



ORTHOPAEDIC INJURIES IN MARTIAL ARTS

Nasri Hani Zreik
MB ChB(Hons) BSc(Hons)
MRCS MCSP

Thesis for MSc (by research) awarded by the
University of Central Lancashire

August 2017



STUDENT DECLARATION FORM

Type of Award – MSc by Research

School of Medicine

*Sections marked * delete as appropriate*

1. Concurrent registration for two or more academic awards

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution

2. Material submitted for another award

I declare that no material contained in the thesis has been used in any other submission for an academic award and is solely my own work

Collaboration

Where a candidate's research programme is part of a collaborative project, the thesis must indicate in addition clearly the candidate's individual contribution and the extent of the collaboration. Please state below:

For the systematic review another 'MSc by Research' student was involved as a second reviewer (Dr. Apostolos Prodromidis). The research student (Dr. Nasri Zreik) undertook all the work independently and the second reviewer was involved in identification of studies for inclusion and data extraction from the selected studies following discussion with the research student.

3. Use of a Proof-reader

No proof-reading service was used in the compilation of this thesis.

Signature of Candidate _____

Print name: Nasri Hani Zreik

ABSTRACT

Background

Injuries in martial arts are commonly reported though little research has been conducted on orthopaedic injuries. Poorly managed or untreated injuries may result in long-term complications. As martial arts present a heterogeneous population, this thesis focusses on contact striking martial arts.

Objectives

To identify the frequency and types of orthopaedic injuries in contact striking martial arts; the factors that may increase the risk of injury and the health seeking behaviour of martial artists.

Methods

A systematic review of studies reporting on the frequency of injury in contact striking martial arts identified in three databases was undertaken followed by a self-report survey of martial artists participating in Chinese Kickboxing

Findings

Systematic review: 15 studies reporting on orthopaedic injury were found, of which 13 reported on event rates of injury. Orthopaedic injury event rates varied between 6.8 and 184.2 injuries per 1000 athlete exposures with considerable heterogeneity between studies. Lower limb injuries were most common accounting for 44.6% (n=228) of injuries. This was followed by upper limb injuries (29.5%, n=151), the trunk (17.4%, n=89) and the neck (8.4%, n=43).

A total of 100 martial artists were recruited to the cross-sectional study. There were 96 orthopaedic injuries reported by these participants giving a one-year period prevalence of orthopaedic injuries of 57% and a mean of 0.96 injuries per participant. The lower limb was the most commonly injured region (61.5%, n=59). This was followed by the upper limb (18.8%, n=18), the trunk (15.6%, n=15) and the neck (4.2%, n=4). Most injuries (86%, n=84) occurred in a class setting and during sparring. In a logistic regression of other risk factors, an increased odds of

injury was seen in male participants, those aged over 30 years and those who attended more than one class per week. In over half of injuries reported (58.3%, n=56), the martial artist sought further help. Most attended a general practitioner or accident and emergency department and over a third of these had onward referral to orthopaedic services.

Conclusion

Orthopaedic injuries are common in contact striking martial arts. The data on the prevalence of injuries and associated risk factors presented in this thesis may assist clinicians and athletes in developing injury prevention and management strategies for contact striking martial artists.

CONTENTS

Student Declaration Form	i
Abstract	ii
List of tables	viii
List of Figures	x
Glossary	xi
Abbreviations	xiv
Acknowledgments	xv
Chapter 1 – Martial Arts and Orthopaedics	1
1.1 Background	1
1.1.1 Martial arts styles	2
1.1.2 Training	3
1.1.3 Sparring	3
1.2 Martial arts and injury	4
1.2.1 Martial artists’ health seeking behaviour	5
1.3 Research context	6
1.3.1 The literature	7
1.3.2 Why this research is important	8
1.4 Study objectives	9
1.5 Outline of thesis chapters	9
Chapter 2 – A systematic review of orthopaedic injuries in contact striking martial arts	11
2.1 Introduction	11
2.2 Review objectives	11
2.3 Methods	12
2.3.1 Study design	12
2.3.2 Selection criteria	12
2.3.3 Search Strategy	14
2.3.4 Screening & eligibility	17

2.3.5	Data extraction	17
2.3.6	Quality assessment	18
2.3.7	Data synthesis	19
2.4	Results	21
2.4.1	The search	22
2.4.2	Included studies	23
2.4.3	Injuries	28
2.4.4	Prevalence studies	30
2.4.5	Event rate studies	32
2.4.6	Summary of main findings	39
2.5	Discussion	40
2.5.1	Summary of main findings	40
2.5.2	Limitations of study methods in the systematic review	41
2.5.3	The study populations	41
2.5.4	Definition of injury	42
2.5.5	Orthopaedic injuries in martial arts and by body region	43
2.5.6	Orthopaedic injury by martial art, setting, participant and contact level	45
2.5.7	Limitations & Strengths	48
2.6	Conclusion	49
Chapter 3 - Survey of Orthopaedic Injuries in Chinese		51
Kickboxing		51
3.1	Introduction	51
3.1.1	Background & research context	52
3.1.2	Survey objectives	53
3.2	Methods	53
3.2.1	Study design	53
3.2.2	Population/participants	54
3.2.3	Identification of participants	54
3.2.4	Injuries of interest	55

3.2.5	Study measures	56
3.2.6	Sample size	56
3.2.7	Data collection	56
3.2.8	Data items	57
3.2.9	Survey development	59
3.2.10	Data protection	60
3.2.11	Ethical approval	60
3.2.12	Piloting of the questionnaire	61
3.2.13	Statistical methods	62
3.3	Survey results	61
3.3.1	Demographics of the population	64
3.3.2	Prevalence of Injuries	65
3.3.3	Injuries by body region	67
3.3.4	Injuries by setting	67
3.3.5	Injuries by activity	68
3.3.6	Other factors	75
3.3.7	Logistic regression to identify independent risk factors for injury	77
3.3.8	Time off training and health seeking behaviour of martial artists	79
3.3.9	Time off training and type of injury	82
3.4	Summary of main findings	
Chapter 4 - Discussion		84
4.1	Introduction	84
4.2	Summary of main findings	84
4.2.1	Systematic review	84
4.2.2	Survey	84
4.3	The main findings in context of the literature	85
4.3.1	Population	85
4.3.2	Injuries	85
4.3.3	Time off training and type of injury	89
4.3.4	Health Seeking behavior of martial artists	90

4.4	Strengths and limitations of the survey	91
4.5	What this study adds	93
	4.5.1 Implications for athletes and the sport	94
	4.5.2 Implications for clinicians	95
	4.5.3 Implications for research	96
4.6	Conclusion	97
	References	98
	Appendices	
	Appendix 1 – Systematic review full protocol	106
	Appendix 2 – Search strategies	116
	Appendix 3 – Prevalence study assessment tool	117
	Appendix 4 – Event rate study assessment tool	119
	Appendix 5 - Survey full protocol	121
	Appendix 6 - Ethical approval letter	126
	Appendix 7 – Cover letter	127
	Appendix 8 – Survey versions	129
	Appendix 9 – Sample weighted proportion and confidence interval calculation	166

List of Tables

Table 2.1a – Key concepts and related synonyms used for the systematic review	15
Table 2.1b – Medline search strategy	16
Table 2.2 - Reasons for study exclusion	23
Table 2.3 - Summary of characteristics and injuries within the included event rate studies	24
Table 2.4 – Summary of characteristics and injuries within the included prevalence studies	25
Table 2.5 - Study definitions of injury	29
Table 2.6 - Relevant number of injuries by body region per prevalence study	30
Table 2.7 – Relevant number of injuries by body region and orthopaedic injury rates per 1000 athlete exposures	31
Table 2.8 - A comparison of injury by martial art	33
Table 2.9 - A comparison of injury by contact level	34
Table 2.10 - Injuries per participant level	36
Table 2.11 - Injuries per setting	37
Table 2.12 - Summary of study validity according to Nguyen checklist	39

Table 3.1 – Distribution of participants by age group	62
Table 3.2 – Comparison of prevalence and injury rate by age group	69
Table 3.3 - Prevalence of injuries per participant level.	71
Table 3.4 - One-year prevalence and rate of injury by participant experience.	72
Table 3.5 - Binary logistic regression of subgroups.	76
Table 3.6 – Weeks off training following injury	77
Table 3.7 - Health seeking behaviour of martial artists and secondary sources of aid/referral.	78
Table 3.8 – Services used when different body regions are injured.	79
Table 3.9 – A table comparing time off training by injury type.	80
Table 3.10 - A comparison of time off training in relation to dislocation by body region.	80
Table 3.11 - A comparison of time off training in relation to fracture by body region.	81
Table 3.12 - Time off training in relation to sprains and strains per body region.	81
Table 3.13 - Time off training in relation to muscular or ligamentous injury by body region.	82

List of Figures

Figure 2.1 – Flow chart of the systematic review search results.	21
Figure 2.2 – Distribution of all injuries by body region.	32
Figure 3.1 - Distribution of training level across 100 participants.	63
Figure 3.2 - Percentage of participants at each point of experience in martial arts.	64
Figure 3.3 - Number of injuries per participant.	65
Figure 3.4 - Proportion of injuries per body region and subdivided by regional anatomy.	66
Figure 3.5 - Percentage of injuries sustained whilst engaged in each activity.	67
Figure 3.6 - Age group comparison of one-year period prevalence of injury.	68
Figure 3.7 - One-year prevalence of injury per participant by the weekly number of training sessions undertaken.	74

GLOSSARY

Please note that the following terms and definitions are to clarify the context in which they are used in this thesis only. They do not include full descriptions of alternative meanings of the terms.

Term	Definition/Description
Class	A class is the standard setting for martial arts lessons. This is designed as a practical exercise session usually comprised of a warm up, drill section in which important movements and techniques are practiced, form/kata practice and sparring, followed by a cool down.
Competition	Martial arts competitions vary in nature. They may be sparring, kata/form or incorporate both. Sparring may occur at different levels of contact (see below).
Contact	<p>The level of contact in each martial art refers to the degree of impact that is allowed during sparring. This is usually divided into three categories: non-contact, semi-contact and full contact.</p> <p>In non-contact, sparring is undertaken but all punches/kicks are held back from the target so that no impact is made. Semi- and full- contact allow contact with varying degrees of impact. In semi-contact a lighter degree of impact is permitted, whereas full contact allows full power behind each punch or kick.</p>
Dislocation	This refers to the disarticulation between bones that make up a joint. It describes a condition where essentially the joint is out of socket. An example of this is the

	<p>shoulder (glenohumeral joint) where the head of the humerus no longer articulates with the glenoid; in effect it is 'out of its socket'.</p>
Form	<p>A form describes a sequence of movements performed flowing as if one were fighting an imaginary opponent attacking in a pattern. These may be performed with or without weapons.</p>
Grading	<p>A grading is an examination where a student must perform forms/katas, sparring and sometimes an oral examination of interpretation of forms. This is done for progression onto the student's next grade (or belt).</p>
Head Injury	<p>A head injury is a slight misnomer in that it usually refers to an injury of the brain or surrounding structures rather than a pure external injury to the head.</p>
Incidence	<p>Refers to the number of new cases identified, e.g., the number of new injuries sustained in a tournament, in a given population occurring over a given period of time.</p>
Injury	<p>This refers to physical damage to the body that results in pain or disability (whether temporary or permanent) resulting in morbidity. An injury is sustained when the energy delivered to the body that overcomes its ability to maintain structural and/or functional stability.</p>
Kata	<p>Synonymous with the term '<i>form</i>'. Please refer to form for a description.</p>
Level of participation	<p>Refers to the level at which the sport is practiced. For example, this can be at elite/professional level, national</p>

(competition) or local level.

Locks	This refers to when a joint is held in a position at the end of range of a combination of movements, beyond which the joint and/or surrounding structures may be disrupted/injured.
Martial Arts	The practice of unarmed and armed combat developed into systems of training.
Maxillofacial	Refers to the face and bones of the skull including the jaw.
Musculoskeletal	Refers to the system of the body that includes bones, muscles, tendons and ligaments. It excludes the major organs of the body.
Orthopaedics	A field of surgery that is concerned with the care and management of musculoskeletal conditions in which surgical intervention may be an option.
Prevalence	This refers to the existing cases in a defined population, e.g., the injuries sustained, over a given period (period prevalence) or at a defined point in time (point prevalence).
Sparring	This is the practice of combat/fighting usually within the limitations of rules that have been stipulated by each martial art.

Abbreviations

AE – Athlete exposures

A&E – Accident and Emergency

ANOVA – Analysis of variance

CI – Confidence interval

df – Degrees of freedom

FC - Full-contact

GP – General practitioner

IC - International competition

IQR – Interquartile range

MA – Martial arts

MMA – Mixed Martial Arts

n – number

N – number (total population)

NC - National competition

NHS – National Health Service

NS - Not specified

PPE – Personal Protective equipment

SC - Semi-contact

X² – Chi-squared test

ACKNOWLEDGEMENTS

I would like to thank Professors Paola Dey and Charalambos Charalambous for their efforts and support throughout this work. I would also like to thank Grand Master CK Chang and Senior Masters Peter Kennedy and Trish Chang for their kind support and help at gradings and classes. Also, all the instructors disseminating the information letter and all the participants for making this research possible. Last (but by no means least), my partner for always supporting and almost never telling me to get off the computer and take a break.

Chapter 1: INTRODUCTION

1.1 BACKGROUND

Martial arts are practices of combat developed into systems of training. The terms martial arts, fighting arts and combat arts tend to be used synonymously and refer to systems of combat using body parts or weapons (Birrer 1996, Birrer & Halbrook 1988). They have been practised worldwide for centuries. Many were originally practiced for self-defence for very real dangers where lawless society reigned and defence of one's family and property was a way of life. Today, martial arts as sport are very popular worldwide. Although it would be impossible to calculate the number of people engaged in these, it is estimated that over 75 million people participate worldwide (Birrer 1996). In France, for example, there are over 200,000 participants in registered Karate clubs (Destombe et al 2006). It is estimated that Shotokan, a style of Karate has over two million participants worldwide (Halabachi et al 2007; Oler et al 1991). Similarly, in the USA it is estimated that 1.5 to 2 million people participate in martial arts with a ratio of 5:1 male to female (Arriaza & Leyes 2005; Oler et al 1991).

Today martial arts are practiced for fitness, self-defence and have been adopted in military training (Buse & Wood 2006). Classes have evolved to cater to a diverse demographic wishing to study, from the very young to the elderly. The benefits of martial arts are widely documented and include improved health and fitness and psychological benefits (Aleisi et al 2014; Zetaruk et al 2005). Martial arts are now also used in rehabilitation and management of chronic conditions, such as, Parkinson's disease and reducing the risk of falls in the elderly (Leung et al 2011; Li & Harmer 2015).

Many martial arts have their own philosophy though the overriding themes tend to be respect, peace, etiquette and honour. To achieve a high level of skill takes years of dedication and practice of techniques that ultimately lead to a deeper understanding of one's own mind and body and how to utilise these to the greatest effect in generating power through mastery of purposeful technique. Most martial

arts incorporate a rank (grading) system, usually through coloured belts. Most start with white and work through several colours to the coveted black belt. Most martial arts employ very strict criteria and difficult tests of skill, knowledge and character before a black belt is awarded. This will take years of practice and training.

The level of participation of athletes varies and refers to the grade of the martial artist whether beginner, leisure, amateur or elite/professional level (such as national, international or Olympic level). In the context of this thesis, beginners are participants from starter level through to coloured belts; those training for leisure do not engage in competition but may attend gradings. Amateur level athletes are those that engage in the same activities as those for leisure but also in competition. Elite level athletes are Olympic level, or those that have attained the level of master (those that have achieved higher dans of black belt). Professional level athletes are those that engage in professional level competition and compete for prize fights.

1.1.1 Martial arts styles

Many styles of martial arts have developed. The most commonly known developed in Asia, where knowledge was passed down through generations. Other styles developed in secrecy amongst slaves who would practice 'dancing' when they were developing techniques of self-defence. The origins of different martial arts are often shrouded in mystery, poorly evidenced and debateable (Burks & Satterfield 1998).

Thousands of styles now exist (Birrer 1996). Many have crossover techniques, though the overall combat style may contrast. These styles vary from standing sparring (fighting) which are contact striking martial arts, to takedowns, where combatants aim to knock opponents down by grappling or off-balancing them. Some styles incorporate 'locks' and throws. Locks involve holding body joints in painful positions, beyond which the joint may be disrupted or dislocated unless the opponent yields. Other styles will incorporate all the above, hence the recent evolution of mixed martial arts (MMA) from traditional forms.

1.1.2 Training

Martial arts training will vary per style. Although the technical and tactical aspects of training may be unique to a martial art, basic movements, warm up and stretching will be common to many martial arts. Most adopt a similar overall structure involving warm up, drill section and sparring. Warm up consists of mobility and stretching exercises, followed by a drill section, where common combat movements are practiced. Sparring usually follows which is where athletes will practice fighting against each other in a controlled environment.

Training intensity may change if, for example, the individual is training for events such as competitions or gradings. Gradings are events whereby an athlete is examined to attain their next grade or belt. This may involve a combination of fixed movements (known as forms or katas) and sparring.

Competitions can be held for sparring or forms. Forms (also known as katas) are a sequential series of movements carried out in an artistic display as if combat is taking place with one or multiple opponents. This may be free hand or with weapons, such as a staff (six-foot stick) or sword.

1.1.3 Sparring

As a code of practice, a martial artist has a responsibility to look after themselves and their opponent. Sparring will be governed by each martial art's rules of engagement and restrictions. It is mostly unarmed combat though some may involve the use of weapons such as knives or a staff.

Several levels of contact exist in sparring. In non-contact, fighting will occur with no physical contact being made, i.e., kicks and punches are stopped prior to making contact. In semi- and full- contact sparring, strikes are permitted with varying degrees of power behind each movement. Sparring level may vary by setting. Often the sparring at competitions is higher level and may be full-contact whereas sparring in class is semi-contact. Training patterns in class may change to reflect this.

Martial arts are as much about defending as attacking. As such, martial artists will also train on how to avoid being thrown, landing safely, escaping locks before they are fully applied, blocking blows or moving with these to reduce the impact. One of the most important skills in defence is avoiding and deflecting strikes so that the energy from these is not fully absorbed. In this way, injury is avoided.

1.2 MARTIAL ARTS AND INJURY

As with all contact sports, martial artists are prone to injury. In the absence of an academic agreed definition, in this context, the research student defined injury as referring to physical damage to the body that results in pain or disability (whether temporary or permanent). An injury is sustained when the energy delivered to the body overcomes its ability to maintain structural and/or functional stability (Lystad et al 2009). Many injuries in martial arts are likely trauma-related and many may be orthopaedic in nature.

Injuries may be sustained during training or sparring with varying patterns. The use of personal protective equipment (PPE) may be used to reduce the risk of injuries. Examples of this are gum shields, gloves and head/torso/groin/shin pads. Previous studies have demonstrated reduced injury with the use of PPE (Johannsen & Noerregaard 1988; McLatchie & Morris 1977). Environmental safety measures may also help reduce risk of injury. If a martial art involves takedowns and throws, then the use of matted/sprung floors will help to absorb impact (Critchley et al 1999).

The other important injury prevention tool is correct technique and experience. Martial artists will be taught how to land/roll when thrown to disperse energy from impact. Other injuries may be sustained during training from overstretching, overtraining and trying to copy advanced techniques without correct understanding. This may be more common in junior grades that start out expecting to be able to perform techniques that take years to master. McLatchie (1976) reported that lower grades and younger age are associated with increased risk of

injury. Conversely, Zetaruk et al (2005) report lower rates of injury in athletes less than 18-years-old and those with less than three years' experience.

Injuries may also be sustained when training on pads from recurrent impact/incorrect striking. When technique is sacrificed for generation of power, this may result in injury. For example, martial artists are taught how to strike correctly with a fist, i.e., which knuckles to punch with and to correctly align the wrist. This is difficult to understand initially, though its importance becomes clearer when striking pads or an opponent. If these are punched with an extended or flexed wrist, tendon injury may result as wrist 'sprain'. Holding pads for a partner also poses a risk if the holder does not understand how to absorb strikes.

Another example of this is when performing a turning kick. To perform this kick correctly the weight-bearing hip is abducted and externally rotated, the kicking leg is flexed and abducted and as the knee of the kicking leg extends, the same hip internally rotates. The kick directs inwards towards the target rather than straight upward. This generates torsional strain on the supporting knee, if this is not pivoted on the supporting foot it may result in strain of the ligamentous structures of the knee. It may be a difficult concept to grasp when first learning a martial art, however, correct techniques may improve power and be joint protective.

1.2.1 Martial artists' health seeking behaviour

When injured, the health seeking behaviour of martial artists can vary from seeking advice from their instructors, a physician attending an event or formal health providers (e.g., general practitioner, emergency department, physiotherapists etc.). Injuries that are inadequately or inappropriately managed or left untreated may take a chronic course resulting in pain or disability. Thus, understanding the health seeking behaviour of martial arts athletes may be important in preventing injury progression and subsequent complications.

There is little written about the health seeking behaviour of martial artists. The research student speculates that the attitude of athletes towards seeking healthcare advice and compliance with this, may present a challenge, as there may

be a race between wanting to return to training and the injury healing. Other factors that may influence seeking advice are accessibility in class to medical advice or not wishing employers to know how an injury is sustained. Martial artists may feel an associated stigma going to work with an injury and an employer knowing this was sustained through pugilism.

Instructors and masters are afforded much respect in the world of martial arts and may be the primary source of advice. Many will not have training in injury management beyond first aid experience. Many gradings and competitions will have a medically qualified individual. This can influence the advice that is given following injury in different settings in that classes may result in generic and experiential advice being given by non-medically qualified individual while informed expertise is available at competition or gradings.

