
		% within Injuries	22,20%	54,00%	48,60%
		% of Total	3,80%	44,80%	48,60%
Total		Count	18	87	105
		% within Do MMA training sessions include: Flexibility	17,10%	82,90%	100,00%
		% within Injuries	100,00%	100,00%	100,00%
		% of Total	17,10%	82,90%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	6.038[a]	1	0,014	0,019	0,013	
Continuity Correction[b]	4,832	1	0,028			
Likelihood Ratio	6,362	1	0,012	0,019	0,013	
Fisher's Exact Test				0,019	0,013	
Linear-by-Linear Association	5.980[c]	1	0,014	0,019	0,013	0,01
N of Valid Cases	105					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.74.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.446.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,24	0,087	2,507	.014[c]	0,019
Ordinal by Ordinal	Spearman Correlation	0,24	0,087	2,507	.014[c]	0,019
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Standing Grappling

			Does training include: Standing grappling		Total
			No	Yes	
Injuries	No	Count	10	8	18
		% within Injuries	55,60%	44,40%	100,00%
		% within Does training include: Standing grappling	27,80%	11,60%	17,10%
		% of Total	9,50%	7,60%	17,10%
	Yes	Count	26	61	87
		% within Injuries	29,90%	70,10%	100,00%
		% within Does training include: Standing grappling	72,20%	88,40%	82,90%
		% of Total	24,80%	58,10%	82,90%
Total		Count	36	69	105
		% within Injuries	34,30%	65,70%	100,00%
		% within Does training include: Standing grappling	100,00%	100,00%	100,00%
		% of Total	34,30%	65,70%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	4.362[a]	1	0,037	0,055	0,037	
Continuity Correction[b]	3,297	1	0,069			
Likelihood Ratio	4,161	1	0,041	0,055	0,037	
Fisher's Exact Test				0,055	0,037	
Linear-by-Linear Association	4.321[c]	1	0,038	0,055	0,037	0,027
N of Valid Cases	105					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.17.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.079.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,204	0,102	2,113	.037[c]	0,055
Ordinal by Ordinal	Spearman Correlation	0,204	0,102	2,113	.037[c]	0,055
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Ground Grappling

			Does training include: Ground grappling		Total
			No	Yes	
Injuries	No	Count	8	10	18
		% within Injuries	44,40%	55,60%	100,00%
		% within Does training include: Ground grappling	30,80%	12,70%	17,10%
		% of Total	7,60%	9,50%	17,10%
	Yes	Count	18	69	87
		% within Injuries	20,70%	79,30%	100,00%
		% within Does training include: Ground grappling	69,20%	87,30%	82,90%
		% of Total	17,10%	65,70%	82,90%
Total		Count	26	79	105
		% within Injuries	24,80%	75,20%	100,00%
		% within Does training include: Ground grappling	100,00%	100,00%	100,00%
		% of Total	24,80%	75,20%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	4.517[a]	1	0,034	0,042	0,038	
Continuity Correction[b]	3,332	1	0,068			
Likelihood Ratio	4,099	1	0,043	0,068	0,038	
Fisher's Exact Test				0,068	0,038	
Linear-by-Linear Association	4.474[c]	1	0,034	0,042	0,038	0,028
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.46.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.115.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,207	0,109	2,152	.034[c]	0,042
Ordinal by Ordinal	Spearman Correlation	0,207	0,109	2,152	.034[c]	0,042
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Injuries vs Ground Strangles

			Does training include: Ground strangles		Total
			No	Yes	
Injuries	No	Count	10	8	18
		% within Injuries	55,60%	44,40%	100,00%
		% within Does training include: Ground strangles	29,40%	11,30%	17,10%
		% of Total	9,50%	7,60%	17,10%
	Yes	Count	24	63	87
		% within Injuries	27,60%	72,40%	100,00%
		% within Does training include: Ground strangles	70,60%	88,70%	82,90%
		% of Total	22,90%	60,00%	82,90%
Total		Count	34	71	105
		% within Injuries	32,40%	67,60%	100,00%
		% within Does training include: Ground strangles	100,00%	100,00%	100,00%
		% of Total	32,40%	67,60%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.329[a]	1	0,021	0,028	0,023	
Continuity Correction[b]	4,128	1	0,042			
Likelihood Ratio	5,022	1	0,025	0,051	0,023	
Fisher's Exact Test				0,028	0,023	
Linear-by-Linear Association	5.278[c]	1	0,022	0,028	0,023	0,017
N of Valid Cases	105					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.83.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.297.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,225	0,103	2,347	.021[c]	0,028
Ordinal by Ordinal	Spearman Correlation	0,225	0,103	2,347	.021[c]	0,028
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Ground Arm-bars

			Does training include: Ground arm-bars		Total
			No	Yes	
Injuries	No	Count	9	9	18
		% within Injuries	50,00%	50,00%	100,00%
		% within Does training include: Ground arm-bars	34,60%	11,40%	17,10%
		% of Total	8,60%	8,60%	17,10%
	Yes	Count	17	70	87
		% within Injuries	19,50%	80,50%	100,00%
		% within Does training include: Ground arm-bars	65,40%	88,60%	82,90%
		% of Total	16,20%	66,70%	82,90%
Total		Count	26	79	105
		% within Injuries	24,80%	75,20%	100,00%
		% within Does training include: Ground arm-bars	100,00%	100,00%	100,00%
		% of Total	24,80%	75,20%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	7.427[a]	1	0,006	0,01	0,01	
Continuity Correction[b]	5,882	1	0,015			
Likelihood Ratio	6,635	1	0,01	0,014	0,01	
Fisher's Exact Test				0,014	0,01	
Linear-by-Linear Association	7.357[c]	1	0,007	0,01	0,01	0,008
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.46.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.712.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,266	0,109	2,8	.006[c]	0,01
Ordinal by Ordinal	Spearman Correlation	0,266	0,109	2,8	.006[c]	0,01
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Falling

			MOI_Falling total		Total
			No	Yes	
Injuries	No	Count	18	0	18
		% within Injuries	100,00%	0,00%	100,00%
		% within MOI_Falling total	22,50%	0,00%	17,10%
		% of Total	17,10%	0,00%	17,10%
	Yes	Count	62	25	87
		% within Injuries	71,30%	28,70%	100,00%
		% within MOI_Falling total	77,50%	100,00%	82,90%
		% of Total	59,00%	23,80%	82,90%
Total		Count	80	25	105
		% within Injuries	76,20%	23,80%	100,00%
		% within MOI_Falling total	100,00%	100,00%	100,00%
		% of Total	76,20%	23,80%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	6.789[a]	1	0,009	0,012	0,004	
Continuity Correction[b]	5,297	1	0,021			
Likelihood Ratio	10,904	1	0,001	0,005	0,004	
Fisher's Exact Test				0,006	0,004	
Linear-by-Linear Association	6.724[c]	1	0,01	0,012	0,004	0,004
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.29.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.593.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,254	0,038	2,668	.009[c]	0,012
Ordinal by Ordinal	Spearman Correlation	0,254	0,038	2,668	.009[c]	0,012
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Falling vs Standing Striking

			Does training include: Standing striking		Total
			No	Yes	
MOI_Falling total	No	Count	4	76	80
		% within MOI_Falling total	5,00%	95,00%	100,00%
		% within Does training include: Standing striking	44,40%	79,20%	76,20%
		% of Total	3,80%	72,40%	76,20%
	Yes	Count	5	20	25
		% within MOI_Falling total	20,00%	80,00%	100,00%
		% within Does training include: Standing striking	55,60%	20,80%	23,80%
		% of Total	4,80%	19,00%	23,80%
Total		Count	9	96	105
		% within MOI_Falling total	8,60%	91,40%	100,00%
		% within Does training include: Standing striking	100,00%	100,00%	100,00%
		% of Total	8,60%	91,40%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.469[a]	1	0,019	0,033	0,033	
Continuity Correction[b]	3,722	1	0,054			
Likelihood Ratio	4,644	1	0,031	0,111	0,033	
Fisher's Exact Test				0,033	0,033	
Linear-by-Linear Association	5.417[c]	1	0,02	0,033	0,033	0,028
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.14.