1.3 RESEARCH CONTEXT

Trauma and orthopaedics is a field of medicine concerned with injuries to the musculoskeletal system, excluding facial injuries. Injuries to the musculoskeletal system in martial arts have been described in the literature. These are typically strains and sprains, though fractures and dislocations are reported (AFHSC 2014; Pappas 2007). These may be sustained during training or sparring. Injuries may result from direct trauma such as a kick or punch to the body, being thrown or joint locks. Studies report most injuries in martial arts are of low to moderate severity (Birrer & Halbrosk 1988; Birrer 1996).

The research students discipline is trauma and orthopaedic surgery. For this reason, the focus of this thesis was orthopaedic injuries. For the duration of this thesis, the injuries referred to, are those that are musculoskeletal and orthopaedic in nature. This excludes the head and maxillofacial injuries. There is a considerable body of work previously undertaken on head and dental injuries and their prevention in martial arts competitions (Bastidas et al 2012; Bledsoe et al 2006; Shimoyama et al 2009), however there has been relatively little work done on orthopaedic injuries, an important cause of morbidity, specifically.

Through this thesis, the research student aimed to understand which injuries are more prevalent in contact striking martial arts and whether style of martial art, setting, participant level and gender impact on the prevalence. Also, which body region is most commonly injured and the mechanism by which these are injured. This may help the ringside physician and those treating these injuries understand what is likely to occur at events and who is more likely to get injured and during which activity. Thus, it may help in developing strategies to manage and reduce the risk of injury.

1.3.1 The literature

Martial arts injuries are varied and may depend on the style. For example, systems focused on throwing and locking techniques may encounter more dislocations whereas those involving full-contact sparring may lead to more fractures. Zetaruk et al. (2005) compared five styles and concluded that different martial arts have variable rates and patterns of injuries.

This thesis only considers orthopaedic injuries because of the role of the research student as an orthopaedic surgeon. Injuries to the head, face and viscera are excluded. These would fall under the remit of neurological, maxillofacial and general surgical specialties respectively. These types of injuries are well documented. Head injuries may result from direct and indirect contact such as a kick or punch to the head, or following a knockdown and subsequent impact with the floor (Hutchison et al 2014). Maxillofacial injuries are common including; mandibular fracture, dental trauma and pre-orbital lacerations (Bastidas et al 2012; Bledsoe et al 2006; Shimoyama et al 2009). Other reported injuries include visceral trauma such as renal contusions, carotid or vertebral artery dissection and hyoid bone fracture (Itagaki & Knight 2004; Pacei et al 2014; Porr et al 2012; Suzuki et al 2014).

Most martial arts incorporate contact sparring and although a review of the literature could find no supporting evidence, the research student believes these are likely to incur more injuries than in non-contact sparring. This is secondary to trauma because of impact being made. For this reason, this thesis only reviewed

contact striking martial arts. This refers to those systems where sparring is semi- or full-contact. Martial arts styles present a heterogenous population. The research student focused on a specific group as this may lend more validity to the results allowing generalisation to similar styles that fall under the umbrella of contact striking. All settings in which injury could occur are considered including class, grading and competition.

1.3.2 Why this research is important

In recent years, martial arts may have seen an increased uptake, especially with the advent of mixed martial arts. This has now seen international fights in Las Vegas (United States of America) and around the world, attracting large audiences. Increasing popularity and advertising may lead to an increase in uptake of martial arts. In turn this may result in an increase in injuries being seen and presenting to health services. With little research published on orthopaedic injuries in contact striking martial arts and the prevalence and risk factors involved, it is important to those providing services to understand these in order to be able to help with management and in developing prevention strategies.

Identifying the prevalence of orthopaedic injuries in martial arts and stratifying by grade and location sustained will help guide clinicians assessing these individuals of the likelihood of certain injuries. Identifying the factors involved in increasing the risk of the more prevalent injuries may help in the development of strategies to reduce these injuries. Understanding the more prevalent injuries may guide clinical examination and imaging requests to look for specific injuries. Further stratification into the setting where injuries are sustained may help inform ringside physicians what injuries may be encountered. Identifying the event rate may help to understand how much input is needed at each event and help to plan the best management of these, what stock is required and the number of physicians required at each event.

It may support the development of training for instructors on what injuries are more likely at different grades and the most appropriate management advice. They may draw on experience to develop strategies to reduce the risk of these.

1.4 STUDY AIM AND OBJECTIVES

The aim of the thesis was to provide a further understanding of orthopaedic injury in martial arts to inform their prevention and management during training and competition. The thesis focuses on contact striking martial arts.

The objectives of this thesis were:

- I) to identify the frequency of orthopaedic injuries, and types of orthopaedic injury, in contact striking martial arts
- II) to identify the factors that may increase the risk of injury, such as style, participant level, setting, level of experience and gender
- III) to review the help seeking behaviour of contact striking martial artists.

To meet these objectives a systematic review of the literature (see chapter 2) and a cross-sectional survey were undertaken (see chapter 3).

1.5 OUTLINE OF THESIS CHAPTERS

Chapter 2 – A systematic review of orthopaedic injuries in contact striking martial arts

Chapter two includes the methods and results of a systematic review of the prevalence and event rate of orthopaedic injury in contact striking martial arts, distribution of injury by body region and comparison across martial art style, level and setting. The discussion of the findings of this systematic review includes how it informed the cross-sectional survey of orthopaedic injury outlined in chapter 3.

Chapter 3 – A cross-sectional survey of orthopaedic injury in a single contact striking martial art

Chapter three includes the methods and findings of a cross-sectional survey of athletes engaging in a single contact striking martial art. This study was undertaken to estimate the one-year period prevalence of orthopaedic injuries in

contact striking martial arts and to explore if this varies according to years of experience, level of participation, setting and demographic factors. A further objective was to identify the help-seeking behaviour of these athletes.

A discussion of the thesis findings and its implications are in chapter 4.

CHAPTER 2 – A SYSTEMATIC REVIEW OF ORTHOPAEDIC INJURIES IN CONTACT STRIKING MARTIAL ARTS

2.1 INTRODUCTION

The last chapter gave an overview of what martial arts are, what training is involved and the potential for injury. It argued that contact martial arts are likely to encounter more injuries than non-contact, hence, this review will focus on martial arts where sparring is contact based. In this chapter, the literature about the prevalence and event rates of orthopaedic injuries in contact striking martial arts is systematically reviewed. This chapter outlines the methods and results of the systematic review, followed by a discussion of the findings. The original protocol is given in appendix 1.

2.2 REVIEW OBJECTIVES

The main objectives of the systematic review were to:

- identify how common orthopaedic injuries were in contact striking martial arts,
- identify rates of injury by body part,
- review how rates vary by martial art, contact level, participant level and the setting in which it has been sustained (e.g., at competition).

2.3 METHODS

2.3.1 Study design - Systematic review.

2.3.2 Selection Criteria

Study population

The population of interest was martial arts athletes aged 16 years old and over. The lower age limit was selected as this is usually the age in which martial artists can engage in adult level competition and participants should have achieved reasonable skeletal maturity.

Studies which included those under 16 years old were excluded, if it was not possible to identify data solely relating to those over 16 years of age.

Type of martial arts

Studies in which athletes were engaged in contact striking martial arts were included. There are many contact striking martial arts; the most commonly practised are karate, kickboxing, kung fu, taekwondo. Martial arts and sports such as Judo, Jujitsu and wrestling were excluded as the sparring in these is grappling only with no striking.

Condition

The focus of the systematic review was on orthopaedic injuries. This was defined as an injury of any severity to the muscles, bones, ligaments, tendons, joints or nerves. The reason for focusing on these injuries is because they fall under the remit of a single clinical discipline, orthopaedics, which is the clinical discipline of the research student. Musculoskeletal injuries of the head and face were excluded; these fall under the remit of maxillofacial and neurosurgical disciplines. Studies were included if they included data on all types of injuries, but data on orthopaedic injuries could be extracted. The site of injury was collected to enable comparison of rates of injury by body region.

Setting

All settings were included, including martial arts classes, gradings and competition (national or international). The actual setting in which the injury occurred was of interest to enable comparison of rates of injury across settings.

Contact Level

Studies on semi- and full- contact martial arts were included. Studies were excluded if sparring was described as non-contact.

Participant Level

Participants of all levels were included unless they were under 16 years of age.

Study outcomes

Studies which reported on the frequency of orthopaedic injury either as the prevalence rate, event rate or incidence rate were included.

Prevalence was recorded if the data was available. It pertained to the percentage of all participants incurring a orthopaedic injury. This can be over a defined time (e.g., one year period prevalence) or at a single point in time (point prevalence). The event rate was recorded if data was available on the relevant injuries occurring at a single event or multiple events. This was the overall number of injuries divided by the number of exposures. Incidence rate was recorded if the number of new injuries occurring over a given period of time was given.

Study designs

This study designs included cross-sectional and observational studies (cohort studies) which estimated orthopaedic injuries in contact striking martial arts as these types of studies measure the prevalence, event and incidence rates. Case reports were not included as these studies do not have denominators. Case-control studies were not included as rates cannot be estimated.

Types of studies

Included studies were restricted to those that were peer reviewed publications. Exclusions were reports of meetings, abstracts, theses, grey literature, books and non-peer reviewed material such as magazine or newspaper articles. Studies related to non-contact martial arts, abstracts of meetings and expert opinion articles were also excluded.

Duplicate studies

Articles with the same data published in more than one journal were counted as one study or, if series of the same data from a study were published, the publication with the most recent data was included.

2.3.3 Search Strategy

An electronic search was undertaken using EBSCO Host as the platform. Three bibliographic databases were searched: Medline, SportDiscus and the Allied and Complementary Medicine Database (AMED). These databases were chosen because of their coverage of orthopaedic, musculoskeletal and sports literature. Medline covers literature on biomedicine and health with articles from over 500 journals from 1946. AMED covers allied and complementary medicine that may not be indexed in the content of biomedical sources and so may cover some of the literature not covered by Medline. Given that a major subject in this research is a sport (martial arts), SportDiscus was also selected to cover the non-medical literature available.

The subject heading and keyword search terms were developed by considering the key concepts for the review. Table 2.1a summarises the search terms used. Group 1 were the terms that related to martial arts and styles of martial arts. This included general terms for the sport and specific terms for contact sparring sports. Those selected for the search represent the most popular contact sparring sports and derivatives of their names. The subject headings used was martial arts (though this was also used as a key word in the search). Group 2 and 3 represented outcome and outcome subtype such as injury and the type such as muscle, ligament, orthopaedic. The subject heading was injury and the key words were the

subtypes (injury was also used as a key word). The final group (4) represented study type. Subject headings were exploded to capture all sub terms.

Table 2.1a – Key concepts and related synonyms used for the systematic review

Group 1 (Population and exposure)	Group 2 (Outcome)	Group 3 (Outcome subtype)	Group 4 (Study)
Martial Art	Injury	Ligament	Prevalence
Martial Arts	Injuries	Ligamentous	Incidence
Martial Artist		Muscular	
Martial Artists	Dislocation	Muscle	Epidemiology
Karate	Subluxation	Musculoskeletal	Epidemiologic
Kickboxing		Musculo-skeletal	Epidemiological
Kung Fu	Fracture	Orthopaedic	
Gong Fu		Orthopedic	
Gung Fu	Trauma	Skeletal	
Taekwondo		Tendon	
Tae Kwon Do		Tendinous	
Tae Kwan Do			

The search was run initially for Group 1 in isolation. The terms in Group 1 were searched for using the Boolean 'OR', for example, martial art* OR Karate OR Kickboxing. Similar processes were followed for the subsequent groups, e.g., injur* OR dislocation OR subluxation. Following this, the groups were combined with the Boolean 'AND', for example, Group 1 AND Group 2. Groups 3 and 4 were covered by the search for groups 1 and 2. Further testing of the search suggested that including terms for outcome subgroup (Group 3) and study design (Group 4) was too restrictive and these were not included in the final search strategies. Table 2.1b shows the final Medline search strategy employed (see appendix 2 for the AMED and SportDiscus strategies).

Table 2.1b Medline search strategy

#	Search Term
#1	Search martial art*
#2	Search “martial arts”[MeSH]
#3	Search exp “martial arts”[MeSH]
#4	Search karate
#5	Search kickboxing
#6	Search “kung fu” OR “gong fu” OR “gung fu”
#7	Search taekwando OR “tae kwan do” OR “tae kwon do”
#8	Search #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8
#9	Search injur*
#10	Search ‘Wounds and Injuries’ [MeSH] OR exp ‘Wounds and Injuries’[MeSH]
#11	Search dislocat*
#12	Search sublux*
#13	Search fractur*
#14	Search fracture[MeSH]
#15	Search exp fracture[MeSH]
#16	Search traum*
#17	Search exp trauma[MeSH]
#18	Search #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17
#19	Search #8 AND #18 (Final search)
<p>The MeSH search for fracture brought up several terms. Those selected were: Fractures, Stress; Hip fractures; shoulder fractures; periprosthetic fractures; intra-articular fractures; fractures, open; fractures, closed; ulna fractures.</p>	

The search was limited to English Language articles only because of the lack of access to and resources for translation. There were no date limits.

Duplicates were recorded. The references of all eligible articles were reviewed to identify any further studies not identified by the electronic search strategy.

2.3.4 Screening and eligibility

The studies returned from the searches were reviewed by title and abstract against the selection criteria by two researchers; one was the research student and the second was another 'Masters by Research' student who was also an orthopaedic specialist registrar (Dr. Nasri Zreik and Dr. Apostolos Prodromidis). The reviewers undertook this process at the same time independently. Those studies that appeared to be eligible based on the title and/or abstract following review were discussed by both reviewers. Any discrepancies that arose were discussed between the reviewers to determine a list for retrieval of the full paper. In the event of a lack of consensus, a third reviewer (one of the supervisors) was available to resolve conflicts.

Full article review

The full-text was requested for the articles that were identified from title and abstract review as eligible. These were assessed for inclusion against the selection criteria by both reviewers independently and discussed to determine eligible studies. If required, the third reviewer was available to resolve any conflicting opinions.

2.3.5 Data extraction

The two reviewers undertook the data extraction from eligible studies independently. Any differences that arose were discussed and a consensus reached. The third reviewer was available to resolve any outstanding conflicting opinions.

The data recorded for each study was the study design, sample size, country, martial art style, the setting the study took place, contact level, participant level and age and gender of the participants. Settings were recorded as class, grading or competition (national or international). The participant level was recorded as the grade of athlete: junior (those less than black belt ranking), senior grade (black belt and above), elite level or professional (competing at national/international competition level or prize fights). Contact level was recorded as semi- or full-contact.

Each study was reviewed as to whether they gave a clear definition of injury. Their definition was recorded if they gave one. If no clear definition was given, this was also recorded. The prevalence, event or incidence rate was recorded as appropriate. The type of injury was recorded as well as the body region in which the injury was sustained was also recorded. The regions were: neck, upper limb, trunk and lower limb. Upper limb was defined as from the acromioclavicular and gleno-humeral joints up to and including the structures of the hand and digits. The neck was the musculoskeletal structures surrounding and including the cervical spine down to the seventh cervical vertebrae. The trunk comprised the thoracic, lumbar and sacral spines and their surrounding musculoskeletal structures, the coccyx, the pelvis and the ribs. Finally, the lower limb was defined from the femoral head down to the foot and its respective digits.

2.3.6 Quality Assessment

Quality assessment was undertaken by the research student alone. In searching the literature, the research student was unable to find a validated tool for assessment of bias in both incidence and prevalence studies or in incidence studies alone. As such they were assessed using two separate tools.

Assessment of prevalence studies

Assessment of bias in the prevalence studies was undertaken using a tool described by Hoy et al (2012) (see appendix 3). This is a ten-question tool that assesses the risk of bias as low, moderate or high. Studies are assessed based on several criteria: whether the sampling population is representative of the true population, appropriate sampling methods, data collection methods, response rates, validity of the data collection tools and statistical methods. This is scored on the number of subjective responses to the questions that returned as low or high risk (i.e., five or more answers of 'high' placed the study at high risk of bias).

Assessment of incidence and event rate studies

These studies were assessed using a criterion developed by Nguyen et al (2009) (see appendix 4). This was originally designed to assess for quality and bias in

observational studies testing the relationship between overjet size and traumatic dental injuries (Nguyen et al 2009). The research student felt that an assessment tool for assessing trauma would allow an objective analysis by which to compare the studies. The tool itself assessed four categories: study design, study conduct, analysis of data and conclusion. There was a total of 18 questions with a score out of a possible 100.

Study design was assessed on seven elements: description of the objectives, population, selection criteria, potential confounders and sample size. The remaining points were for type of study and pre-investigation sample size estimation. The maximum score available for study design was 34. Longitudinal studies were scored 6 out of a possible 10 points.

Study conduct assessed the description of data collection methods and blinding with a maximum score of 30. Analysis of data was also scored out of 30. This looked at whether statistical methods were appropriate, how data was presented and whether confounders were analysed. The remaining score (6 points) was for the conclusion and whether this was related back to the statistics.

For event rate studies, the maximum available score was 68. This was due to the limited score given for longitudinal studies and losing points on elements such as whether blinding was used, number of examiners and description and level of agreement between examiners. There were no thresholds to define a good study, as a compromise, the research student decided that the lower threshold for the interquartile range would be used to define a 'good' quality study. A potential limitation of this is that the score is relative to the overall quality of the studies and so if all studies were of poor quality, a study might be considered 'good' if it was within the interquartile range.

2.3.7 Data Synthesis

Data items were tabulated to facilitate evaluation. Data were summarised then stratified to allow review of injuries by: martial art, setting, participant level and

contact level. Injuries were further stratified by body region: neck (cervical spine), trunk, upper and lower limbs.

There was only sufficient data on event rates to consider meta-analysis. Data was extracted for each study on orthopaedic injury rates per 1000 athlete exposures (AE). For each of the characteristics such as martial art, contact level, setting etc., a weighted estimate of injury per 1000 AE was calculated with weighted confidence intervals for each of the categories within this characteristic (an example calculation is given in appendix 9). This was the most common approach to report event rate data in the literature. This data demonstrated considerable heterogeneity in outcome between categories (which could also be surmised by the range of rates within the categories), and, therefore, a meta-analysis for all studies to provide an overall weighted orthopaedic injury event rate in contact sparring martial arts was not calculated.

When data was divisible into injuries by body region, it is summarised by using percentage injury per body region. This was the injury as a percentage for that region, of the total number of orthopaedic injuries. This was to provide a representation of the most commonly injured body region in contact striking martial arts. The number of orthopaedic injuries are summarised as a percentage of total injury to demonstrate the importance of these.

2.4 RESULTS

The following section summarises the results of the systematic review from the initial search through to the review of the selected articles.

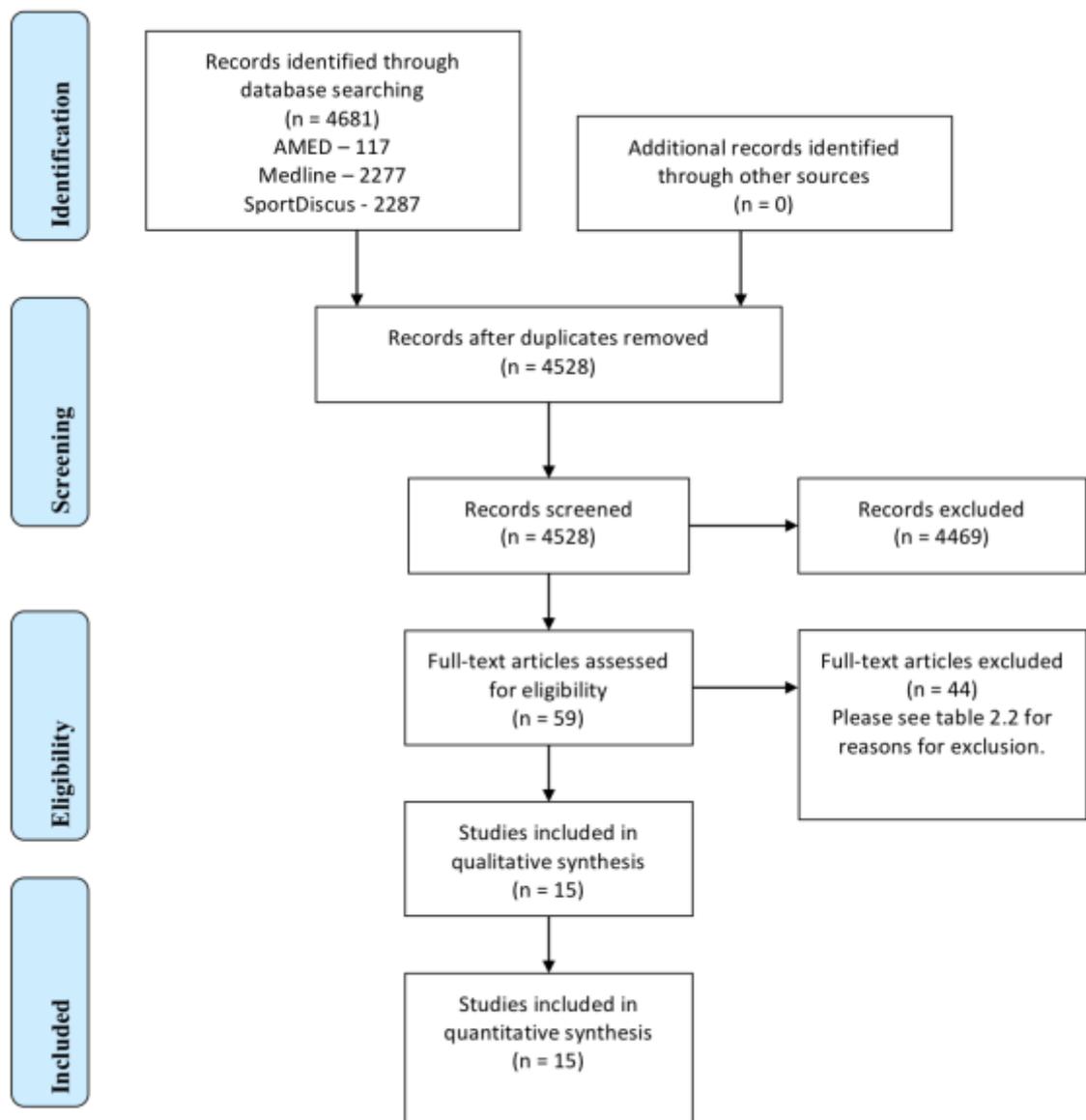


Figure 2.1 – Flow chart of the systematic review search results.

2.4.1 The Search

The literature search was run on 8th September 2015 with no restriction on date of publication. The final searches resulted in 4681 articles being returned. Figure 2.1 summarises the process using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline checklist (Moher et al 2009). Both reviewers screened all the titles and abstracts. During the screening process, 153 duplicates were identified and manually removed.

Following the title and abstract search, the research student found 59 studies for full review and the second reviewer identified 52. Both reviewers agreed to assess the additional 7 studies identified by the research student.

From these 59 papers, the research student identified 17 articles which met the eligibility criteria and the second reviewer identified 19: 15 were in common giving a total of 21. For two of these studies, the reviewers could not separate the data into relevant orthopaedic injuries. The research student attempted to contact the authors via the corresponding author emails. Unfortunately, there was no response from one and the second email address was no longer in service and therefore these two studies were excluded. Another four studies had broad definitions of their population and so it was unclear if they included participants under 16 years old, or injury included lacerations or bruises and the orthopaedic data was not separable. The reviewers agreed on excluding these 4 studies leaving a final 15 eligible studies for review. The third reviewer was not needed to resolve any conflicts in opinions.

The reasons for exclusion of the 44 studies not included in the review are shown in table 2.2. Most articles that were excluded contained data that could not be separated into the required components. This was the case for 15 studies that included data for under 16-year-old candidates. A further 16 studies were excluded as they included data on non-orthopaedic injuries. Six studies contained data on martial arts that were purely grappling sports (e.g. Judo, grappling arts, other sports) that could not be separated to acquire relevant data. There were 7

review and opinion articles that were also excluded. No further studies were identified from review of reference lists or from other sources.

Table 2.2 - Reasons for study exclusion

Reason	Number of articles
Data included participants under 16-years old	15
Data included non-orthopaedic injuries	16
Data on grappling sports not separable	6
Review or opinion article	7

2.4.2 Included studies

Fifteen studies met the inclusion criteria (table 2.3 and 2.4). None of the studies reported on incidence. Thirteen studies collected information regarding new injuries at single events and calculated the injury event rate (table 2.3). Two studies collected data retrospectively and measured the prevalence of injuries occurring in the previous 12-months (Feehan & Waller 1995; Wier & Carline 1997; table 2.4).

A summary of the study characteristics is given in tables 2.3 and 2.4. Five studies looked at Karate (Arriaza & Leyes 2005; Arriaza & Leyes 2009; Boostani et al 2012; McLatchie 197; Wier & Carline 1997). Seven looked at Taekwondo (Beis et al 2001; Burke et al 2003; Elsayy 2011; Feehan & Waller 1995; Kazemi & Pieter 2004; Pieter et al 1998; Ziaee et al 2010). Two looked at Wu Shu (Blijd et al 1995; Yiemsiri & Wanawan 2014). One study looked at mixed martial arts (MMA) (Scoggin et al 2010).

Table 2.3 - Summary of characteristics and injuries within the included event rate studies.

Study	Martial Art	Setting	Country of study	Level of fighters	Contact level	N	Mean age (Range)	Male: Female	No. of Injuries	No. of relevant injuries (% of total injuries)
Arriaza & Leyes 2005	Karate	IC	Brazil, South Africa, Germany	Elite	SC	NS	NS	NS	891	128 (14.4%)
Arriaza et al 2009	Karate	IC	Spain, Mexico, Finland	Elite	SC	NS	NS	NS	497	24 (4.8%)
Boostani et al 2012	Karate	IC	Iran	Elite	SC	NS	NS	NS	179	75 (42.1%)
McLatchie 1976	Karate	NC	UK	Amateur	SC	NS	NS	NS	80	25 (31.3%)
Scoggin et al 2010	MMA	NC	Hawaii	Professional	FC	179	(18-40)	179:0	55	11 (20%)
Beis et al 2001	Tae Kwon Do	NC	Greece	Elite	FC	749	NS	533:216	36	27 (75%)
Burke et al 2003	Tae Kwon Do	NC	USA	Amateur	SC	2498	(18-66)	NS	33	17 (51.5%)
Elsawy 2011	Taekwondo	IC	Egypt	Elite	FC	312	NS	240:72	76	45 (59.2%)
Kazemi & Pieter 2004	Taekwondo	NC	Canada	Unclear	FC	318	22.0 (16-34)	219:99	40	29 (72.5%)
Pieter et al 1998	Taekwondo	NC	UK	Amateur	FC	126	NS	102:24	20	12 (60%)
Ziaee et al 2010	Taekwondo	NC	Iran	Professional	FC	204	22.9 (17-30)	NS	93	86 (92.5%)
Blijd et al 1995	Wu Shu	NC	Netherlands, Philippines	Elite	SC	77	NS	64:13	14	11 (78.6%)
Yiemsiri & Wanawan 2014	Wu Shu	IC	Thailand	Elite	FC	60	22.49 (±3.75)	38:22	26	21 (80.8%)

NS = Not specified. FC=Full-contact SC= Semi-contact IC=international competition NC=national competition

Table 2.4 Summary of characteristic and injuries within the included prevalence studies.

Study	Martial Art	Setting	Country of study	Level of fighters	Contact level	N	Mean age (Range)	Male: Female	No. of Injuries	No. of relevant injuries (% of total injuries)
Feehan & Waller 1995	Taekwondo	Class	New Zealand	Elite	FC	48	22.2 (16-45)	39:9	77	69 (89.6%)
Wier & Carline 1997	Karate	Class	UK	Amateur	SC	73	31 (18-54)	55:18	56	28 (50%)

FC=Full-contact SC= Semi-contact

Studies were conducted worldwide: Brazil (1), Canada (1), Egypt (1), Finland (1), Germany (1), Greece (1), Hawaii (1), Iran (1), Mexico (1), Netherlands (1), New Zealand (1), Phillipines (1), South Africa (1), Spain (1), Thailand (1), UK (2), USA (1) (Table 2.3) (Arriaza & Leyes 2005; Arriaza & Leyes 2009; Beis et al 2001; Blijd et al 1995; Boostani et al 2012; Burke et al 2003; Elsayy 2011; Feehan & Waller 1995; Kazemi & Pieter 2004; McLatchie 1976; Pieter et al 1998; Scoggin et al 2010; Wier & Carline 1997; Yiemsiri & Wanawan 2014; Ziaee et al 2010).

Six studies were conducted at international competitions (Arriaza & Leyes 2005; Arriaza & Leyes 2009; Blijd et al 1995; Boostani et al 2012; Elsayy 2011; Yiemsiri & Wanawan 2014). Seven studies were conducted at national competitions (Beis et al 2001; Burke et al 2003; Kazemi & Pieter 2004; McLatchie 1976; Pieter et al 1998; Scoggin et al 2010; Ziaee et al 2010). Two studies were undertaken in the class setting (Feehan & Waller 1995; Wier & Carline 1997).

The level of fighters varied between studies. Eight looked at elite level fighters (Arriaza & Leyes 2005; Arriaza & Leyes 2009; Beis et al 2001; Blijd et al 1995; Boostani et al 2012; Elsayy 2011; Feehan & Waller 1995; Yiemsiri & Wanawan 2014). Two studies looked at professional fighters (Scoggin et al 2010; Ziaee et al 2010). Four studies reviewed amateur level fighters (Burke et al 2003; McLatchie 1976; Pieter et al 1998; Wier & Carline 1997). In one study this was unclear (Kazemi & Pieter 2004).

Contact level within the studies was almost an equal split, in that seven studies were of semi-contact sparring (Arriaza & Leyes 2005; Arriaza et al 2009; Blijd et al 1995; Boostani et al 2012; Burke et al 2003; McLatchie 1976; Wier & Carline 1997). The remaining eight were of full-contact sparring (Beis et al 2001; Elsayy 2011; Feehan & Waller 1995; Kazemi & Pieter 2004; Pieter et al 1998; Scoggin et al 2010; Yiemsiri & Wanawan 2014; Ziaee et al 2010).

The age range covered by the studies was 16-66 years old with a weighted mean of 26.8 years (from the seven studies providing a mean age – tables 2.3 and 2.4).

From the studies providing the relevant data, 76% of the participants were male (tables 2.3 and 2.4).

Due to the heterogeneity of the studies with respect to the style of martial art, the settings, the level of fighters and contact level it was not possible to undertake meta-analysis. Three studies displayed homogeneity in these characteristics though the research student felt that a limited meta-analysis of three studies would add little to achieving the original objectives (table 2.3)

Methods of data collection

In the two prevalence studies (Feehan & Waller 1995; Wier & Carline 1997), this was done by questionnaire handed out at classes and events and collected back by a drop off box at the end of the event. In both studies, the participants completed the questionnaire themselves anonymously.

The remaining studies collected information regarding new injuries at single events and calculated the injury event rate. Data were collected through survey by athletes presenting to the attending physicians at the events. In five of the studies, data were collected by forms completed by the ringside physicians and subsequent collection of these by the project team (Arriaza & Leyes 2005; Arriaza et al 2009; Burke et al 2003; Kazemi & Pieter 2004; McLatchie 1976). In three of the studies, forms were completed by the physician and project team at the ringside when participants sought medical attention (Beis et al 2001; Blijd et al 1995; Boostani et al 2012). In two studies forms were completed by the project staff and/or physician via face to face interview (Scoggin et al 2010; Ziaee et al 2010). In Pieter et al (1998), forms were completed by the project staff following identification of a relevant injury by the medical team. In the study by Yiemsiri & Wanawan (2014) data was recorded by observation of injuries by project staff and physicians at the ringside. It was unclear in one study how data was collected (Elsawy 2011). The event rate studies reported overall injury rate per 1000 AE. This included all orthopaedic and other injuries in the rate. They summarised injuries by location which allowed data extraction on orthopaedic injuries.

2.4.3 Injuries

The number of orthopaedic injuries was available from all the included studies. The number of injuries by region was available from 14 studies which allowed separation of data by body region (Arriaza & Leyes 2005; Arriaza & Leyes 2009; Beis et al 2001; Blijd et al 1995; Boostani et al 2012; Burke et al 2003; Elsayy 2011; Feehan & Waller 1995; Kazemi & Pieter 2004; McLatchie 1976; Pieter et al 1998; Scoggin et al 2010; Yiemsiri & Wanawan 2014; Ziaee et al 2010). One study gave data only for lower limb injuries (Wier & Carline 1997).

A total number of 2173 injuries were recorded in the 15 studies. All head and visceral injuries were excluded resulting in 608 relevant injuries (see tables 2.3 and 2.4). These represented 28% of the total number of all injuries sustained as an un-weighted proportion. This varied from 4.8%-92.5% in the studies. The remaining findings relate only to orthopaedic injuries.

Injury definition

Injury definition varied throughout the studies. The most common definition was any injury for which a participant sought advice from the medical team, or minor variations thereof. Seven studies (46.7%) did not define injury (Blijd et al 1995; Boostani et al 2012; McLatchie 1976; Pieter et al 1998; Scoggin et al 2010; Wier & Carline 1997; Yiemsiri & Wanawan 2014). Table 2.5 summarises the definitions for the studies that provided this.

Table 2.5 - Study definitions of injury.

Study	Definition of Injury
Arriaza & Leyes 2005	Any injury recorded by the medical team. Severity defined using the injury severity classification
Arriaza et al 2009	Any injury recorded by the medical team. Severity defined using the injury severity classification
Beis et al 2001	Any circumstance in which help was sought from the medical team.
Burke et al 2003	Any event that caused the athlete to cease the event.
Elsawy 2011	Any circumstance in which help was sought from the medical team.
Feehan & Waller 1995	Injury was defined as 'a physical problem that caused you to miss (a) at least one taekwondo practice of scheduled training session OR (b) required at least one visit to a health professional for treatment.'
Kazemi & Pieter 2004	Any of the following situations constituted an injury: a) Any circumstance that the athlete had to leave the competition b) Any circumstance for which the athlete or referee stopped the competition. c) Any circumstance where the athlete requested medical attention.
Ziaee et al 2010	Any affliction leading the athlete to visit the medical team during or after the competition. The injuries were further defined by severity.

2.4.4 Prevalence Studies

Two studies reported twelve-month period prevalence of injury. Feehan & Waller (1995) reviewed all Taekwondo injuries sustained over the course of a one year period in the class setting in elite level full-contact sparring. Wier & Carline (1997) studied amateur level Karate in a class setting with semi-contact sparring and reviewed only lower limb injuries sustained over the course of a year. However, prevalence rate was not reported in the manuscripts for orthopaedic injuries. Over a one-year period, 48 participants reported 69 orthopaedic injuries (Feehan & Waller 1995). In the study by Wier & Carline (1997) there were 28 lower limb orthopaedic injuries in 73 participants. As it is unclear whether multiple injuries occurred in the same individual, period prevalence could not be estimated.

In the study by Feehan and Waller (1995), the lower limb was the most commonly injured region representing 58% (n=40) of orthopaedic injuries (Feehan & Waller 1995). In this study, 48 participants sustained the 40 lower limb injuries (Feehan & Waller 1995). As reported above, Wier & Carline (1997) reported that 73 participants sustained 28 injuries. Therefore, the frequency per participant of lower limb orthopaedic injuries sustained was lower in the amateur level Karate participants sparring at semi-contact level (Weir and Carline 1997), than in the elite level full-contact sparring in Taekwondo (Feehan and Waller 1995) (see table 2.6).

Table 2.6 Relevant number of injuries by body region per prevalence study.

Study	N	Neck (n)	Upper Limb (n)	Trunk (n)	Lower limb (n)
Feehan & Waller 1995	48	1	14	14	40
Weir & Carline 1997	73	NA	NA	NA	28

N=number of participants; n= number of injuries; NA = not applicable

Assessment of bias

The prevalence studies (Feehan & Waller 1995; Wier & Carline 1997) were assessed for bias using the tool by Hoy et al (2012) (see section 2.3.6). These were assessed as having an overall low risk of bias as they both scored less than 5 items

as 'high risk'. (See appendix 3 for the tool). High risk items included whether; the population and sampling frame were representative of the total population; the sampling methods were random and data was collected directly from subjects; there was a case definition; if non-response bias was considered and if tests used were correct.

Table 2.7 - Relevant number of injuries (n) by body region and orthopaedic injury rates per 1000 AE in the 13 event rate studies.

Study	AE	Orthopaedic injury rate per 1000 AE	Neck (n)	Upper Limb (n)	Trunk (n)	Lower Limb (n)
Arriaza & Leyes 2005	2837	45.1	34	28	9	57
Arriaza et al 2009	2762	8.7	1	12	1	10
Beis et al 2001	1434	18.8	0	6	4	17
Blijd et al 1995	204	53.9	0	0	5	6
Boostani et al 2012	462	162.3	0	18	51	6
Burke et al 2003	2498	6.8	3	3	5	6
Elsawy 2011	624	72.1	0	15	3	27
Kazemi & Pieter 2004	636	45.6	1	3	6	19
McLatchie 1976	295	84.7	0	15	3	7
Pieter et al 1998	220	54.5	2	2	0	8
Scoggin et al 2010	232	47.4	1	8	0	2
Yiemsiri & Wanawan 2014	114	184.2	1	0	0	20
Ziaee et al 2010	1338	64.3	0	41	2	43
Total	13656		43	151	89	228

AE = athlete exposures; n= number of injuries

2.4.5 Event rate studies

From all studies there were 13656 AE with a total of 2040 injuries sustained, 25% (n=511) of which were orthopaedic. From the thirteen studies providing event rates, the rate per study varied between 6.8 and 184.2 injuries per 1000 AE (See table 2.7).

All studies provided data that enabled the orthopaedic injuries to be divided by body region. The most commonly injured body region was the lower limb (228 injuries). This was followed by upper limb (151 injuries) and trunk (89 injuries). The least injured region was the neck (43 injuries) (see table 2.7 and figure 2.2).

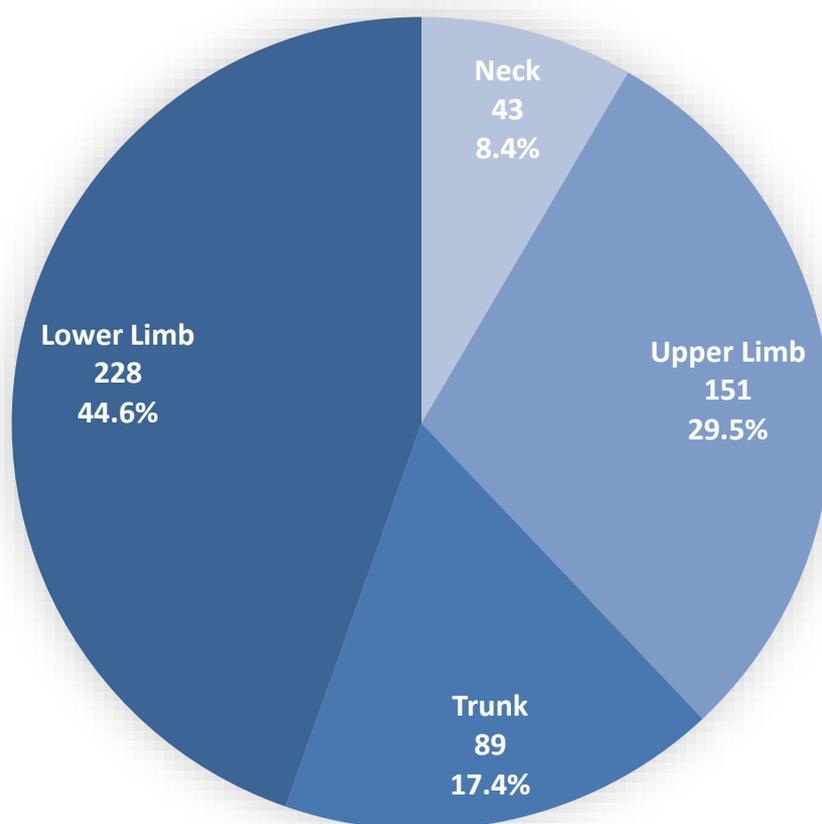


Figure 2.2 –Distribution of all injuries by body region. This illustrates the un-weighted proportion of injuries.

Table 2.8 - A comparison of injury by martial art.

Martial art (number of studies)	AE	nri	Injury rate range per 1000 AE	Weighted proportion of injury per 1000 AE (95% CI)	Body region (n)			
					Neck	Upper Limb	Trunk	Lower Limb
Karate (4)	6356	252	8.7-162.3	39.6 (35.4-43.9)	35 (13.9%)	73 (29%)	64 (25.4%)	80 (31.7%)
MMA (1)	179	11	14.6	61.5 (unweighted)	1 (9.1%)	8 (72.7%)	0 (0%)	2 (18.2%)
Taekwondo (6)	6750	216	6.8-72.1	32.0 (27.8-35.3)	6 (2.8%)	70 (32.4%)	20 (9.3%)	120 (55.6%)
Wu Shu (2)	318	32	53.9-184.2	100.6 (71.6-129.7)	1 (3.1%)	0 (0%)	5 (15.6%)	26 (81.3%)

The percentage shown in each body region is that of the total number of relevant injuries (i.e., 35 neck out of 252 orthopaedic injuries represents 13.9% of the total number of relevant injuries in the Karate group). AE = Athlete exposures; CI = Confidence interval; MMA = Mixed Martial Arts; n= number of injuries; nri = number of relevant injuries.

Table 2.9 - A comparison of injury by contact level.

Contact level (number of studies)	AE	nri	Injury rate range per 1000 AE	Weighted proportion of injury per 1000 AE (95% CI)	Body region (n)			
					<i>Neck</i>	<i>Upper Limb</i>	<i>Trunk</i>	<i>Lower Limb</i>
Full (7)	4598	231	18.8-184.2	50.2 (44.0-56.5)	5 (2.2%)	75 (32.5%)	15 (6.5%)	156 (67.5%)
Semi (6)	9058	280	6.8-162.3	30.9 (27.8-34.1)	38 (13.6%)	76 (27.1%)	74 (26.4%)	92 (32.9%)

AE = Athlete exposures; CI = Confidence interval; n= number of injuries; nri = number of relevant injuries.

Injury and martial art

Studies were aggregated by martial art. Table 2.8 compares the weighted estimates of injuries per 1000 AE by martial art and presents the distribution of injuries by body region. The highest rate of orthopaedic injury was in Wu Shu at 100.6 injuries per 1000 AE. Within styles, study event rates varied considerably. Karate and Taekwondo had similar event rates (39.6 and 32.0 injuries per 1000AE respectively) and confidence intervals. In Karate, this was between 35.4 to 43.9 whereas in Taekwondo, it was between 28.7 and 35.3 injuries per 1000 AE. No range is given for MMA as this was from a single study with a rate of 14.6 injuries per 1000 AE. When comparing martial art style, there was considerable variation in the number of studies and the number of AE within each category. The lower limb remained the most injured region except in MMA which there was a higher proportion of upper limb injuries (though it must be noted this was from a small population in a single study).