b. Computed only for a 2x2 table

c. The standardized statistic is -2.327.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	-0,228	0,115	-2,379	.019[c]	0,033
Ordinal by Ordinal	Spearman Correlation	-0,228	0,115	-2,379	.019[c]	0,033
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Impact onto Ground vs Take Downs

			Does training include: Take downs		Total
			No	Yes	
MOI_Impact onto ground total	No	Count	23	61	84
		% within MOI_Impact onto ground total	27,40%	72,60%	100,00%
		% within Does training include: Take downs	100,00%	74,40%	80,00%
		% of Total	21,90%	58,10%	80,00%
	Yes	Count	0	21	21
		% within MOI_Impact onto ground total	0,00%	100,00%	100,00%
		% within Does training include: Take downs	0,00%	25,60%	20,00%
		% of Total	0,00%	20,00%	20,00%
Total		Count	23	82	105
		% within MOI_Impact onto ground total	21,90%	78,10%	100,00%
		% within Does training include: Take downs	100,00%	100,00%	100,00%
		% of Total	21,90%	78,10%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	7.363[a]	1	0,007	0,006	0,003	
Continuity Correction[b]	5,849	1	0,016			
Likelihood Ratio	11,779	1	0,001	0,003	0,003	
Fisher's Exact Test				0,006	0,003	
Linear-by-Linear Association	7.293[c]	1	0,007	0,006	0,003	0,003
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.60.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.700.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,265	0,039	2,787	.006[c]	0,006
Ordinal by Ordinal	Spearman Correlation	0,265	0,039	2,787	.006[c]	0,006
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Joint Locks vs Other Joint Locks Standing

			Does training include: Other joint locks standing		Total
			No	Yes	
MOI_Joint lock total	No	Count	51	37	88
		% within MOI_Joint lock total	58,00%	42,00%	100,00%
		% within Does training include: Other joint locks standing	91,10%	75,50%	83,80%
		% of Total	48,60%	35,20%	83,80%
	Yes	Count	5	12	17
		% within MOI_Joint lock total	29,40%	70,60%	100,00%
		% within Does training include: Other joint locks standing	8,90%	24,50%	16,20%
		% of Total	4,80%	11,40%	16,20%
Total		Count	56	49	105
		% within MOI_Joint lock total	53,30%	46,70%	100,00%
		% within Does training include: Other joint locks standing	100,00%	100,00%	100,00%
		% of Total	53,30%	46,70%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	4.664[a]	1	0,031	0,037	0,029	
Continuity Correction[b]	3,587	1	0,058			
Likelihood Ratio	4,74	1	0,029	0,037	0,029	
Fisher's Exact Test				0,037	0,029	
Linear-by-Linear Association	4.619[c]	1	0,032	0,037	0,029	0,022
N of Valid Cases	105					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.93.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.149.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,211	0,092	2,188	.031[c]	0,037
Ordinal by Ordinal	Spearman Correlation	0,211	0,092	2,188	.031[c]	0,037
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Striking Opponent vs Surgery For Fracture Repair