Injury and sparring contact level

Full-contact sparring resulted in more injuries than semi-contact; 50.2 injuries per 1000 AE compared to 30.9 respectively (table 2.9). They had a similar number of studies in each category, though the semi-contact group had almost twice the exposure than the full-contact group. The lower limb was the most commonly injured region for both contact levels. The distribution of injury in the semi-contact group showed a relatively even distribution across regions. Full-contact sparring demonstrated the same pattern as for the overall data in terms of body region injury which was: lower limb > upper limb > trunk > neck (table 2.9).

Injury by participant level

Injuries by participant level were also explored (table 2.10). The study by Kazemi & Pieter (2004) did not stipulate participant level and was excluded from the analysis. From the other studies, professional level participation resulted in the greatest number of injuries per 1000 AE (61.8 compared to 17.9 and 39.2 in the amateur and elite groups respectively). The frequency of upper limb (n=49) and lower limb injury was very similar (n=45) in the professional group.

Table 2.10 - Injuries by participant level.

Participant level (number of studies)	AE	nri	Injury rate range per 1000 AE	Weighted proportion of injury per 1000 AE (95% CI)	Body region (n)			
					Neck	Upper Limb	Trunk	Lower Limb
Amateur (3)	3013	54	6.8-84.7	17.9 (14.7-21.1)	5 (9.3%)	20 (37.0%)	8 (14.8%)	21 (38.9%)
Elite (7)	8437	331	8.7-184.2	39.2 (35.5-43.0)	36 (10.9%)	79 (23.9%)	73 (22.1%)	143 (43.2%)
Professional (2)	1570	97	47.4-64.3	61.8 (49.0-74.6)	1 (1%)	49 (50.5%)	2 (2.1%)	45 (46.4%)

Please also note that one study did not report participant level and was not included in this analysis (Kazemi & Pieter 2004).

AE = Athlete exposures; CI = Confidence interval; n= number of injuries; nri = number of relevant injuries.

Table 2.11 - Injuries by setting.

Setting (number of studies)	AE	nri	Injury rate range per 1000 AE	Weighted proportion of injury per 1000 participants (95% CI)	Body region (n)			
					Neck	Upper Limb	Trunk	Lower Limb
National competition (8)	6857	218	6.8-84.7	31.8 (28.5-35.1)	7 (3.2%)	78 (35.8%)	25 (11.5%)	188 (86.2%)
International competition (5)	6799	293	8.7-184.2	43.1 (38.9-47.3)	36 (12.3%)	73 (24.9%)	64 (21.8%)	120 (41%)

AE = Athlete exposures; CI = Confidence interval; n= number of injuries; nri = number of relevant injuries.

The injury rate varied between studies, though this was greatest in the elite group studies (8.7-184.2 injuries per 1000 AE).

Injury by setting

When setting was compared, international competition resulted in a higher rate of injuries (43.1 per 1000 AE) compared to the national competition setting (31.8 injuries per 1000 AE) (table 2.11). The confidence intervals demonstrate no overlap. No event rate studies assessed the class setting. Both national and international competition demonstrated that the lower limb was the most injured body region.

Study validity of event rates studies

The event rate studies were reviewed for quality and bias using a separate tool to that for the prevalence studies (Nguyen et al 2009 – see section 2.3.6 and appendix 4). Their scores ranged from 36 (Boostani et al 2012) to 65 (Beis et al 2001) with a median of 52 and an interquartile range (IQR) of 47-59. The scores are summarised in table 2.12. Please note the maximum available score from this tool was limited to 68 for these types of studies. For this review, any studies that achieved 47 or over were considered good quality, because this was the lowest IQR score. Three studies fell below this threshold: Boostani et al (2012); Kazemi & Pieter (2004) and McLatchie (1976). Kazemi & Pieter (2004) fell 1 point short of the minimum score. Boostani et al (2012) and McLatchie (1976) both dropped their scores on study conduct and analysis; both studies gave a limited description of their methods of measurement and did not mention dropouts or assessment of confounding.

Table 2.12 - Summary of study validity according to Nguyen checklist.

Study	Study design	Study conduct	Study analysis	Conclusion	Total Score
Arriaza & Leyes 2005	26	14	16	3	59
Arriaza et al 2009	26	14	16	6	62
Beis et al 2001	25	15	22	3	65
Blijd et al 1995	20	12	16	3	51
Boostani et al 2012	20	6	7	3	36
Burke et al 2003	26	13	22	3	64
Elsawy 2011	22	6	16	3	47
Kazemi & Pieter 2004	22	11	10	3	46
McLatchie 1976	18	4	8	6	36
Pieter et al 1998	22	12	16	3	53
Scoggin et al 2010	22	14	10	6	52
Yiemsiri & Wanawan 2014	22	14	16	3	55
Ziaee et al 2010	22	12	10	3	47

There was little variability in the scores for study design with a median score of 22 (IQR 20-24.5). The median score for study conduct was 12 (IQR 7.25-14). The median score for analysis of data was 16 with a range 7-22. Most studies presented their data in a clear format that was simple to follow and interpret. Finally, most studies gave a good clear conclusion, though did not refer back to their statistical analysis. Only 3 studies met the criteria for full marks on their conclusion (Arriaza et al 2009; McLatchie 1976; Scroggin et al 2010).

2.4.6 Summary of main findings

- A clear definition of injury was only given in 53.3% (n=8) of the studies.
- Orthopaedic injuries represented 28% of the total number of all injuries sustained.

- There were no incidence studies. The two studies purporting to be prevalence studies did not provide sufficient information to estimate prevalence rates of orthopaedic injuries.
- Most studies estimated event rates. The event rate of orthopaedic injuries varied between 6.8 and 184.2 injuries per 1000 AE.
- The lower limb was the most commonly injured body region overall.
- Injuries per 1000 AE varied between styles, though Wu Shu resulted in the greatest rate.
- Full-contact sparring resulted in greater injury rates than semi-contact.
- Professional level participation and the international competition setting resulted in greater injury rates. Event rates could not be estimated in the class setting due to lack of studies.

2.5 DISCUSSION

Martial arts injuries are commonly reported. In reviewing the literature, there were no studies looking solely at orthopaedic injuries reporting on prevalence and incidence. This section presents a discussion of the findings of the systematic literature review.

2.5.1 Summary of main findings

The objectives of this systematic literature review were to identify how common orthopaedic injuries were in contact striking martial arts and identify the distribution of injuries by body region. Further, to review how rates vary by martial art, contact level, participant level and setting in which it has been sustained (e.g., at competition).

The systematic review demonstrated that over a quarter of the total injuries sustained were orthopaedic. Although these were not the most common, they still represented a significant proportion of all injuries.

In the 13 event rate studies, injury rates varied considerably between 6.8 and 184.2 injuries per 1000 AE. Injuries were more likely in professional level fighters,

international level competition, full-contact sparring and Wu Shu as a martial art style. No event rate studies looked at injuries in a class or grading setting. The most commonly injured limb was the lower limb.

The twelve-month period prevalence of orthopaedic injury could not be estimated from the included studies. One study provided data on all injuries and one was solely on lower limb injuries (Feehan & Waller 1995; Wier & Carline 1997).

2.5.2 Limitations of study methods in the systematic review

Data collection in most studies was either by the project team themselves or through the attending physicians. This opens the data collection up to interviewer bias if they were completing the survey for the participants. No studies indicated how data was handled when more than one injury was sustained in a single participant. From the study methodology, inference can be made that it was included in the overall injury rate, as they were not looking at individuals and the number of injuries they sustained, but the total number of injuries sustained. The limitations were mostly due to studying a subset of that data i.e. orthopaedic injury. There was no standardisation in reporting of martial arts studies and so data separation was difficult which limited the data synthesis.

2.5.3 The study populations

The variation in the event rates across studies is large. This might be because of the heterogeneity of the study populations regarding the range of martial arts and settings. Heterogeneity exists within each style. Karate for example has many sub-styles from Kyokushshinkai to Shotokan. Kickboxing may include Muay Thai or traditional styles. One may allow strikes using elbow, whereas the other may restrict kicking to above the waist only. Each again will have their own rules of engagements when sparring and regarding contact (Zazryn et al 2003). This presents a challenge to interpretation of the results when pooling data and is discussed later. The implication of this for future study would suggest studying a single martial art to reduce heterogeneity.

Zetaruk et al (2005) commented on the limited application of pooling different styles together under a single umbrella of sport such as the many styles of karate. They alluded to the heterogeneity of the fighting styles and contact level of sparring. Furthermore, they echo the concerns in this systematic review of comparing styles that have joint locks and throws to those that involve contact striking sparring. This is addressed to some degree in this thesis in that the martial arts reviewed had similar fighting styles and the contact levels were stated. The implication for future work is that unless the studies are comparing style of martial art in particular, there is limited value in pooling data from a mix of martial arts unless they employ similar techniques.

2.5.4 Definition of injury

There was no consensus on the definition of injury. Only 8 of the 15 studies provided a definition of injury and in most studies this was a limited one. Some studies defined 'injury' as any situation in which a participant sought the medical team (Beis et al 2001; Elsayy 2011; Kazemi & Pieter 2004; Ziaee et al 2010). Other studies defined injury as any situation where the athlete was unable to continue in the competition (Burke et al 2003; Kazemi & Pieter 2004). A potential limitation of this is selection bias and that any participant with an injury who decided not to seek medical attention at the event would have been missed, as would those whose injury only becomes a problem after events, as there was no follow up. Implication for future would suggest that studies that ask all participants if they have been injured would capture more information both on the impact of those injuries on the participant and the staffing requirements at events.

In the prevalence study by Feehan & Waller (1995), a clear definition of injury was provided as a question on their survey. They asked participants about any physical condition whereby the athlete had to miss at least one training session or where medical attention was sought. Again, injuries may have been missed as not all athletes might consider missing a session for an upper limb injury, for example, they may just alter their training habits within the session.

The research student feels that a clear definition of injury should be given in each study. This is especially important if the study subject is 'injuries'. What one individual classifies as injury another may not. Hence leaving the term injury open to interpretation may limit the accuracy of data collection and introduce detection bias. Data may be collected on all injuries and later, injuries of interest may be filtered i.e., filtering out bruises, scratches or contusions.

Furthermore, participants may not disclose all injuries. This may be due to recall bias or their interpretation of injury. Some may not wish to disclose injuries due to fear of being withdrawn from participation in their sport. This and the methods of data collection may result in underreporting of injuries.

2.5.5 Orthopaedic injuries in martial arts and by body region

The musculoskeletal system represents a large proportion of the human body. Multiple targets for striking include the upper and lower limbs and trunk (including the cervical spine) make orthopaedic injuries almost inevitable when engaging in contact striking martial arts. Risk of injury is likely multi-factorial and may include factors such as: martial art style, sparring rules at the competition and setting.

In this systematic review, period prevalence could not be estimated, however the event rate of these injuries varied between 6.8 and 184.2 injuries per 1000 AE. Due to the significant heterogeneity of the studies, a meta-analysis was not undertaken, so it was not possible to estimate an overall event rate of these injuries but rather a range reported from the studies. Three studies were homogenous enough to permit a limited meta-analysis, though this would have had limited application in the context of this thesis and so was not undertaken. Two of these had the same definition of injury (Arriaza & Leyes 2005; Arriaza & Leyes 2009). The other did not define injury (Boostani et al 2012).

Overall orthopaedic injuries represented only a quarter of all injuries. The most commonly injured region was the lower limb (44.6% of orthopaedic injuries). This agreed with previous studies that identified that lower limb digit injuries were the

most common injuries though these were soft tissue trauma, muscle injuries, lacerations and haematomas (Destombe et al 2006; Gartland et al 2001; Gartland et al 2005; Pieter et al 2012). Other studies on all martial arts injuries have found this to be the second most commonly injured region following the head and face when all injuries are considered (Gartland et al 2005; Zazryn et al 2003). The upper limb, trunk and neck were sequentially less injured with respect to orthopaedic injuries.

The lower limbs may be used proportionately more during sparring in certain styles. For example, in competitive Taekwondo, 80% of the techniques used are kicks (Serina & Lieu 1991; Zetaruk et al 2005). This may be similar with other styles such as kickboxing. As the name suggest, it includes a range of kicking techniques. With the greater strength and range afforded to the lower limbs, this may result in increased injury. Also, the PPE available for the lower limb is limited in that this usually protects the shin and instep region, however, the toes are left exposed, as are the large bony prominences of the knee and ankle.

The trunk is the largest body region proportionally, though it is not the most commonly injured. Orthopaedic injuries in the trunk represented only 17.4% of the total. It is likely that the trunk is well protected by the participants guarding stance. Fewer injuries may have been incurred with the use of PPE. For example, in Taekwondo, the use torso guards (foam pads protecting from the neck to the lower pubis) are commonly used. These absorb a portion of the impact delivered by strikes to the trunk. Previous studies agree that the use of personal protective equipment reduces the number and severity of injuries sustained (Birrer 1996; Khurland 1980; McLatchie 1976). Interestingly, Critchley et al (1999) reported that the use of PPE is more for the protection of the attacker than the wearer. This is secondary to many injuries being a result of poor technique, striking to bony prominences (Johannsen & Noerregaard 1988; Critchley et al 1999). Schmid et al (1969) on the other hand, found a head guard to reduce peak acceleration of punches by 15-25%. Other simulation studies using dummies demonstrated reduced peak acceleration, however the force imparted was still significant with the use of boxing gloves and foot pad (Schwartz et al 1986). It is believed that a

similar pattern of injury will occur with or without the use of these (Critchley et al 1999).

The neck was the least injured region. This may be because of the guarding stance adopted in that the hands protect the jaw and with the head flexed the neck is not very exposed during sparring. Torsional injuries are possible when the jaw is punched which may cause a rotational strain through the neck.

Upper limb injuries represent over a quarter of the total orthopaedic injuries. The upper limb is used for striking and defending. As the athlete develops in their training, they will learn how to deflect strikes rather than absorbing the full impact. This is usually easier to do with the upper limbs being shorter and faster than the lower limbs. The hands are also usually well protected using gloves. Some martial arts will also use forearm and elbow pads to reduce the impact of strikes. Collectively this may help to explain why fewer injuries are sustained to the upper limbs than the lower. Interestingly, the highest proportion of upper limb injuries occurred in the MMA group. This may be a result of the use of fingerless gloves, or the use of joint locks used. This group included only one study with a small study population compared to the other martial arts and further research is needed (Scoggin et al 2010).

2.5.6 Orthopaedic injury by martial art, setting, participant and contact level

Karate and Taekwondo had similar rates of injury (39.6 and 32.0 per 1000 AE respectively), MMA was higher (61.5) and Wu Shu had the highest (100.6). The large discrepancy in Wu Shu may be related to the relatively small number of studies (2), participants (N=137) and exposures (318) in comparison to Karate (studies=4, AE=6356) and Taekwondo (studies=6, AE=6750). MMA, through a single study, had a similar number (N=179, AE=232) to Wu Shu. Wu Shu had a wide confidence interval compared to the other group, which is likely a reflection on the low numbers and exposures in the studies. Further study is required on whether the style of martial art impacts on the proportion of orthopaedic injuries. The two studies that constituted the Wu Shu population (Blijd et al 1995; Yiemsiri & Wanawan 2014) had both full- and semi-contact sparring with similar numbers

of participants in the studies so this is unlikely to account for the discrepancy in injury rate. They also employed similar designs in methods and data collection. Their event rates were 53.9 and 184.2 injuries per 1000AE respectively. It may be that the style of fighting incurs more orthopaedic injuries, however both studies had small populations thus this is difficult to ascertain without further study. In comparing five styles of martial arts, Zetaruk et al (2005) concluded that more injuries are sustained in Taekwondo than in Shotokan Karate and that different injury types and distribution are seen in different martial arts. In this systematic review, Taekwondo, Karate and Wu Shu exhibited a similar distribution of injuries by body region.

In comparing contact level, there were a similar number of studies of full and semi-contact but the combined study populations varied considerably in terms of AE (4598 and 9058, respectively). The orthopaedic injury rate was higher for full contact sparring (50.2 injuries per 1000 AE) compared to semi contact (30.9 injuries per 1000 AE) with no overlap in confidence intervals. Full contact sparring may result in more injuries due to unrestrained striking and thus a greater delivery of energy which may increase the risk of injury. Although beyond the remit of this thesis, it would be interesting to assess whether the increased injury is incurred when striking or defending.

When participant level was compared, the professional level group had the highest injury rates (61.8 injuries per 1000 AE). This may be spurious because there were only two studies with small number of exposures (AE=1570) compared to amateur (AE=3013) and elite (AE=8437) groups. The weighted estimate per 1000 participants was 61.8 for the professional group compared to 17.9 and 39.2 for the amateur and elite groups respectively. There was a wide confidence interval for the professional group. The professional group populations were mixed martial arts and Taekwondo. Without knowing the exact rules of engagement for these fighters it is difficult to provide clarity as to why they should incur a higher injury rate. In theory, in a professional fight, if the participants are aiming for knockout to win, the level of fighting and delivery of energy with blows may result in more injury. Given this and the small study populations with wide confidence interval, it

is unclear without further study why the professional population should acquire more injuries than the other groups.

Description of the participant level was a potential limitation. This may represent a heterogeneous population in that a professional could have any length of experience and this was not described. Does a professional fighter with one-year experience suffer the same injuries as one with 15 years' experience? The research student was unable to determine this from the data.

In comparing settings, international level competition resulted in more injuries than national level (43.1 compared to 31.8 injuries per 1000 AE respectively). The confidence intervals for both were not particularly wide and demonstrated no overlap. Both groups had similar numbers of semi contact sparring studies (3 in each), however there were more full contact studies in the national competition setting (5 compared to 2 in the international setting). The rules of engagement are likely similar in both settings and similar personal protective equipment is likely used. Comparison to the class setting was not possible as no studies reported on this. Previous studies have reported that competition and tournaments pose the greatest risk of injury to participants (Jaffe & Minkoff 1988; Zetaruk et al 2005). Gartland et al (2001) disagree with this and report that they are associated with fewer injuries than training, however, a greater severity of injury. It is unclear why the international setting should result in greater rates of injury and the aetiology is likely multi-factorial. Without further study, it is difficult to draw robust conclusions on whether setting significantly impacts on injury numbers. Furthermore, studies are needed on the class setting to allow comparison to competition whether national or international.

None of the studies compared injury by age, gender, setting, participant level or grade. These were compared indirectly in this systematic review, though could only be compared in the event rate studies. No such comparison was conducted for the prevalence studies as they looked at different injuries and so could not provide further insight.

2.5.7 Limitations and strengths of the review

There were some limitations in the search and the protocol for the systematic review. Only three databases were searched. This may have limited the return of valid studies. However, a preliminary search for this niche subject on several databases including CINAHL and Cochrane (CENTRAL) returned no results. The databases that were selected, cover a broad range of biomedical and sports research literature. These were chosen because they cover most of the peer reviewed, published research available. There was also limited time and resources available to the student to include more databases.

The exclusion of non-English articles was again due to time constraints, funding and resources available. A large volume of research may have been missed especially the literature from Asia. Due to the origins of many martial arts and other factors such as the integration of these into school curriculums, there may be a wealth of scientific studies available, albeit not in the English language. This may mean that important studies may have been missed. Restricting the studies to an adult population, limited the analysis of whether age and grade may influence orthopaedic injury; however, this was done to allow comparison of a skeletally mature population with similar skeletal biomechanics. Finally, there are over a thousand styles of martial arts and it was not possible to perform a search for each one individually with their alternative spelling, thus only the most popular styles were included in the electronic search.

There were also limitations in assessing the studies for bias. For this thesis, only the research student assessed the studies due to time constraints and limited resources. There were several limitations in using the assessment tool by Nguyen et al (2009) for assessing the event rate studies. The tool was originally designed to qualitatively assess studies for a meta-analysis on the relationship between overjet size and traumatic dental injuries. The scoring was limited for the studies included in this analysis and they could achieve a maximum of 68 out of a possible 100. In the tool, several factors could not be scored in the selected studies as these were not relevant to this type of study. These include items such as the description of confounders, follow-up time, subgroup comparability, inter- and intra-examiner

reliability and level of agreement between them could not be scored due to study designs. There was no description of thresholds for the quality of the studies and this was left open to interpretation. However, the research student had undertaken an extensive search for appropriate tools for this type of study, and failed to identify a more appropriate one.

2.6 CONCLUSION

The main findings of this study demonstrate that 28% of all injuries were orthopaedic in nature, that the most commonly injured body region was the lower limb and that event rates of orthopaedic injuries vary between 6.8 and 184.2 injuries per 1000 AE. Further, injury rates varied between styles, setting and contact level. Prevalence of injury could not be estimated due to limited numbers of studies. Furthermore, only 53.3% of studies provided a clear definition of injury.

In conclusion, there were no studies conducted purely on orthopaedic injuries in contact striking martial arts in an adult population, although these were shown to be a common injury. Studies mainly measured injuries at specific events and in specific groups; there was limited information on all such injuries sustained across a period of time which would allow direct comparison between injuries sustained in different settings, experience and contact levels. Two studies purported to capture information on prevalence; however, they presented their data in such a way that prevalence of orthopaedic injury could not be calculated. Furthermore, the studies mainly collected information on injuries reported to a member of the medical team and this may underestimate the amount of injury as some might not report for fear of being withdrawn from further participation in the sport, and some types of injury, such as strains or sprains may be ignored but then result in severe limitation later. Therefore, there is limited information from the systematic review to help understand potential for prevention or provide advice on orthopaedic injuries and training of those who have access to these athletes.