			Surgery Type Fracture repair		Total
			No	Yes	
MOI_Striking opponent total	No	Count	81	3	84
		% within MOI_Striking opponent total	96,40%	3,60%	100,00%
		% within Surgery Type Fracture repair	82,70%	42,90%	80,00%
		% of Total	77,10%	2,90%	80,00%
	Yes	Count	17	4	21
		% within MOI_Striking opponent total	81,00%	19,00%	100,00%
		% within Surgery Type Fracture repair	17,30%	57,10%	20,00%
		% of Total	16,20%	3,80%	20,00%
Total		Count	98	7	105
		% within MOI_Striking opponent total	93,30%	6,70%	100,00%
		% within Surgery Type Fracture repair	100,00%	100,00%	100,00%
		% of Total	93,30%	6,70%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	6.467[a]	1	0,011	0,028	0,028	
Continuity Correction[b]	4,219	1	0,04			
Likelihood Ratio	5,1	1	0,024	0,028	0,028	
Fisher's Exact Test				0,028	0,028	
Linear-by-Linear Association	6.405[c]	1	0,011	0,028	0,028	0,025
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 1.40.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.531.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,248	0,124	2,6	.011[c]	0,028
Ordinal by Ordinal	Spearman Correlation	0,248	0,124	2,6	.011[c]	0,028
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Sharp Turn/Twist vs Surgery For Ligament Repair

			Ligament repair		Total
			No	Yes	
MOI_Sharp turn/twist total	No	Count	80	4	84
		% within MOI_Sharp turn/twist total	95,20%	4,80%	100,00%
		% within Ligament repair	83,30%	44,40%	80,00%
		% of Total	76,20%	3,80%	80,00%
	Yes	Count	16	5	21
		% within MOI_Sharp turn/twist total	76,20%	23,80%	100,00%
		% within Ligament repair	16,70%	55,60%	20,00%
		% of Total	15,20%	4,80%	20,00%
Total		Count	96	9	105
		% within MOI_Sharp turn/twist total	91,40%	8,60%	100,00%
		% within Ligament repair	100,00%	100,00%	100,00%
		% of Total	91,40%	8,60%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	7.778[a]	1	0,005	0,015	0,015	
Continuity Correction[b]	5,537	1	0,019			
Likelihood Ratio	6,211	1	0,013	0,015	0,015	
Fisher's Exact Test				0,015	0,015	
Linear-by-Linear Association	7.704[c]	1	0,006	0,015	0,015	0,013
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 1.80.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.776.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,272	0,122	2,871	.005[c]	0,015
Ordinal by Ordinal	Spearman Correlation	0,272	0,122	2,871	.005[c]	0,015
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Neck Injury vs Ground Strangles

			Does training include: Ground strangles		Total
			No	Yes	
Area - Neck	No	Count	34	60	94
		% within Area - Neck	36,20%	63,80%	100,00%
		% within Does training include: Ground strangles	100,00%	84,50%	89,50%
		% of Total	32,40%	57,10%	89,50%
	Yes	Count	0	11	11
		% within Area - Neck	0,00%	100,00%	100,00%
		% within Does training include: Ground strangles	0,00%	15,50%	10,50%
		% of Total	0,00%	10,50%	10,50%
Total		Count	34	71	105
		% within Area - Neck	32,40%	67,60%	100,00%
		% within Does training include: Ground strangles	100,00%	100,00%	100,00%
		% of Total	32,40%	67,60%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.884[a]	1	0,015	0,015	0,01	
Continuity Correction[b]	4,348	1	0,037			
Likelihood Ratio	9,213	1	0,002	0,011	0,01	
Fisher's Exact Test				0,015	0,01	
Linear-by-Linear Association	5.828[c]	1	0,016	0,015	0,01	0,01
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.56.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.414.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,237	0,04	2,473	.015[c]	0,015
Ordinal by Ordinal	Spearman Correlation	0,237	0,04	2,473	.015[c]	0,015
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Elbow Injury vs Ground Arm-bars

			Does training include: Ground arm-bars		Total
			No	Yes	
Area - Elbow	No	Count	26	65	91
		% within Area - Elbow	28,60%	71,40%	100,00%
		% within Does training include: Ground arm-bars	100,00%	82,30%	86,70%
		% of Total	24,80%	61,90%	86,70%
	Yes	Count	0	14	14
		% within Area - Elbow	0,00%	100,00%	100,00%
		% within Does training include: Ground arm-bars	0,00%	17,70%	13,30%
		% of Total	0,00%	13,30%	13,30%
Total		Count	26	79	105
		% within Area - Elbow	24,80%	75,20%	100,00%
		% within Does training include: Ground arm-bars	100,00%	100,00%	100,00%
		% of Total	24,80%	75,20%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.316[a]	1	0,021	0,04	0,014	
Continuity Correction[b]	3,893	1	0,048			
Likelihood Ratio	8,653	1	0,003	0,014	0,014	
Fisher's Exact Test				0,019	0,014	
Linear-by-Linear Association	5.266[c]	1	0,022	0,04	0,014	0,014
N of Valid Cases	105					

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 3.47.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.295.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,225	0,036	2,344	.021[c]	0,04
Ordinal by Ordinal	Spearman Correlation	0,225	0,036	2,344	.021[c]	0,04
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Joint Sprain vs Ground Arm-bars

			Does training include: Ground arm-bars		Total
			No	Yes	
Injury Type_Joint sprain Total	No	Count	22	43	65
		% within Injury Type_Joint sprain Total	33,80%	66,20%	100,00%
		% within Does training include: Ground arm-bars	84,60%	54,40%	61,90%
		% of Total	21,00%	41,00%	61,90%
	Yes	Count	4	36	40
		% within Injury Type_Joint sprain Total	10,00%	90,00%	100,00%
		% within Does training include: Ground arm-bars	15,40%	45,60%	38,10%
		% of Total	3,80%	34,30%	38,10%
Total		Count	26	79	105
		% within Injury Type_Joint sprain Total	24,80%	75,20%	100,00%
		% within Does training include: Ground arm-bars	100,00%	100,00%	100,00%
		% of Total	24,80%	75,20%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	7.558[a]	1	0,006	0,009	0,005	
Continuity Correction[b]	6,332	1	0,012			
Likelihood Ratio	8,33	1	0,004	0,006	0,005	
Fisher's Exact Test				0,006	0,005	
Linear-by-Linear Association	7.486[c]	1	0,006	0,009	0,005	0,004
N of Valid Cases	105					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.90.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.736.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,268	0,081	2,826	.006[c]	0,009
Ordinal by Ordinal	Spearman Correlation	0,268	0,081	2,826	.006[c]	0,009
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Joint Sprain vs Ground Grappling

			Does training include: Ground grappling		Total
			No	Yes	
Injury Type_Joint sprain Total	No	Count	21	44	65
		% within Injury Type_Joint sprain Total	32,30%	67,70%	100,00%
		% within Does training include: Ground grappling	80,80%	55,70%	61,90%
		% of Total	20,00%	41,90%	61,90%
	Yes	Count	5	35	40
		% within Injury Type_Joint sprain Total	12,50%	87,50%	100,00%
		% within Does training include: Ground grappling	19,20%	44,30%	38,10%
		% of Total	4,80%	33,30%	38,10%
Total		Count	26	79	105
		% within Injury Type_Joint sprain Total	24,80%	75,20%	100,00%
		% within Does training include: Ground grappling	100,00%	100,00%	100,00%
		% of Total	24,80%	75,20%	100,00%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.215[a]	1	0,022	0,035	0,018	
Continuity Correction[b]	4,206	1	0,04			
Likelihood Ratio	5,605	1	0,018	0,023	0,018	
Fisher's Exact Test				0,035	0,018	
Linear-by-Linear Association	5.165[c]	1	0,023	0,035	0,018	0,013
N of Valid Cases	105					

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.90.

b. Computed only for a 2x2 table

c. The standardized statistic is 2.273.