The next chapter reports on the method and findings of an empirical study to address some of these shortcomings. It is a prevalence study of participants of

different grades and focuses on one style of martial art because of the heterogeneity introduced when multiple martial arts are included. In undertaking this study care has been taken to carefully define injury as this was an observed shortcoming of the studies in the systematic review. Furthermore, because the data is being collected through a confidential questionnaire given to participants to self-complete, injury needed to be carefully described to reduce problems with interpretation. Given the concerns above about potential for underreporting to officials and to help provide a more complete understanding of the burden of musculoskeletal orthopaedic injuries, information is also collected on help seeking behaviour in the survey.

CHAPTER 3 – SURVEY OF ORTHOPAEDIC INJURIES IN CHINESE KICKBOXING

In chapter 2, a systematic literature review was presented which demonstrated limited evidence on the impact on the number of injuries by martial art, contact level, participant level and setting. In this chapter, the background, methods and results of a survey are given. This aimed to estimate the prevalence of orthopaedic injuries in a single contact striking martial art and describe the settings in which these injuries are sustained. Further it aimed to identify the health-seeking behaviour of martial arts athletes.

3.1 INTRODUCTION

3.1.1 Background & Research Context

In chapter 2, the systematic review demonstrated no studies looking solely at orthopaedic injuries in contact striking martial arts. Only two studies examined frequency of injury over a retrospective time period, one of which only looked at lower limb injuries (Feehan & Waller 1995; Wier & Carline 1997). Period prevalence could not be estimated from these due to the limited data available. Neither of these studies compared prevalence of orthopaedic injury by setting or level of experience. Some information on differences in these factors could be extracted from studies examining injury event rates, but the diversity of martial arts practices and sparring styles introduced considerable heterogeneity into the population, which along with the varied methods of data collection and study objectives, limited the interpretation. Furthermore, there were no event rates studies of class settings.

Understanding the more prevalent injuries may guide clinical examination to be aware of and look for specific injuries. Stratification into setting may help inform ringside physicians what injuries may be encountered. They can therefore plan the best management and what stock is required at each event. Identifying the prevalent injuries and the risk factors for these may help to find strategies to reduce the risks also. In a class setting it may help advise the instructor what may

be required in their first aid kit and encourage them to get basic training in first aid and what advice to give to members of their class.

Some of the shortfalls of the systematic review are addressed through a survey presented in this chapter. It would be logical that increased exposure would increase risk of injury. For this reason, as well as comparing the socio-demographic details of participants, years of experience, number of martial arts practiced, level and number of classes trained per week will also be explored in this survey. Level may not always equate to years of experience as a black belt may have a wide range of experience from 2 years to over 15 years' experience. Participants may also engage in more than one martial art, increasing their risk of injury. Previous studies have not commented on these factors.

Understanding the health seeking behaviour of martial arts athletes may help those involved in the organisation of the sport understand the need to develop health promotion strategies to ensure these athletes are well informed on what to do in case of injuries and the importance of not neglecting injuries and continuing training when this could be detrimental.

In this chapter, the methods and findings of a cross-sectional survey of orthopaedic injuries undertaken on a single martial art, Chinese Kickboxing, are reported. The overriding sparring style for this is contact striking with limited grappling. By focusing on a single contact striking martial art, the aim was to limit the heterogeneity in the study to enable subgroup comparison.

3.1.2 Survey Objectives

The study had the following objectives:

- To estimate the one-year period prevalence of orthopaedic injuries in a single contact striking martial arts.
- To estimate the average one-year rate of injury per participant.

- To estimate the proportion and prevalence of these injuries per body region: neck, upper limb, trunk and lower limb.
- To explore whether the one-year period prevalence of orthopaedic injury varies by: participant socio-demographic characteristics, years of experience, level of participation, frequency of training sessions and setting (such as class, competition or grading).
- To describe how injuries were sustained by activity.
- To explore the help-seeking behaviour of martial arts athletes and the length of time taken off training following injury.

3.2 METHODS

This section describes the survey methods for this prevalence study. The systematic review revealed few studies on period prevalence of injuries and none specifically on orthopaedic injuries in contact striking martial arts.

3.2.1 Study design

A cross-sectional self-reported questionnaire survey to estimate prevalence of orthopaedic injury in a single contact sparring martial art.

3.2.2 Population/Participants

The participants for the survey were athletes, aged 16-years-old and over, engaged in one main contact striking martial arts. Athletes attending grading and classes in Chinese Kickboxing (Wu Shu Kwan) were given the survey. Inclusion was limited to participants over 16 years old to allow data collection on a population who had reached a reasonable skeletal maturity and can participate in adult level sparring. Participants were of any level from beginner to professional or elite to ensure variation in the number of years' experience, the number of martial arts practiced and the number of sessions attended per week.

3.2.3 Identification of participants

Two organisations practicing forms of Chinese Kickboxing were contacted regarding permission to attend gradings and classes to disseminate and collect the data. Approval was granted from the following organisations Wu Shu Kwan and San Shou Kwan.

Instructors were invited to participate through the central organisations. Instructors were asked to speak to their students to assess whether they would like to take part in the study and that it would involve a short anonymous survey about injuries sustained in martial arts. If they agreed, the research student attended the class or grading and supplied a questionnaire and envelope to return this to a marked box. A minimum of one week before this, potential participants were provided with an information sheet to allow them to make an informed decision as to whether they wished to participate.

3.2.4 Injuries of interest

The survey is concerned with orthopaedic injuries sustained in the practice of contact striking martial arts either in class, grading or competition. The research student could find no definition in the academic literature for orthopaedic injury, thus for this thesis, orthopaedic injuries refer to any injury to the muscles or skeleton and their supporting structures including: cartilage, tendon, ligaments and nerves. Effectively this is the musculoskeletal system and this term is used synonymously with orthopaedic injury in this thesis. For the survey, injury was defined as any that the participant felt was an injury that they sustained in the course of practicing their martial art excluding scratches and bruises.

Exclusion Criteria: The injuries of interest for this study were orthopaedic in nature. Any injuries that fell under the remit of other disciplines such as maxillofacial or neurosurgery were excluded. These included head injuries (e.g. brain injury or concussion), and maxillofacial injuries (e.g. mandibular and orbital fractures). Visceral injuries (organ injuries such as splenic or kidney injury) were also excluded, as were contusions, abrasions and lacerations. Injuries sustained outside of the martial arts setting such as a street fight/assault were excluded.

3.2.5 Study measures

The principal study measures reflect the objectives of the survey.

The first objective was to identify the one-year period prevalence of orthopaedic injuries in contact striking martial arts. This is the percentage of participants incurring a relevant injury over the preceding twelve months. The overall prevalence was calculated as well as that for each body region (upper limb, lower limb, neck and trunk). Where relevant, a one-year injury rate per participant is also described.

The body regions were divided into neck, upper limb, trunk and lower limb. The neck pertains to the musculoskeletal structures around the cervical spine up to but not including the base of the skull. The trunk includes all musculoskeletal structures from the first thoracic vertebrae down to and including the pelvis. It does not include the visceral structures. The upper limb included all upper limb structures from the digits up to and including the shoulder complex, which includes the acromioclavicular joint. It does not include the scapulae or the sternoclavicular joints. The lower limb included all structures from the digits up to and including the hip joint and capsule. Injuries to the innominate bone or its individual components were considered pelvic injuries and therefore part of the trunk.

Risk factors for injury were also of interest. Previously age and gender had been implicated as risk factors. It was thought that any factor that increased exposure may also increase the risk of injury and so the following factors were also assessed: years of experience, level, number of training sessions attended per week and the number of martial arts practiced.

To analyse the health seeking behaviour of athletes, data was collected on whether help or advice was sought, who this was sought from and the services utilised to treat the injury. For example, a participant may have attended a local accident & emergency (A&E) service and then been referred onto an orthopaedic surgeon.

3.2.6 Sample size

As there was limited research on the prevalence of injury in this group, a 50% one-year period prevalence of injury rate was assumed as the worst-case scenario. Using this, it was estimated that at least 96 respondents were required for the prevalence rate to be estimated to within no more than +/- 10% with 95% confidence. This was calculated using Stats Calculator (www.mccallum-layton.co.uk).

3.2.7 Data collection

The data were collected through a questionnaire survey. An information sheet and sample survey was sent to instructors a minimum of one week prior to class or grading so that students could assimilate the information and decide on whether they wished to participate. The information sheet detailed who the researchers were, the research centre, the purpose of the research and it was stipulated that participation was strictly voluntary and that by completing the questionnaire, implied consent was given (see appendices 7 and 8).

The research student attended participating classes and all gradings between February and July 2016. The questionnaire was given to all attendees with a pen and an envelope in which the questionnaire was to be sealed and returned to a labelled box at the event. The envelopes were then collected from the box by the research student at the end of each event. The number of surveys handed out was counted as well as those returned to calculate a response rate.

3.2.8 Data Items

The data items collected reflected the objectives (see section 3.1.2). The data requested included socio-demographic, martial arts related, injury and health seeking behaviour related to injury. These items were as follows:

- Socio-demographic: age and gender
- Martial arts related: years of experience, level, number of training sessions attended per week, number of martial arts practiced
- Injury related

- Number of injuries sustained in the last 12 months as a result of their martial art
- Location of injury e.g. upper limb.
- Setting sustained e.g. class/grading/competition
- Was time taken out of training? If so, how long?
- Were any of these re-injuries or were they new?
- Health seeking behaviour
 - If injury occurred, was help or advice sought?
 - If help/advice was sought, who was this from?

Participant level was classified as beginner, leisure, amateur and elite or professional. Beginner refers to very junior belts with limited experience. Those in the leisure group were defined by their training pattern in that they trained only for leisure purposes, they did not compete. The amateur group engaged in competitions though did not compete in prize fights for financial gain. The professional and elite group were senior master level (higher dan black belts) or those engaged in prize fights.

Settings were classified as class, grading, competition or demonstration. Demonstration refers to a display put on as advertisement and may include sparring, destruction of materials and forms. Years of experience was subdivided into: less than 6 months, 6-12 months, 1-2 years, 2-4 years, 5-10 years, 10-15 years and greater than 15 years.

The body regions were defined in section 3.2.5. The types of injuries were left to be described by the participant, using examples in the question to aid the respondent, such as knee sprain. The only restriction was that the injury could not include scratches or bruises.

3.2.9 Survey Development

The survey underwent several stages in its development. The data required on the survey was that to enable the objectives to be achieved and answered. The aim was to keep the language as simple as possible to facilitate understanding of the

questions being asked with use of example answers to assist. The research student wanted to ensure no jargon was used in any definition and that questions were put into plain language to avoid leaving lots of questions open to interpretation therefore returning data that would be difficult to interpret or standardize.

The first version of the survey was discussed informally with some martial arts students (who were excluded from participating from the final data collection to avoid bias). They were given the first draft of the questionnaire to look at and then to discuss at the following session (one week later). Their feedback was that the form was too congested with not enough space to fill in for multiple injuries. There was also too little information to allow participants to make an informed choice as to whether to participate or not. It also did not contain information on what to do with the form once complete. Further, the student's felt that it would be more confidential to tick an age group rather than have a specific age as it meant that they were less likely to be identified.

In the second version, an information sheet was created which included information on the research student, the purpose of the study, how confidentiality would be maintained and how to complete the questionnaire (see appendix 7). The questionnaire was simplified again following further discussion with the same students as for the first version (who were excluded from the study). They preferred the age range tick box question to being directly asked their age, however, they expressed that some of the questions were asking for too much information in the same question such as injury type, mechanism and setting sustained. The survey also remained a little congested visually. Questions that involved ticking an item did not have boxes to tick. One question was identified as irrelevant to the study and was deleted on the future versions. This related to other sporting activities engaged in outside of the participants' martial art such as gym or cycling.

After discussion with the same group, the third version remained congested in that questions with lists had too many boxes and questions were very close to each other. Also, after reviewing the questionnaire, questions requiring actions such as

“tick or circle” required this information in to be stated in the question. This was addressed for version 4.

Version four of the survey used lists in the questions where something could be ticked or circled. Icons were also used to give information to the type of question (whether it required a tick or written data). It was ensured that each question was not asking for multiple data to keep things easy to follow. It also included data on when the survey was complete if for example a participant had no injuries, and what to do with the completed survey. Following discussion with the same group of martial arts students some changes were made regarding definition of injury.

In the fifth version, definition of injury was also refined to exclude minor bruises and cuts. It was also noted that age groups overlapped i.e. 20-25 and 25-30.

The final version of the survey refined the age groups so that there was no overlap, e.g. 20-25 and 25-30 years old were changed to 20-24 and 25-29 years old respectively. One question was removed regarding belt colour/grading as the heterogeneity in this group may be vast. For example, a black belt may have two years’ experience in total, whereas a participant who chooses to take longer to grade may still be a junior colour belt and have five years’ experience. For simplicity and comparability, it was decided that level and years of experience would be sufficient for comparison. All versions of the survey are given in the appendix 8.

3.2.10 Data Protection

To comply with the Data Protection Act (1998), no personal details were collected, as no further contact was required for this research following the primary data collection. Participants gave implied consent by completing the survey, with the understanding that no personal identifying information was to be provided. It was also made clear that data was only for the sole purpose of this research and subsequent publications.

All data was kept in a single file with the research student in a locked filing cabinet. The anonymous data was uploaded onto the university system in the form of an MS-excel spread sheet that was password protected. This data will be transferred to the DoS at the end of the MSc and kept for five years. Only the research student and supervisors have access to the raw data.

3.2.11 Ethical approval

Prior to any data collection, ethical approval was gained via the UCLAN STEMH ethics committee (see appendix 6). Ethical approval was granted, the STEMH unique reference number was STEMH 446.

The research student wanted to ensure that the participants knew that engagement with the study was strictly voluntary and confidential. It was also important to ensure that they had all information necessary to make an informed choice. Therefore, they were asked through their instructor and given the information sheet and questionnaire to look at prior to any researcher involvement. The information sheet clarified how their data was to be used and stipulated that their individual questionnaire would not be identifiable nor seen by any other student or instructor. It was also stipulated that for this reason, individual questionnaires could not be withdrawn after it was dropped into the collection box. Further, giving everyone a questionnaire also meant that no participating student was identified personally by the research student or other participants.

3.2.12 Piloting of the questionnaire

Quality assessment of the data was undertaken on review of the completed questionnaires. Following completion of the final version, it was piloted with a small group of martial arts students who completed the questionnaire with the research student to observe any difficulties. These were excluded from the final data collection. These were checked to see if they were completed properly and the data was assessed to see if the data items returned were as expected for the final data collection. The questionnaire had been simplified to give standardised answers to most questions. Variability was introduced in the open questions,

though the examples given, helped to reduce this. The process was repeated after the first visit, though this data was included in the final collection.

3.2.13 Statistical methods

The overall one-year period prevalence was calculated for orthopaedic injuries: the numerator was the number of participants who received a relevant injury divided by the denominator of the number of participants and reported as a percentage. The mean number of injuries per participant was also estimated. In this estimate, re-injuries were included as these were interpreted as representing a 'new' injury occurring as previous injuries had healed. 95% CI were estimated for both measures.

Differences between groups were investigated using either chi squared tests (X^2) for prevalence data or, for mean injury rate, t-test for comparison of two groups and one way analysis of variance (ANOVA) tests for analysis of more than two groups. A P-value less than 0.05 denoted statistical significance.

Pearson's correlation coefficient allowed for analysis to see if years of experience is statistically related to injury prevalence. Statistical significance was denoted by a $P < 0.05$. Binary logistic regression was used to analyse the effect of subgroups (independent variables) on presence of injury (dependent variable). The dependent variable was assessed as whether injury was incurred and not the total number of injuries. The subgroups analysed were gender, age, years of experience, number of martial arts practiced, level and number of classes trained per week.

Statistical analysis was undertaken using MS Excel (2013), SPSS (IBM Corp. Released 2013 (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) and STATSPLUS (StatPlus:mac, AnalystSoft Inc. - statistical analysis program for Mac OS®, version v6 <http://www.analystsoft.com/en/>).

3.3 SURVEY RESULTS

The questionnaire was handed out at five gradings and seven Wu Shu Kwan classes across the United Kingdom (London, Wales and the North West). Of 157 surveys handed out, 101 were returned. One questionnaire was excluded as although the demographics section was completed, the injury section was left blank. Although it could be assumed that there were no injuries, however, without this being clearly stated, a decision was made to exclude; given it was only one questionnaire it was unlikely to introduce any bias. With the excluded survey, the response rate was 63.7%. Questionnaires were returned with all questions completed bar one with missing data on injury setting.

3.3.1 Demographics of the population

This section describes the demographics of the population. There were 69 (69%) males and 31 (31%) females. Mean age could not be calculated. The distribution of age is shown in table 3.1.

Table 3.1 Distribution of participants by age group.

Age Group	16-19	20-24	25-29	30-34	35-39	40-49	50-59	60-70
N	15	21	13	9	8	20	12	2
	(15%)	(21%)	(13%)	(9%)	(8%)	(20%)	(12%)	(2%)

Although, the primary martial art of all participants was Chinese Kickboxing (Wu Shu Kwan), eight participants also undertook another. Seven participants undertook one other martial art, their secondary being: Karate, Kickboxing, Kung Fu, Taekwondo, Tai Chi, Thai boxing or Wing Chung. One participant undertook three martial arts (including the primary), the others were Tai Chi and Wing Chung.

Most participants (56%, n=56) considered that their training level was 'leisure'. The others were beginner (16%, n=16), amateur (9%, n=9) and professional or elite level (19%, n=19) (figure 3.1).

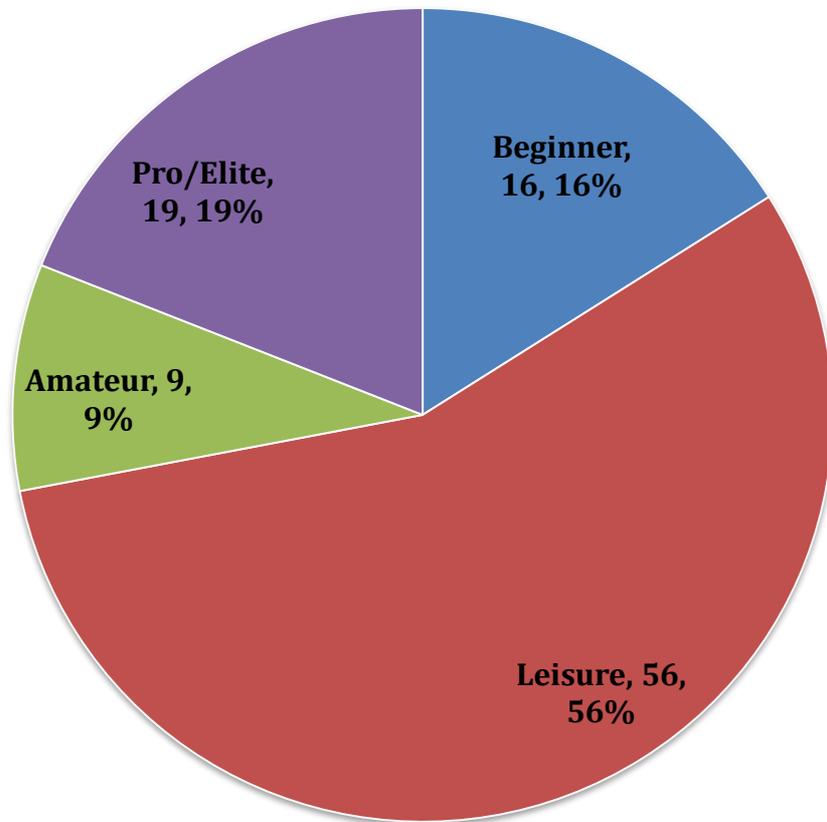


Figure 3.1 - Distribution of training level across 100 participants.

There was a good range of experience among the survey participants. About a quarter of participants had less than 2 years' experience and a quarter had more than 15 years' experience (figure 3.2).

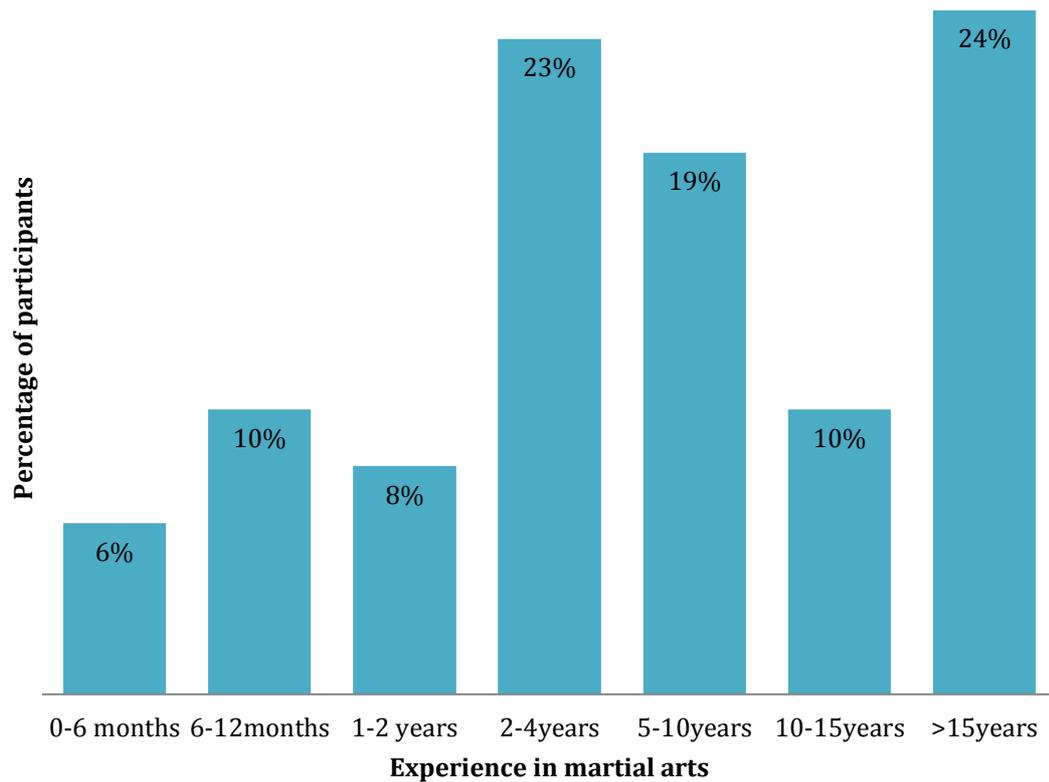


Figure 3.2 - Percentage of participants at each point of experience in martial arts.