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,223	0,085	2,32	.022[c]	0,035
Ordinal by Ordinal	Spearman Correlation	0,223	0,085	2,32	.022[c]	0,035
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

MMA Injuries vs Days Missed From Training Due To Injury

Directional Measures

			Value
Nominal by Interval	Eta	Injuries Dependent	,617
		Days Out Dependent	,241

Falling vs Days Missed From Training Due To Injury

Directional Measures

			Value
Nominal by Interval	Eta	MOI_Falling total Dependent	,683
		Days Out Dependent	,322

Dislocation vs Days Missed From Training Due To Injury

Directional Measures

			Value
Nominal by Interval	Eta	Injury Type_Dislocation Total Dependent	,800
		Days Out Dependent	,373

Fracture vs Days Missed From Training Due To Injury

Directional Measures

			Value
Nominal by Interval	Eta	Injury Type_Fracture Total Dependent	,816
		Days Out Dependent	,395

Period Actively Doing MMA vs Favour Dominant Hand

Directional Measures

			Value
Nominal by Interval	Eta	MOI_Falling total Dependent	,683
		Days Out Dependent	,322

Muscle Tear vs Days Missed From Training Due To Injury

Directional Measures

			Value
Nominal by Interval	Eta	Injury Type_Muscle tear Total Dependent	,928
		Days Out Dependent	,544

Age vs MMA Injuries

Directional Measures

			Value
Nominal by Interval	Eta	Age Dependent	0,109
		Injuries Dependent	0,619

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,109	0,113	1,112	.269[c]	0,274
Ordinal by Ordinal	Spearman Correlation	0,154	0,113	1,578	.118[c]	0,118
N of Valid Cases		105				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Weight vs MMA Injuries

Directional Measures

			Value
Nominal by Interval	Eta	Weight Dependent	0,101
		Injuries Dependent	0,706

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,101	0,081	1,006	.317[c]	0,318
Ordinal by Ordinal	Spearman Correlation	0,076	0,091	0,757	.451[c]	0,453
N of Valid Cases		101				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Height vs Upper Limb Injuries

Directional Measures

				Value
Nominal by Interval		Eta	Height Dependent	0,067
			Upper_Limb Dependent	0,623

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,067	0,103	0,651	.517[c]	0,52
Ordinal by Ordinal	Spearman Correlation	0,083	0,102	0,813	.418[c]	0,418
N of Valid Cases		97				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Height vs Lower Limb Injuries

Directional Measures

				Value
Nominal by Interval		Eta	Height Dependent	0,112
			Lower_Limb Dependent	0,615

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance	Exact Significance
Interval by Interval	Pearson's R	0,112	0,102	1,103	.273[c]	0,271
Ordinal by Ordinal	Spearman Correlation	0,138	0,101	1,353	.179[c]	0,179
N of Valid Cases		97				

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Appendix K: Letter of information and informed consent to Expert Group participants

DUT DURBAN UNIVERSITY OF TECHNOLOGY INSTITUTIONAL RESEARCH ETHICS COMMITTEE

LETTER OF INFORMATION (Expert group)

Dear Expert Group participant

I would like to welcome you into my study.

Study title:

The prevalence of and risk factors associated with musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area

Brief Introduction to the Study:

Due to the nature of MMA, practicing the sport is a high-risk activity for injury, with athletes participating in competitions sustaining more than one injury per fight on average. Musculoskeletal injuries in MAA athletes are inevitable, with the risk of further injury multiplied should the athlete fight with existing injury. While there is evidence to support the high incidence of injuries sustained in the practice of MMA, limited information is available on the description and profile of these injuries and their risk factors.

Study Aim:

The aim of this study is to determine the prevalence of and risk factors for musculoskeletal injuries in Mixed Martial Arts athletes in the greater Durban area.

Expert group procedure:

The members of the expert group will read through the questionnaire individually, followed by a group discussion facilitated by the researcher, discussing each question in terms of face and content validity in order to ensure that the questionnaire meets the aims and objectives of the study. The expert group will make any additions, changes or deletions that the group feels is necessary

Benefits, risks and costs:

This study may contribute to the knowledge and understanding surrounding injuries and their risk factors in MMA athletes. Results of the study will be available in the form of a dissertation in the DUT library. There are no risks involved or costs associated regarding your participation in this study.