3.3.2 Prevalence of Injuries

The orthopaedic injuries reported by the survey are summarised below. Two injuries were excluded, as one was a jaw dislocation and the other a burst kidney. These both fall under the auspices of other surgical disciplines. All other injuries were orthopaedic and therefore included. The following section summarises the injuries for the study.

The one-year period prevalence was 57% (95% CI 47.3%-66.7%). In this instance the numerator was the total number of participants who had at least one relevant injury (regardless of the number of injuries per participant). The denominator was the total number of participants.

The frequency of injury in the previous 12 months is shown below (figure 3.3). Of the 100 included participants, 43% (n=43) sustained no injuries. The total number of injuries in the other 57 participants was 96. The mean overall rate of injury was 0.96 injuries per candidate in one-year. From figure 3.3, there is a clear positive skew, with a median number of injuries of 1 (IQR=1-2). In the group who sustained injuries, the number per person ranged from 1-11, with a mean of 1.7 injuries (median=1, IQR=1-2).

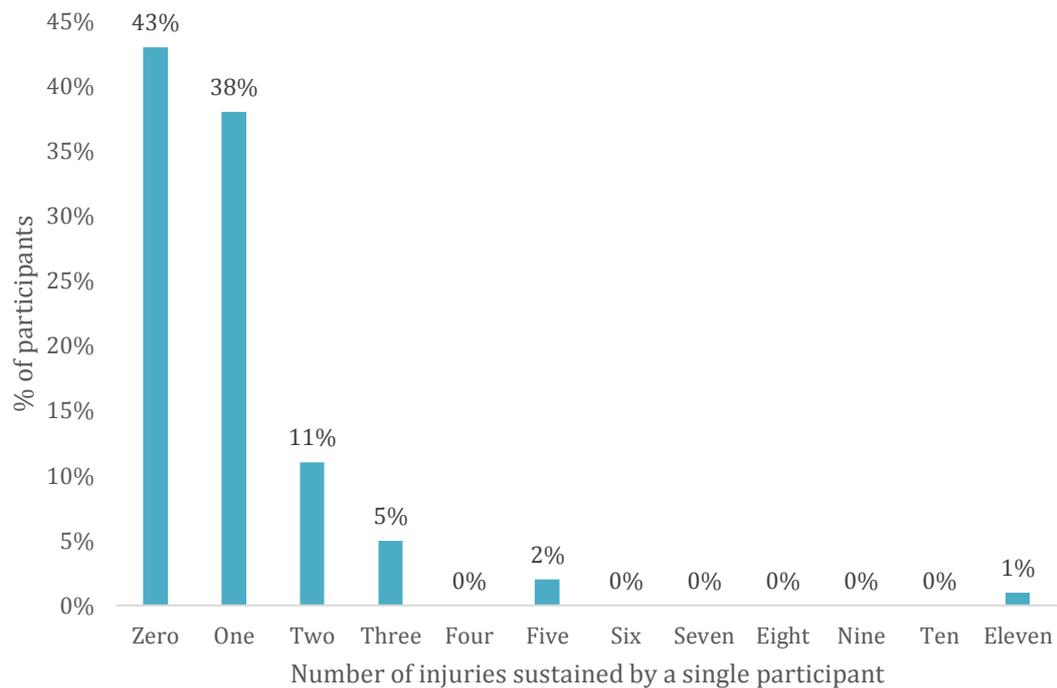


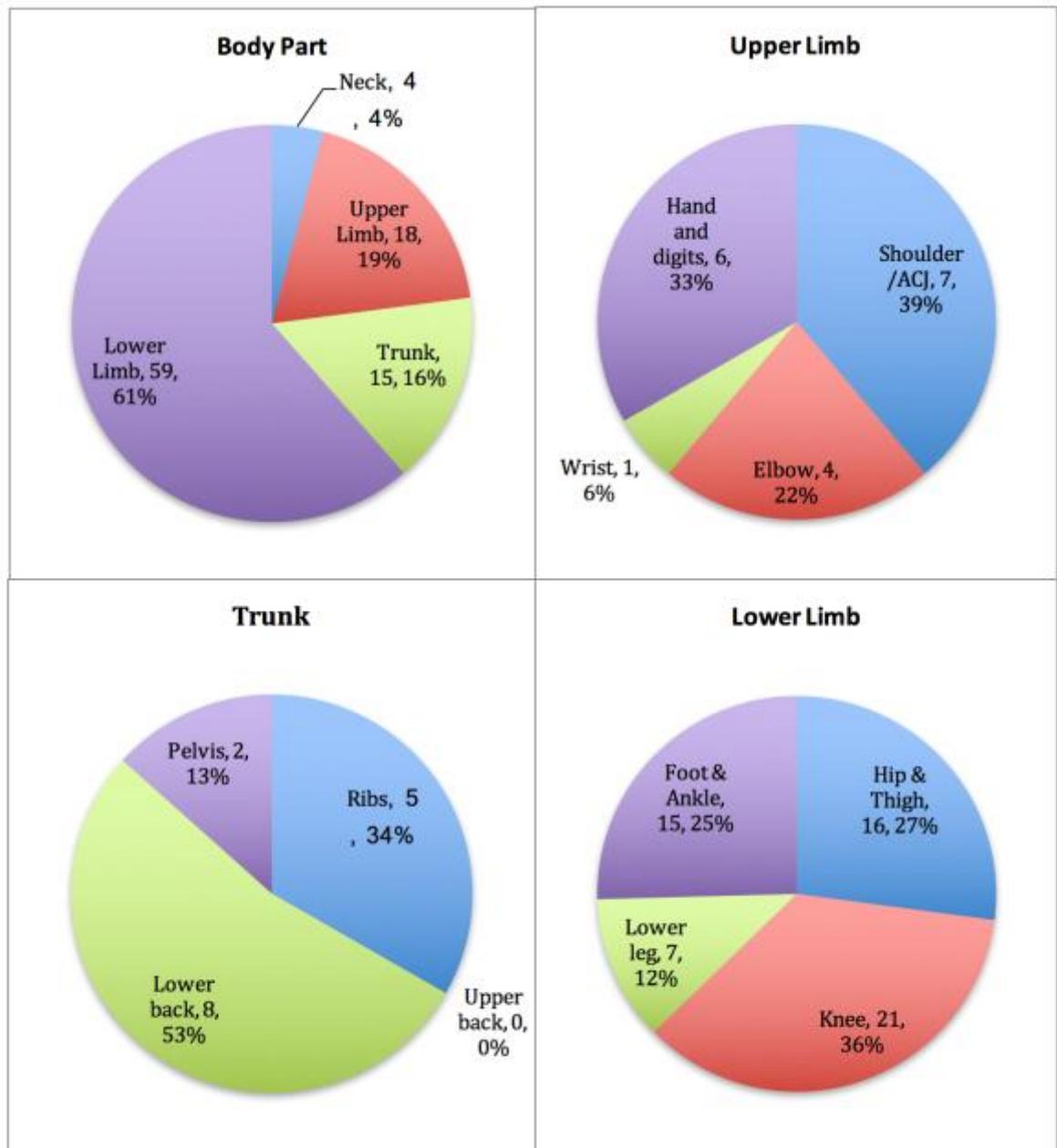
Figure 3.3 - Number of injuries per participant.

3.3.3 Injury by body region

The most commonly injured body part was the lower limb (61.5% of all injuries, n=59). Within this, the knee was the most injured (35.6% of lower limb injuries, n=21).

Within the other body regions, the most commonly injured parts were the shoulder complex in the upper limb (38.9%, n=7) and the lower back in the trunk (53.3%, n=8). Figure 3.4 illustrates the proportion of injuries per body part and subdivided by the anatomy of that region. All 4 injuries to the neck were strains.

Figure 3.4 - Proportion of injuries per body region and subdivided by regional anatomy. (The number given is the n value followed by the percentage).



3.3.4 Injuries by setting

The 96 injuries occurred in three settings: 86% of these injuries occurred in a class setting (n=84), 17.5% occurred at grading (n=10) and 1.8% occurred at a demonstration (n=1). One person did not specify a setting (1.8%).

In the class setting, 49 participants sustained 84 injuries. This gives a mean of 1.7 injuries per participant. At gradings, 10 students sustained 10 injuries giving a mean of 1.0 injury per participant.

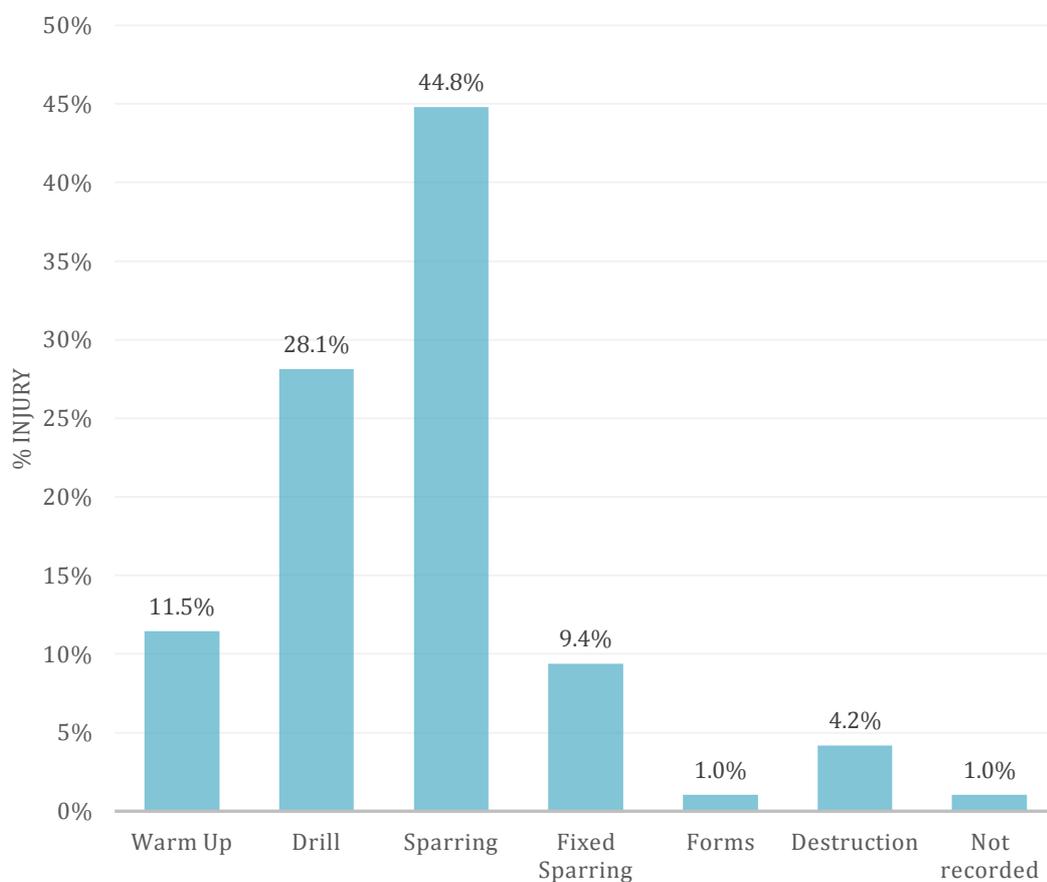


Figure 3.5 - Percentage of injuries sustained whilst engaged in each activity.

3.3.5 Injuries by activity

One of the aims of the survey was to identify how injuries were most commonly sustained. This was the activity the participants undertook at the time of injury, e.g., warming up, undertaking drills, sparring, etc. Of the 96 injuries, sparring was responsible for 44.8% of all injuries (n=43). A further 28.1% of injuries were

acquired during drill training (n=27). Injuries sustained during warm up comprised 11.4% of injuries (n=11). Most these were during stretching (8.3%, n=8). Figure 3.5 summarises the proportion of injuries sustained by the activity the participants were engaged in.

3.3.6 Other factors

Further subgroup analysis allowed comparison of whether there were differences in injury proportions by age, gender, level, years of experience, number of training sessions and the number of martial arts undertaken.

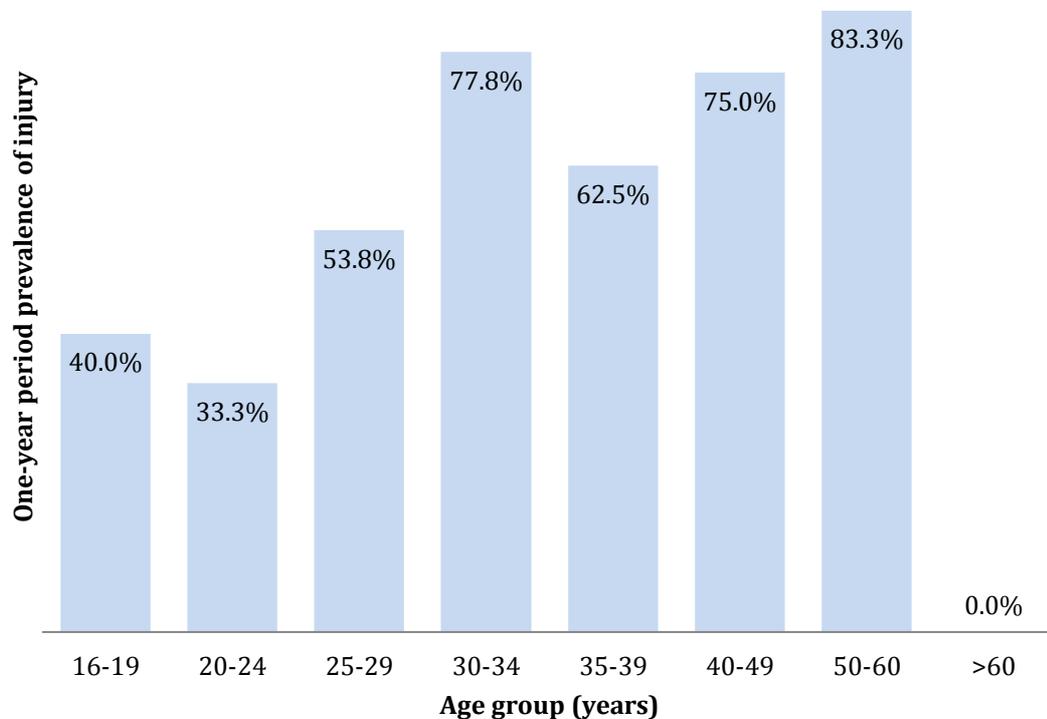


Figure 3.6 - Age group comparison of one-year period prevalence of injury.

Age and injury

The highest one-year period prevalence of injury was 83.3% in the 50-60 year age group, however the highest mean number of injuries was 2.2 injuries per participant in the 30-34-year-old group. This is influenced by the one participant with 11 injuries. If they are treated as an outlier, the mean number of injuries reduces to 1.13 per participant.

Table 3.2 Comparison of prevalence and injury rate by age group.

Age Group	N	Number of injured participants	Number of injuries	Range	One-year period prevalence	95% CI for prevalence	Injury Rate	95% CI for injury rate
16-19	15	6	7	0-2	40.0%	14-66%	0.47	0.14-0.79
20-24	21	7	7	0-2	33.3%	13-54%	0.33	0.13-0.54
25-29	13	7	9	0-2	53.8%	26-82%	0.69	0.28-1.10
30-34	9	7	20	0-11	77.8%	49-100%	2.22 (1.13)*	0-4.46
35-39	8	5	8	0-2	62.5%	27-98%	1.00	0.36-1.64
40-49	20	15	27	0-5	75.0%	56-94%	1.35	0.78-1.92
50-59	12	10	18	0-5	83.3%	61-100%	1.50	0.72-2.28
>60	2	0	0	0	0%	-	0.00	-

The event rate is the number of total injuries sustained per group divided by N. This represents the injury rate per participant per year.

**this represents the injury rate with the outlier excluded. A single participant received 11 injuries, the range without this was 0-3 injuries.*

This would make the 50-60-year-old age group have the highest mean number of injuries at 1.5 per participant (table 3.2). Overall, the trend would suggest that the prevalence of injury increases with age (figure 3.6).

Gender and Injury

There were 69 males to 31 females giving a ratio of 6.9:3.1 respectively. The one-year period prevalence of injury was 65.2% (n=45) in the male group and 38.7% (n=12) in the female. In comparing prevalence, the difference between the groups was statistically significant ($X^2=6.13$, $df=99$, $P=0.013$).

The mean injury per person for the male group was 1.00 injury per participant (SD=1.08, 95% CI=0.74-1.26). In the female group this was 0.87 (SD=2.05, 95% CI=0.15-1.59). This did not reach statistical significance ($t=0.412$, $df=99$, $P=0.681$).

Level, years of experience and injury

The level of participation in martial arts was categorised as beginner, leisure (where the participant does not compete), amateur and professional or elite. The highest one-year period prevalence of orthopaedic injury was 77.8% (n=7) in the amateur group. This group also had the highest mean injury rate at 1.67 injuries per participant (SD=1.94, 95% CI=0.40-2.93). The prevalence and injury rates for each group are summarised in table 3.3. When comparing injury rates between these groups, one-way ANOVA test does not reach statistical significance ($df=3$, $F=2.66$, $F\text{-Crit}=2.70$, $P=0.052$).

Table 3.3 - Prevalence of injuries by participant level.

Level	N	Number of injured participants	Number of injuries	Range	One-year period prevalence	95% CI for prevalence	Injury Rate	95% CI for injury rate
Beginner	16	6	6	0-1	37.5%	13-62%	0.38	0.13-0.62
Leisure	56	37	65	0-11	66.1%	54-79%	1.16	0.73-1.59
Amateur	9	7	15	0-5	77.8%	49-100%	1.67	0.40-2.93
Pro/Elite	19	7	10	0-2	36.8%	14-59%	0.53	0.18-0.87

Please note the CI for prevalence was changed for the amateur group as it is not possible to have more than 100% prevalence of injury. The event rate is the number of total injuries sustained per group divided by N. This represents the injury rate per participant per year.

Table 3.4 - One-year prevalence and rate of injury by participant experience.

Experience	N	Number of injured participants	Number of injuries	Range	One-year period prevalence	95% CI for prevalence	Injury Rate	95% CI for injury rate
0-6m	7	3	3	0-1	42.9%	3-83%	0.43	0.03-0.82
6-12m	10	4	5	0-2	40.0%	8-72%	0.50	0.06-0.94
1-2y	8	2	4	0-2	25.0%	0-57%	0.50	0.00-1.14
2-4y	23	16	23	0-3	69.6%	50-89%	1.00	0.61-1.39
5-9y	19	13	17	0-3	68.4%	47-90%	0.89	0.53-1.26
10-15y	10	6	8	0-2	60.0%	28-92%	0.80	0.31-1.29
15y+	23	13	36	0-11	56.5%	36-77%	1.57	0.53-2.60

Please note the CI for prevalence was changed for 1-2 years' experience group as it is not possible to have less than 0% prevalence of injury. The event rate is the number of total injuries sustained per group divided by N. This represents the injury rate per participant per year.

A comparison of injury rates by number of years' experience was also conducted. This demonstrated that the group with greater than fifteen years' experience had the highest one-year injury rate at 1.57 injuries per participant (SD=2.54, 95% CI=0.53-2.6). The group with less than six-months experience had the lowest injury rate at 0.43 (SD=0.53, CI 95%=0.03-0.82). One-year period prevalence of injury was greatest in the group with 2-4 years' experience at 69.6%. The prevalence for participants with over 2-years' experience was almost uniform. This was lower and was more variable for those with less than 2 years' experience (between 25-42.9%). Table 3.4 demonstrates the one-year period prevalence and injury rates per group. Comparing these groups using a one-way ANOVA test demonstrates no significant difference between groups (df=6, F=1.18, F-Crit=2.20, P=0.323).

Number of martial arts, training sessions and injury

Participants may train in their martial art with different frequency. In the surveyed population, the range was from 1-5 training sessions per week. Most participants (84%, n=84), trained 1-2 sessions per week. The remainder (16%, n=16) trained between 3-5 sessions per week. The groups were divided into 1, 2 or 3-5 training sessions for comparison.

One-year period prevalence of injury appeared to increase with the number of training sessions. This was 27% in those training once a week (n=10) and 70.2% (n=33) and 87.5% (n=14) in those training twice a week or three to five times a week respectively. This was statistically significant when the groups were compared ($X^2=23.0$, df=99, $P<0.001$).

Injury rate also appeared to increase from 0.32 injuries per participant per year in the once a week training group to 1.06 in the twice a week group to 2.13 in the three or more group. When compared using a one-way ANOVA test, this was highly statistically significant (df=2, F=10.7, F-Crit=3.09, $P<0.001$). A further analysis using Pearson's coefficient of correlation demonstrates a linear relationship between the groups ($R^2=0.989$, $P<0.0001$). This is illustrated in figure 3.7.

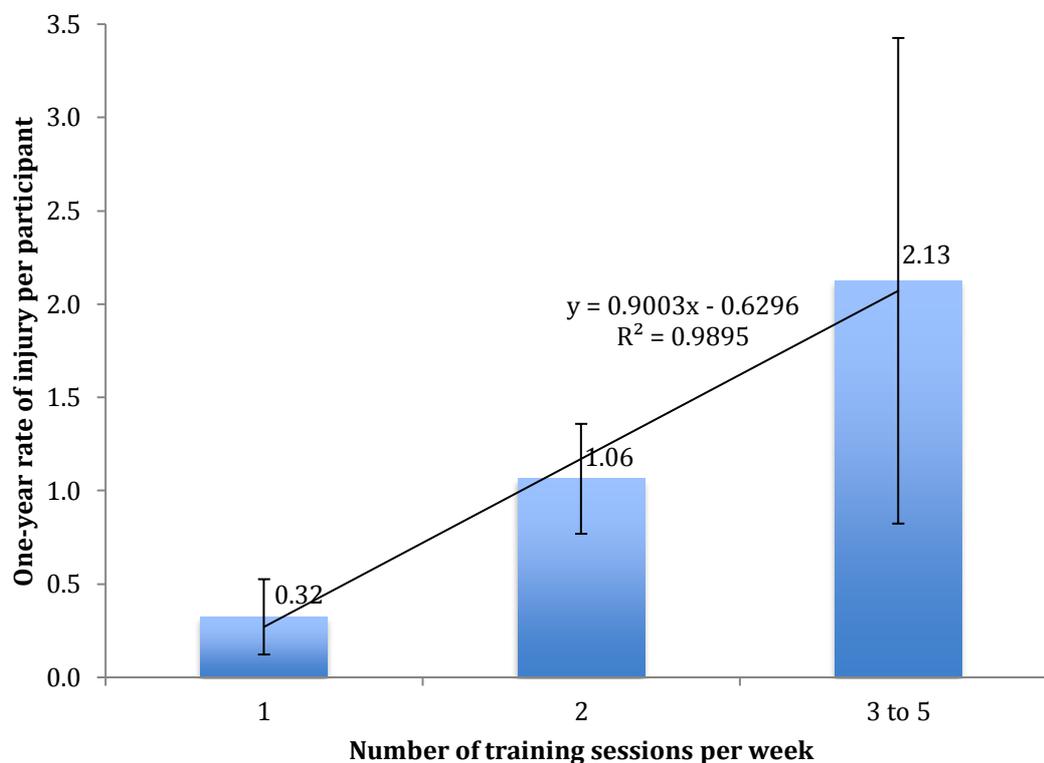


Figure 3.7 - One-year prevalence of injury per participant by the weekly number of training sessions undertaken.

Some participants engage in more than one martial art at the same time. This ranged between 1-3 (including their primary martial art). Most participants (92%, n=92) of the population studied only the martial art described as their primary, but 7% studied two (n=7) and only 1% studied three (n=1). Prevalence of injury in the single martial art group was 58.7% and 37.5% in the group with more than one. Comparing prevalence did not reach statistical significance ($X^2=1.35$, $df=99$, $p=0.250$)

Injury rate was 1.0 injury per participant per year in the single martial art group and 0.5 in the other group. Comparison of these did not reach statistical significance ($t=0.94$, $df=99$, $p=0.349$).

3.3.7 Logistic regression to identify independent risk factors for injury

Binary logistic regression was undertaken to see which independent variables influenced the dependent variable (the presence of injury). It must be stressed that in performing this test, it looked only at whether injury occurred and did not take into consideration the number of injuries e.g. a participant with one or eleven injuries were treated in the same category as 'injured'.

Due to the low numbers of participants in each category, the groups were collapsed to binary groups, though in a way which followed trends in the data. Age was collapsed into two groups: those 30-years-old or over and those under 30-years-old. Years of experience was divided into those with less than two years' experience and those over. The number of martial arts was divided into those studying the primary martial art (Wu Shu Kwan) and those studying more than one. The average number of classes attended per week was also collapsed into one class or more than one per week. Level of participation left as their individual groups e.g. beginner, leisure, amateur and professional/elite.

The data was dichotomous and thus binary and categorical. The reference categories in each group were determined: in the gender category, female was the reference category; in the age group, it was the under 30-years-old group; in the number of martial arts category, it was one martial art; in the average number of classes trained per week, it was one class per week and in participant level it was beginner.

The null hypothesis in each instance was that the subgroup was not associated with being injured. Table 3.5 gives a summary of the results per group.

Table 3.5 - Binary logistic regression of subgroups. This was to test a null hypothesis of no association between the independent variables (subgroup) and the dependent variable 'injury'.

Independent Variables	Odds Ratio	95% CI for Odds Ratio	p-value
Gender	3.99	1.23-12.93	0.021
Age	4.12	1.37-12.41	0.012
Years of Experience	1.20	0.32-4.52	0.788
Number of martial arts practiced	0.47	0.08-2.69	0.394
Average number of classes attended per week	8.99	2.91-27.79	<0.001
Level of participant			
<i>Leisure</i>	0.25	0.02-3.29	0.290
<i>Amateur</i>	0.48	0.05-4.67	0.530
<i>Elite/Professional</i>	0.06	0.00-0.76	0.030

In testing at the 95% confidence level, binary logistic regression demonstrates that years of experience, the number of MA practiced and participant level (leisure and amateur) result in a p-value greater than 0.05 and so the null hypothesis cannot be rejected with these. This means that these independent variables are not associated with the odds of injury.

Gender and age reached significance at the 5% level whereas the number of classes trained per week and professional level participation reached significance at the 1% confidence level. For these the null hypothesis was rejected and it was concluded that being male, over 30 years and participating in more than one class per week is associated with a 4x, 4x and 8x increased odds of injury. Elite and professional level participation was associated with reduced odds of injury. Again, it must be reiterated this is testing for an association with receiving an injury and does not consider the number of injuries within each subgroup. The area under the Roc curve was 0.88.

3.3.8 Time off training and health seeking behaviour of martial artists

Following injury, many participants could go back to training immediately, or adjust their training so that they can engage in the activities (n=43). Some required rest and time out of training to allow recovery (n=53). The mean time taken out of training following injuries was 3.92 weeks (SD=11.5, 95% CI=1.66-6.17). This ranged from 0 to 104 weeks. The median for this was 1 week with an IQR of 0-4 weeks. Table 3.6 shows the summary data of time taken off per body region. A one-way ANOVA demonstrated no significance between body region injury and time off training (F=0.26, F-crit=2.70, df=3, P=0.85).

Table 3.6 Weeks off training following injury.

Body Region	n	Mean time off training	Range	Median	IQR
Neck	4	0	0	0	0
Upper limb	18	3.3	0-16	2	1-3.8
Trunk	15	5.4	0-26	1	0-10
Lower limb	59	4.0	0-104	1	0-3

Please note that the unit for time off training is weeks. Range is the number of weeks taken off. n is the number of injuries sustained not the number of participants.

Another of the survey objectives was to define whom, if anyone, martial artists sought help or advice from on incurring an injury. Of the 96 injuries sustained, 56 (58.3%) required the participant to seek help from a variety of sources including: the class instructor (1.8%, n=1), first aider (14.5%, n=8), NHS and private services. Accident and Emergency (A&E) departments and General Practice (GP) were proportionately the most common services used (23.6% and 25.5% respectively). These are essentially gateway services and thus onward referral to secondary services was warranted in some cases. This was to an orthopaedic surgeon or to physiotherapy. From the participants attending A&E, 23.1% (3 of 13 participants) were referred on; 1 was referred to physiotherapy and 2 to orthopaedics. From GP, 35.7% (5 of 14 participants) were referred onwards: 2 to physiotherapy and 3 to

orthopaedics. Table 3.7 shows the proportion of participants seeking aid and who from with onward referral information.

Table 3.7 - Health seeking behaviour and secondary sources of aid/referral of 100 martial artists.

Primary source of advice	N (%) of those seeking help	N (%) receiving onward referral	Referred to
A&E	13 (23.6%)	3 (23.1%)	1 to physiotherapy 2 to orthopaedics
Chiropractor	1 (1.8%)	1 (100%)	1 to GP 1 to A&E
First Aider	8 (14.5%)	3 (37.5%)	1 to walk-in-centre 1 to chiropractor 2 to physiotherapy
GP	14 (25.5%)	5 (37.5%)	3 to orthopaedics
Instructor	1 (1.8%)	0 (0%)	n/a
Internet	2 (3.6%)	0 (0%)	n/a
NHS 111	1 (1.8%)	0 (0%)	n/a
Osteopath	6 (10.9%)	1 (16.7%)	1 to physiotherapy
Pharmacist	1 (1.8%)	0 (0%)	n/a
Physiotherapy	7 (12.7%)	0 (0%)	n/a
Sports Therapist	1 (1.8%)	0 (0%)	n/a
Walk in centre	1 (1.8%)	0 (0%)	n/a

A&E = Accident & Emergency, GP = General Practitioner, n/a = not applicable, NHS = National Health Service.

When contrasting the body region with seeking help or advice, the lower limb was most likely to result in a participant seeking help. More participants with lower limb injuries (62.7%, n=37) sought advice compared with upper limb injuries

(55.6%, n=10) and trunk injuries (53.3%, n=8). No participants with neck injuries sought help.

When upper or lower limb injuries were incurred, the most commonly used primary services used were GP and walk-in-centres. 30% of those with an upper limb injury (n=3) sought help from these and 29.6% of those with a lower limb injury (n=8). In the trunk, A&E was the most commonly used service (37.5%, n=3). Table 3.8 shows the commonly used services by body region injured.

Table 3.8 Services used when different body regions are injured.

Service	Upper limb	Trunk	Lower limb
A&E	2 (20%)	3 (37.5%)	8 (21.6%)
GP or walk-in-centre	3 (30%)	0 (0%)	11 (29.7%)
Instructor/first aider or medic at grading	2 (20%)	1 (12.5%)	6 (16.2%)
Internet/NHS 111	1 (10%)	2 (25%)	4 (10.8%)
Therapies	2 (20%)	2 (25%)	7 (18.9%)
Other	0 (0%)		1 (2.7%)

3.3.9 Time off training and type of injury

When injuries are compared by type, the most common were strains and sprains (61.5% of injuries). When outliers were excluded the average time taken off was greatest for joint dislocations, though the range was greatest for fractures (see table 3.9).

Table 3.9 - Time taken off training by injury type.

Injury	N	Percentage of total injuries	Mean time off training (weeks)	Range of time off training
<i>Dislocation</i>	6	6.3%	7.5	0-12
<i>Fracture</i>	11	11.5%	5.6	0-26
<i>Sprain/Strain</i>	59	61.5%	1.7	0-16
<i>Tear/Rupture</i>	20	20.8%	8.50 (3.5)*	0-104 (0-16)*

**A single participant had 104 weeks off training following an injury the mean and upper limit of range in brackets are those when this participant is treated as an outlier.*

Subsequent expansion of these individual groups of injuries are compared below. The shoulder complex was the most common dislocated joint (comprising one shoulder dislocation and one acromioclavicular joint dislocation) though this had the lowest mean time off training (see table 3.10)

Table 3.10 - A comparison of time off training in relation to dislocation by body region.

Region	Injury	N	Percentage of total injuries	Mean time off training (weeks)	Range of time off training
<i>Upper limb</i>	<i>Shoulder complex</i>	2	33.3%	6.5	1-12
	<i>Finger</i>	1	16.7%	12	N/A
<i>Trunk</i>	<i>Rib</i>	1	16.7%	12	N/A
<i>Lower limb</i>	<i>Patella</i>	1	16.7%	0	N/A

N/A = not applicable

When fractures are compared, rib fractures were most common, though hand fractures resulted in the most time off following injury (see table 3.11).

Table 3.11 - A comparison of time off training in relation to fracture by body region.

Region	Injury	N	Percentage of total injuries	Mean time off training (weeks)	Range of time off training
Upper limb	<i>Hand</i>	3	30%	12.7	4-26
Trunk	<i>Ribs</i>	4	40%	2.8	0-7
Lower limb	<i>Tibia</i>	1	10%	1	N/A
	<i>Toes</i>	2	20%	4	0-8

N/A = not applicable

Sprains and strains represent the most common injuries. Knee and thigh were the most common in this group and represented 27.1% of sprains and strains. Low back strains resulted in the greatest mean time off from training with the greatest range of 0-16 weeks (see table 3.12).

Table 3.12 - Time off training in relation to sprains and strains per body region.

Region	Injury	N	Percentage of total injuries	Mean time off training (weeks)	Range of time off training
Neck	<i>Neck</i>	4	6.8%	1.3	0-2
Upper limb	<i>Shoulder</i>	4	6.8%	0.3	0-1
	<i>Elbow</i>	4	6.8%	0	0
	<i>Wrist/hand</i>	3	5.1%	0	0
Trunk	<i>Low back</i>	8	13.6%	3.8	0-16
	<i>SIJ/Coccyx</i>	2	3.4%	6	0-12
Lower limb	<i>Hip/groin</i>	7	11.9%	2.3	0-5
	<i>Thigh/knee</i>	16	27.1%	1.4	0-6
	<i>Foot/ankle</i>	7	11.9%	1.4	0-3
	<i>Toes</i>	4	6.8%	0.8	0-2

N/A = not applicable; SIJ = Sacroiliac joint

The most frequently injured region in relation to a muscle tear or ligamentous rupture was the hamstrings which represented 40% of these injuries (see table 3.13). Most time off was taken in relation to patella tendon rupture, however, this contained a single participant whom was considered an outlier with 104 weeks off training. When the outlier is eliminated, most time off was taken for calf and ankle musculo-ligamentous injuries which also had the largest range in terms of time off training.

Table 3.13 - Time off training in relation to muscular or ligamentous injury by body region.

Region	Injury	N	Percentage of total injuries	Mean time off training (weeks)	Range of time off training
Upper limb	<i>Shoulder</i>	1	5%	0	N/A
Lower limb	<i>Calf and ankle</i>	4	20%	7.8	0-16
	<i>Hamstring</i>	8	40%	0.5	0-3
	<i>Patella</i>	7	35%	19.1 (5)*	0-104 (0-12)*

N/A = not applicable

**A single participant had 104 weeks off training following an injury the mean and upper limit of range in brackets are those when this participant is treated as an outlier.*

3.4 Summary of main findings

- The one year period prevalence of injury was 57%.
- The one year injury rate was 0.96 injuries per participant.
- The lower limb was the most commonly injured body region (61.5% of all injuries).
- The knee was the most commonly injured area of the lower limb (35.6% of lower limb injuries).
- There was no significant difference in injury rate between class and gradings.
- Sparring was the most common activity for injury to occur (44.8% of all injuries).

- There was a higher prevalence of injury in age groups over 30-years-old.
- Male gender was associated with a higher prevalence of injury.
- A higher rate of injury was demonstrated in those with greater than fifteen years' experience (1.57 injuries per participant per year) compared to those with less than 6 months experience (0.43 injuries) though this did not reach statistical significance.
- There was a positive correlation with the number of training sessions per week and incurring injury.
- Binary logistic regression demonstrated age, gender and the number of training sessions per week to be independent variables associated with increased odds of injury.
- Elite and professional level participation resulted in lower odds of injury.
- The athletes sought help for 58.3% of their injuries. GP and A&E are the most commonly used resources for martial artists seeking help or advice following injury.
- Sprains and strains were the most common injury type, though dislocations result in the greatest amount of time off training post injury.

These findings are discussed in detail in chapter 4.

Chapter 4 - DISCUSSION

4.1 INTRODUCTION

This chapter discusses the findings of the survey with reference to the systematic review findings and other literature. To this end, there is a short summary of the systematic review as well as a summary and discussion of the findings of the survey. After this there is discussion of the strength and limitations of the survey and then of the important implications of both studies for clinicians, the sport, athletes and for research.

4.2 SUMMARY OF MAIN FINDINGS

The main findings of the systematic review and the survey are summarised below.

4.2.1 Systematic review (Chapter 2)

The main findings of the systematic review demonstrated that orthopaedic injuries represent over a quarter of injuries sustained. The lower limb was the most commonly injured body region. Prevalence and incidence could not be estimated, but the injury rate in 13 studies was between 0.003 and 79.8 injuries per 1000 athlete exposures. However, there were too much heterogeneity in types of martial arts, setting, contact level and participant level to estimate an overall rate. There was suggestion of variation across martial arts with a higher rate in Wu Shu compared to the others and that full-contact sparring and professional level competition result in higher numbers of injury.

4.2.2 Survey (Chapter 3)

The lack of prevalence studies of all types of settings and athlete level was thought to be important because this type of data gives better information to guide comprehensive management and prevention across the sport, rather than just at competition. However, it was felt that because of the heterogeneity introduced through pooling of multiple martial arts, it was better to study a single martial art. Therefore, a survey to estimate the injury prevalence in one martial art was conducted. In this survey, one-year period prevalence of orthopaedic injuries in Chinese Kickboxing was 57%, with a frequency of 0.96 injuries per participant per

year. The lower limb was the most commonly injured body region (61.5% of injuries) with the knee being most frequently involved joint (35.6% of lower limb injuries). Most injuries occurred in a class setting and during sparring. Over half of those injured sought advice, most of these seeking help from A&E and GP services. Onward referral to orthopaedic services from these was 23.1% and 35.7% respectively.

4.3 The main findings of the cross-sectional study in context of the literature

4.3.1 Population

As with previous studies, most of the population was male (69%) which was also the case for the population of the systematic review (70.7%). The mean age in the systematic review was 26.8 years. This was similar to studies in the systematic review.

The studies in the systematic review focused mainly on elite level athletes at international or national competition settings. By contrast, the empirical study looked at the broader population to include athletes of all levels in several settings and at different levels of experience. This varied in the survey from beginner to professional/elite, with most participants training for leisure. This allowed for comparison of these subgroups. Years of experience of the participants in the empirical study was of 8.4 years on average. Weir & Carline (1997) had a mean length of training of 4 years (range 1-15 years), however the other studies did not stipulate the years of experience of athletes, but defined them as elite. Comparison by settings and years of experience was not previously reported. This again allowed for analyses of these as risk factors for injury.

4.3.2 Injuries

The one-year period prevalence of orthopaedic injuries was 57% with an injury rate of 0.96 injuries per participant per year.

Injuries and body region

The most commonly injured region was the lower limb. This agrees with the systematic reviews findings and other studies: Gartland et al (2001) and Pieter et al (2012). Other studies also confirm that the lower limb is the most commonly injured body region in Karate and Taekwondo (Birrer et al 1981; Feehan & Waller 1995; Weir & Carline 1997; Zemper & Pieter 1989).

The legs are used in offensive and defensive techniques during sparring. They are also relatively unprotected during training and competition (Destbombe et al 2006). Most martial arts will train barefooted. In Taekwondo, Serina & Lieu (1991) demonstrated up to 80% of techniques used in competition are kicks. In Chinese kickboxing, foot protection is optional, most will wear foam shin and instep protection pads or foam shoe which covers the dorsum of the foot, but only has strapping under the foot.

Kicks have very high injury potential (Feehan & Waller 1995; Serina & Lieu 1991; Zemper & Pieter 1989). In Karate, a typical kick can deliver 675lbs per square inch of force (McLatchie, 1981; Wier & Carline 1997). This is a significant amount of energy transfer to the opponent, but also to the limb delivering the kick. If this connects with a bony prominence delivered through the wrong part of the foot (i.e. the toes), this may increase the risk of injury. The feet are often given little protection (Gartland et al 2005) and foot padding has been shown to have no effect on acceleration and resultant force of kicking (Swartz et al 1986; Wier & Carline 1997). Thus, it may be surmised that the risk of injury may be the same with or without foot padding. The combination of the lack of adequate foot protection and kicking force may help to explain the proportionately higher injury seen in the lower limb. Other studies have reported injuries via karate players' toes being caught in mats whilst participating (Hillman et al 1993; Wier & Carline 1997).

The knee was the most frequently injured within the empirical study, representing 36% of all lower limb injuries. This may be due to the torsional force demands on the knee. Further, kicking without proper technique (i.e. rotation on the supporting leg) may further subject the knee to torsional strain and result in

injury. Previous studies have commented on the risk of injury associated with poor technique (Critchley et al 1999; Johannsen & Noerregaard 1988). Thus it may be that as experience increases and correct techniques are acquired, certain types of injury may be seen less. This would be an interesting area for future research.

Orthopaedic injuries by setting

Whereas the systematic review results were based on a single setting of competition (either at national or international level), the survey participants sustained injuries in a range of settings: class, grading and demonstrations. No participants incurred injury at competition.

The most common setting for injury was in class during training. Injured participants in the class setting sustained a mean of 1.7 injuries each per year. Previous studies also report that most injuries occur in a class setting (Destombe et al 2006; Kujala et al 1995). Weir & Carline (1997) also report that most injuries occur in a class or training setting. This is logical as the majority if not all of the time spent by participants, is in training. Kujala et al (1995) reported a training/competition injury ratio of 77%:23%. This is similar to that of this survey which identified an injury ratio of 86%:18% training to grading (the remaining 4% were due to missing data or demonstration setting). A potential shortcoming of the literature was that most studies focus on the competition setting. Given that increased exposure may result in injury and that most exposure is during training which occurs mostly in a class setting, it is important that further research looks at this to gain a full picture of orthopaedic injuries in contact striking martial arts.