Confidentiality:

The expert group attendance and proceedings are strictly confidential, enforced by the participants of the expert group signing a confidentiality statement. The questionnaire is anonymous and no personal/identifying information will be recorded. All information that is obtained will be treated as strictly confidential. The usage of the data collected in this study will be used solely as outlined above.

Persons to Contact in the Event of Any Problems or Queries:
Researcher: Mr DA Jack (083 481 3090)
Supervisor: Dr G Haswell MTech: Chiropractic (DUT), B.Com (UND), MCASA (031 563 4451)

Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the
DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

Thank you for participating in research.

Yours sincerely

____

Duncan Jack
BTech: Chiropractic
Researcher

____

Dr G Haswell
MTech: Chiropractic (DUT), B.Com (UND), MCASA
Supervisor

<u>**CONSENT: Expert group**</u>

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Duncan Jack, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my age and injuries will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Please circle yes or no (as is appropriate for yourself):

1. Have you had time to ask questions about the study? Yes / No
2. Have you received satisfactory answers to your questions? Yes / No
3. Have you had an opportunity to discuss this study? Yes / No
4. Have you received enough information about this study? Yes / No
5. Who have you spoken to regarding this study? ______________________________
6. Do you understand the implications of your involvement in this study? Yes / No
7. Do you understand that you are free to drop out of this study at any time? Yes / No

8. Do you agree to voluntarily participate in this study? Yes / No

If you have answered NO to any of the above, please obtain the necessary information from the researcher and / or supervisor before signing. Thank You.

____________________	__________	___________________
Full Name of Participant	**Date**	**Signature**

I, Duncan Jack herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

__Duncan Jack____	__________	___________________
Full Name of Researcher	**Date**	**Signature**

Appendix L: Confidentiality statement (Expert group)

IMPORTANT NOTICE: This form is to be read and filled in by every member participating in the expert group, before the focus group meeting convenes.

<u>CONFIDENTIALITY STATEMENT AND CODE OF CONDUCT: Expert group</u>

1. All information contained in the research documents and any information discussed during the focus group meeting must be kept private and confidential. This is especially binding to any information that may identify any of the participants in the expert group.

2. None of the information shall be communicated to any other individual or organisation outside of this specific focus group as to the decisions of this expert group.

3. The information from this focus group will be made public in terms of a dissertation/thesis and/or journal publication, which will in no way identify any of the participants involved in this expert group.

4. The returned questionnaires will be coded and kept anonymous in the research process.

5. The expert group may be either voice or video recorded, as a transcript of the proceedings will need to be made. The data will be stored securely under password protection.

6. All data generated from this expert group (including the recording) will be kept for 5 years in a secure location at Durban University of Technology and thereafter will be destroyed.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.
Please print in block letters:

Focus Group Member:
________________________________Signature:_____________________

Witness Name:
_________________________________Signature:___________________

Researcher's Name:
_________________________________Signature:____________________

Supervisor's Name:
_________________________________Signature:___________________

Appendix M: Permission for use of questionnaire component

March 17, 2015

To Whom It May Concern,

I hereby give my consent to Duncan Jack for the use of a modified version of my pre-competition habits questionnaire', in his research.

Sincerely,

[redacted]

Dr. Mohsen Kazemi, RN, DC, MSc., FRCCSS(C), FCCPOR(C), DACRB, PhD (Cand)
Doctor of Chiropractic, Sports and Rehabilitation specialist, Acupuncture
Fellow of Royal College of Chiropractic Sports Sciences
Fellow of College of Chiropractic Physical and Occupational Rehabilitation
Diplomate of American Chiropractic Rehabilitation Board
Associate Professor, Sports Sciences Residency coordinator, Canadian Memorial Chiropractic college
Medical Chair, Ontario Taekwondo Association
President, Kazemizer Inc.
President, VMTX Vibromax Therapeutics Inc.
WTF 7th Dan Black Belt

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