Orthopaedic injury by activity

Most of the orthopaedic injuries (44.8%) were sustained during free-sparring in the class setting. Other studies have previously demonstrated this when all injuries are considered (Destombe et al 2006; Kujala et al 1995). Jaffe & Minkoff (1988) reported that tournament sparring is responsible for most injuries in martial arts. This may be associated with the usual risks whilst training, such as overstretching a limb, or twisting injuries to ankles and knees, with the added insult of trauma whilst sparring. These collectively may help explain why there is a higher risk of

injury during sparring. It was beyond the scope of this study to identify how injuries are sustained during sparring.

Other factors

In comparing period prevalence by age, this reached statistical significance. There was an increased one-year period prevalence of injury in the age group 50-60, though the increase is evident from the 30+ age groups. When age was compared using binary logistic regression, age over 30 years was associated with a four-fold increase in odds of injury.

Age could not be correlated with experience as beginners may start at any age. Increasing age may lead to increasing injury secondary to previous injuries or those that may have not been managed correctly which may make an athlete more prone to re-injuring those parts. In other sports such as elite level football, previous injury has been shown to increase the risk of re-injury (Hägglund et al 2006). This may also be true of martial arts. Degenerative changes may also play a role.

When gender was compared, the male group had a statistically significant higher prevalence of injury and on regression analysis they were four times more likely to incur injury than the female group. Prevalence of orthopaedic injury was not previously reported comparing gender in contact striking martial arts. Literature on whether gender is a risk factor for injury was contentious. Some studies have reported no difference in injury rates between male and female participants (Lystad et al 2009; Zetaruk et al 2005). Other studies disagree and report male participants were more prone to injury than female participants (Kazemi & Pieter 2004; Zemper & Pieter 1989). It is difficult to comment as to why this is the case. The increased uptake of martial arts by females and rules and regulations being updated in different martial arts to reflect equal participation, may help to explain why this may be a changing trend from the older studies to the newer. A definitive explanation cannot be made at this stage and further study is required.

As aforementioned, years of experience could not be correlated to level. This thesis demonstrated that the amateur group had the highest one-year prevalence of injury, though this was not statistically significant. In comparing level, regression analysis demonstrated that there was no difference between beginner, leisure and amateur levels, however elite and professional level participation resulted in a statistically significant reduction in odds of injury. The group with the greatest years of experience demonstrated the highest one-year injury rate, though this again was not statistically significant. Regression analysis demonstrated no difference when less than two years' experience was compared to greater experience.

Previous studies have demonstrated experienced Karate players are more prone to injury (Mbubaegbu & Perry 1994; Wier & Carline 1997). This is a contentious finding as other studies disagree and conclude that those with less experience are at greater risk of injury (Birrer 1996; Gartland et al 2001; Wilkerson 1997). The reasons for these differing may be multifactorial. However, Destombe et al (2006) suggested a potential factor is that experienced martial artists may be faster, be more confident and therefore develop a more aggressive fighting style. Other factors may include the style of martial art (Zetaruk et al 2005) and exposure to sparring. Some martial arts restrict the level of contact sparring for lower level participants.

With respect to the number of training sessions attended per week by participants, there was a statistically significant positive correlation between increasing the number of training sessions per week and the risk of injury. This is consistent with the findings of Destombe et al (2006). The more time spent training per week, increases exposure and risk of injury. The number of martial arts practiced did not however, impact the risk of injury.

4.3.3 Time off training and type of injury

Types of injury were divided into four groups: sprains and strains, fractures, dislocations and muscular tears and ligamentous ruptures. The most common injuries were sprains and strains, representing over 60% of injuries, followed by

tears and ruptures (21%). This may be a result of the nature of martial arts training through torsional forces and over stretching of muscles and ligaments. Sprains and strains around the knee were the most common injuries, similarly, tears of the hamstring were also common.

Dislocations and fractures resulted in the most time off following injury. Shoulder complex dislocations were the most common whereas the ribs were the most common fracture. Fractures and dislocations may warrant more time off following injury due to their nature and may limit function and prevent training until recovery.

The research student could not find studies reporting on time off training by orthopaedic injury type. Gartland et al (2001) previously reported on level and time off following injury with more beginners requiring time off compared to amateurs and professionals. This did however consider all injuries as opposed to orthopaedic injuries.

4.3.4 Health seeking behaviour of martial artists

Previous studies have demonstrated that the most commonly used service following exercise related morbidity in the United Kingdom was the general practitioner (GP) (Nicholl et al 1995). Over 25% of those with injuries will seek out help. In the empirical study, the number of athletes seeking assistance was higher with over half of those injured seeking advice/help. Most of these presented to their GP or to A&E department which was similar to what has previously been reported (Nicholl et al 1995). Studies have previously reported that, of all sports related injuries presenting to hospital, martial arts accounted for 11.4% (Velin et al 1994). Of the injured participants seeking help, 35.7% required referral onto musculoskeletal services (either an orthopaedic surgeon or physiotherapy).

The higher proportion of martial arts athletes seeking help compared to other sports or exercise related injuries may be due to the nature of the injuries sustained. Studies have previously reported 15% of martial arts injuries to be fractures (Halbrook 1998). This may be related to the fact that Nicholl et al (1995)

reported on all injuries no matter how minor and that in the empirical study reports only on orthopaedic injuries.

Furthermore, injuries may go unreported. Birrer & Birrer (1983) estimated that up to 60% of injuries are unreported. Crosby (1985) demonstrated previously undiagnosed fractures of the hands and wrists of Karate participants. In this thesis, 41.7% of injuries were not previously reported and the participants dealt with these on their own. Injuries may not be reported for many reasons, such as fear of reprisal if they were sustained outside the rules of that martial art or being withdrawn from grading or competition. For this reason, the research student ensured that the survey was confidential in the hope of capturing as much of the data as possible. Most participants returned to training immediately. The mean amount of time off training was 3.92 weeks though time off up to 104 weeks was reported. There was no relationship between body region injury and time off training. The decision to take time off training may be down to several factors apart from the severity of the injury. Reasons have been suggested for this and under-reporting of injuries which include: ignoring minor injuries, denial of vulnerability, fear of instructors' perception of injury and raised pain threshold (Birrer & Birrer 1983; Gartland et al 2005).

4.4 Strengths and Limitations of the survey

One of the strengths of this study was that a clear definition of injury was given to participants. It reflects only relevant orthopaedic injuries which can be used to inform the services employed by these martial arts athletes. Previous studies have provided a limited definition of injury or none. Either it was limited to so called time-loss injuries where an injury was only included if the participant took time off training, or if a participant at a competition sought help from the medical team. In this sense, injuries may have been missed if participants sought help outside the competition, or as this study has demonstrated, most participants will return to training immediately, though may modify their training. This study addressed this by anonymous collection of data on all injuries. The use of an anonymous data collection should have allowed participants to include all injuries without concern that what they consider an injury somehow makes them weak in the eyes of their

peers. Further, by including all injuries (within the definition provided) this gave a clearer picture of the injuries incurred.

The retrospective data collection makes this study prone to recall bias (Hassan 2005). However, the research student attempted to minimise this by using only a twelve-month recollection period. The anonymous data collection should help minimise underreporting of injuries, however, it is possible that participants may still not report all injuries despite the definition. The research student was present at all data collection events should anyone have wished to ask any questions or required clarification.

Although the minimum number of participants was reached according to the power calculation for this thesis, 100 participants is still a small number compared to previous studies, though those were prospective at elite level competitions. This limited the analysis of subgroups as further subdivision meant smaller numbers and would have limited the precision of the estimates and therefore validity. This is evidenced by the wide confidence intervals as demonstrated particularly in the regression analysis. This study had an excellent response rate of 63.7% in comparison to previous studies such as Birrer & Halbrook (1988) who had a response rate of 33%.

Whilst attempting to simplify the questionnaire, age range tick boxes were used for age and years of experience. This was requested when piloting the questionnaire to help improve the anonymity of the participants. This in retrospect limits the accuracy of the data for these groups not allowing an estimate of the mean and range to be calculated. The research student would not recommend this in future work. Further, the research student did not ask about whether multiple injuries occurred simultaneously, which may impact on time off training. This should also be considered in future research.

The mean rate of injury per participant, but not the prevalence rate, is to some degree skewed by the high proportion of injuries for a single participant. The data was compared to see if treating this single participant as an outlier made a difference to analysis, which they did for age group comparison. They had no

impact on prevalence analyses. This was the main aim of the survey. This is because the data for injury was converted to dichotomous data when calculating prevalence, i.e. participants were either injured or not. The total number of injuries did not affect this.

The heterogeneity of the population in terms of age, gender, grade and years of experience in this study is likely to be representative of populations within other martial arts. That selected is a contact striking martial art and the class structure and sparring is likely to be similar to others. In this respect the research student believes the results of this thesis would be a good representation of other similar styles. Thus, the results may be useful in comparing similar styles in future studies of injuries in contact striking martial arts.

Due to the heterogeneity of the studies in the systematic review, a meta-analysis was not undertaken. Three studies in Karate demonstrated some homogeneity, however a meta-analysis of these three studies would have limited value in answering the original objectives.

4.5 What this study adds

This study has identified a one-year period prevalence of orthopaedic injury in a single contact striking martial arts as 57%. The research student believes this is the first study to define this and could not find any evidence in the literature reporting this.

This study has helped to support that the lower limb is the most commonly injured limb and the knee is the most injured region. It also supports that sparring is the most common activity that results in injury. Further it has identified that several factors increase the risk of injury: age, male gender and the number of training sessions attended per week.

This study helped to identify the health seeking behaviour of injured martial arts participants in the number that seek advice and the sources utilised and their onward referral to specialist services. This is helpful for the health professionals whom might encounter these athletes.

4.5.1 Implications for athletes and the sport

Given the high prevalence of injuries in martial arts, these athletes should be aware of the injuries that they may be prone to and what increases their odds of injury. The lower limb is the most commonly injured body region. The use of protective equipment may help to reduce the prevalence of injury (Birrer 1996; Khurland 1980; McLatchie 1976). Further, previous findings demonstrated that poor or incorrect technique may lead to injury. The knee was the most commonly injured region in the lower limb, which undergoes torsional strain during kicking as the supporting limb. It is important for instructors to demonstrate and teach correct technique and for participants to understand the importance of this not only for generation of power, but the for injury prevention.

It was previously shown, and the empirical study concurs, that sparring is the most common activity that results in injury (Other studies have previously demonstrated this when all injuries are considered (Destombe et al 2006; Jaffe & Minkoff 1988; Kujala et al 1995). Participants and instructors should be aware of this which may make them more vigilant during sparring. Further the more classes attended per week correlated with increased risk of injury. Increasing the number of classes attended per week would increase exposure to sparring and thus may result in an increase in risk of injury. This does not necessarily mean that participants should reduce the number of training sessions to reduce injury. However, they may wish to consider modification of what activities they engage in, if attending more than one session per week. For example, if a participant attends more than one session per week, they may wish to restrict sparring to one session. Further research is required to identify if a reduction in training would reduce injury rates and potential long term implications of re-injuries.

Getting appropriate help early or correct advice may help prevent future injuries. As demonstrated, in other sports, injuries are correlated with increased risk of re-injury. If martial arts athletes are injured, it may increase their risk of further injury. Furthermore, if injuries are poorly managed or neglected they may lead to degenerative changes or increase potential for re-injury. For this reason, it is

important that athletes are encouraged to seek advice for the management of injuries for future prevention.

The recommendations from this thesis would be that all instructors acquire a knowledge of basic first aid and that they may help prevent injuries by guiding students to seek early help to prevent further injury or sequelae of neglected injuries. Further implications would be that all classes/settings should be stocked with at least a basic first aid kit to manage wounds, though at gradings and competitions, stock should include basic splints and dressings to manage fractures whether open or closed. Further, martial artists should be made aware of the importance of seeking advice for injuries and the implications of over training. This is also important for coaches when athletes are training for competition to understand. If they are aware of the injuries the athletes may sustain, they may formulate strategies and training to help avoid them.

4.5.2 Implication for clinicians

A large proportion of martial arts athletes sought help when injured. GP's and A&E are most likely to encounter these athletes, with over a third being referred to orthopaedic services. It is important that these clinicians understand the more prevalent injuries and identify the mechanisms to aid diagnosis. Many athletes are keen to return to sport as soon as possible and hence it is important for the clinicians seeing these to iterate the importance of managing their injury correctly.

Understanding the more prevalent injuries and who is most at risk may help the ringside physician to identify the stock they require at gradings and competitions. Given that up to 15% of all injuries are fractures, it is important that clinicians identify these and that they are referred to the appropriate service. Stock should include simple splints for fractures, simple slings as well as the standard first aid kits.

Further, understanding the common injuries and motivation of these athletes would be useful for allied health professionals that would be involved in their

rehabilitation such as physiotherapist and sports therapists. It would help them to also manage the expectations of the athlete as well as advise on return to sport.

4.5.3 Implications for research

From the systematic review and empirical study there are several implications for research. Firstly, a clear definition of injury is important when undertaking studies. A lack of definition may result in under reporting of injuries. Similarly, if injuries are only selected based on presentation of participants to medical teams, many may be missed. Some studies gave no definition and so left this open to interpretation. Studies should identify clearly their definitions. Further, description of participant level should be given in detail as this can be quite a heterogeneous population. As aforementioned a 'professional' may have any number of years' experience and hence it may be better to report that as oppose to the level. This would allow future research to compare participants more readily across studies.

Limited conclusions could be drawn on the types of injury in relation to time off training due to small numbers. This would be interesting for future work to undertake whether certain types of injuries result in more time off training and who help is sought from according to type of injury.

The contentious subject of whether gender is a risk factor requires further clarification. Previous studies have shown the male gender to increase the risk, where others disagree. In the empirical study, the prevalence of injury was higher in males. Increased uptake of martial arts by females may see a rise in injuries and equalisation between genders. Higher powered studies may help to clarify this further.

The systematic review compared national and international competition for injury rate whereas the empirical study identified prevalence rates in a class, grading and demonstration setting. Further study to compare all of these settings using prevalence and injury rates would help to compare which if any, are independent risk factors for injury. Further analysis may help to identify whether activity is the

pertinent factor in risk of injury rather than the actual setting. As previous studies reported and the empirical study concurs, sparring results in most injuries. This may be the influencing factor in settings, as some, such as competition are based around sparring.

Reporting of martial art injury studies should be standardised. Describing the demographics, martial art style and injuries in a standardised manner may allow future studies to undertake meta-analyses. This in turn would allow a more comprehensive analysis of all injuries in martial arts and allow a comparison of martial arts styles. Comparison of whether different styles result in different patterns of injury would be interesting to see if injury prevention techniques could be applicable across martial arts.

4.6 Conclusion

The high one-year period prevalence of orthopaedic injuries in contact striking martial arts and the high rate of presentation of these athletes to healthcare services and subsequent referral to orthopaedics makes them important sports injuries.

The health seeking behaviour of martial arts athletes is poorly understood, though within the limitations of this study, it has been shown that many will seek advice from healthcare services and be referred on to orthopaedic services.

Further study is needed to see if appropriate advice and support is available within organisation, if this could reduce the number of these athletes requiring these services, but also encourage those injuries that may have been missed to be managed appropriately.

Furthermore, it highlighted the limitations in the data presentation and reporting within the available literature warrant development of guidance and recommendations on publishing studies on martial arts. This would help future systematic review and meta-analyses to generate meaningful results.

References

Armed Forces Health Surveillance Center (AFHSC). (2014) Injuries associated with combat sports, active component, U.S. Armed Forces, 2010-2013. *Medical Surveillance Monthly Report*. May 21(5): 16-18.

Arriaza R, Leyes M. (2005) Injury profile in competitive karate: prospective analysis of three consecutive World Karate Championships. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal Of The ESSKA*, 13(7): 603-607.

Arriaza R, Leyes M, Zaeiemkohan H, Arriaza A. (2009) The injury profile of Karate World Championships: new rules, less injuries. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal Of The ESSKA*, 17(12): 1437-1442.

Bastidas N, Levine JP, Stile FL. (2012) The "sweet science" of reducing periorbital lacerations in mixed martial arts. *Annals of Plastic Surgery*. Jan 68(1): 43-5.

Bledsoe GH, Hsu EB, Grabowski JG, Brill JD, Li G. (2006) Incidence of injury in professional mixed martial arts competitions. *Journal of Sports Science and Medicine*, Jul 5(CSSI): 136-42.

Beis K, Tsaklis P, Pieter W, Abatzides G. (2001) Taekwondo competition injuries in Greek young and adult athletes. *European Journal of Sports Traumatology & Related Research*, 23(3): 130-136.

Birrer RB. (1996) Trauma epidemiology in the martial arts. The results of an eighteen-year international survey. *The American Journal of Sports Medicine*, 24(6): S72-S79.

Birrer RB, Birrer CD. (1983) Unreported injuries in the martial arts. *British Journal of Sports Medicine*, 17: 131-134.

Birrer RB, Birrer C, Son DS, Stone D. (1981) Injuries in tae kwon do. *Physician Sports Medicine*, 9: 97-103.

Birrer RB, Halbrook SP. (1988) Martial arts injuries: the results of a five year national survey. *The American Journal of Sports Medicine*, 16(4), pp408-10.

Blijd C, Blijd E, Pieter W. (1995). Wushu injuries: a pilot study. *Biology of Sport*, 12(3): 161-166.

Boostani MH, Boostani MA, Nowzari V. (2012) Type, incidence and causes of injuries in elective karate national team competition for dispatch to Asian karate championship in Uzbekistan 2012. *Journal of Combat Sports & Martial Arts*, 3(2): 43-45.

Burke DT, Barfoot K, Bryat S, Schneider JC, Kim HJ, Levin G. (2003) Effect of implementation of safety measures in tae kwon do competition. *British journal of sports medicine*, 37(5): 401-404.

Burks JB, Satterfield K. (1998) Foot and ankle injuries among martial artists: results of a survey. *Journal of the American Podiatric Medical Association*, 88(6): 268-278.

Buse GJ, Wood RM. (2006) Safety profile of amateur kickboxing among military and civilian competitors. *Military Medicine*, 171(5): 443-47.

Cashdan, E. (1998). Are men more competitive than women? *The British Journal of Social Psychology*, 37(2): 213-229.

Critchley GR, Mannion S, Meredith C. (1999) Injury rates in Shotokan karate. *British Journal of Sports Medicine*, 33: 174-177.

Crosby AC. (1985) The hands of karate experts. *British Journal of Sports Medicine*, 19: 41-42.

Destombe C, Lejeune L, Guillodo Y et al. (2006) Incidence and nature of karate injuries. *Joint Bone Spine*, 73: 182-188.

Elsawy GV. (2011) Assess the Incidence Rate and Severity of Injuries in 4th Alexandria's International Open Taekwondo Championships. *Ovidius University Annals, Series Physical Education & Sport/Science, Movement & Health*, 11(2): 190-195.

Feehan M, Waller AE. (1995) Precompetition injury and subsequent tournament performance in full-contact taekwondo. *British journal of sports medicine*, 29(4): 258-262.

Gartland S, Malik MHA, Lovell ME. (2001) Injury and injury rates in Muay Thai boxing. *British Journal of Sports Medicine*. 35: 308-313.

Gartland S, Malik MHA, Lovell ME. (2005) A prospective study of injuries sustained during competitive Muay Thai kickboxing. *Clinical Journal of Sports Medicine*, 15(1): 34-36.

Hägglund M, Waldén M, Ekstrand J. (2006) Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *British Journal of Sports Med*, 40(9): 767-772.

Halabachi F, Ziaee V, Lotfian S. (2007) Injury profile in women Shotokan Karate championships in Iran (2004-2005). *Journal of Sports Science and Medicine*, 6(CSSI-2): 52-57.

Hassan E. (2005) Recall Bias can be a Threat to Retrospective and Prospective Research Designs. *Internet Journal of Epidemiology*, 3(2): 1-7.

Hillman S, Dicker G, Sali A. (1993) Non contact karate injuries. *Australian Journal of Science and Medicine*, 25: 73-75.

Hoy D, Brooks P, Woolf A et al. (2012) Assessing risk of bias in prevalence studies: modification of an existing tool and evidence of interrater agreement. *Journal of Clinical Epidemiology*. 65(9): 934-939.

Hutchison MG, Lawrence DW, Cusimano MD, Schweizer TA. (2014) Head Trauma in Mixed Martial Arts. *American Journal of Sports Medicine*. 42(6): 1352-1358.

Itagaki MW, Knight NB. (2004) Kidney trauma in martial arts: a case report of kidney contusion in jujitsu. *American Journal of Sports Medicine*. Mar 32(2): 522-524.

Jaffe L, Minkoff J. (1988) Martial arts: a perspective on their evolution, injuries, and training formats. *Orthopedic Review*, 17: 208-21.

Johannsen HV, Noerregaard FO. (1988) Prevention of injury in karate. *British Journal of Sports Medicine*, 22: 113-15.

Kazemi M, Pieter W. (2004) Injuries at the Canadian National Tae Kwon Do Championships: a prospective study. *BMC Musculoskeletal Disorders*, 5: 22-22.

Khurland HL (1980). Injuries in Karate. *Physician Sports medicine*, 8(10): 80-85.

Kujala UM, Taimela S, Antti-Poika I, Orava S, Tuominen R, Myllynen P. (1995) Acute injuries in soccer, ice hockey, volleyball, basketball, judo, and karate: analysis of national registry data. *British Medical Journal*, 311(7018): 1465-1468.

Leung DP, Chan CK, Tsang HW, Tsang WW, Jones AY. (2011) Tai chi as an intervention to improve balance and reduce falls in older adults: A systematic and meta-analytical review. *Alternative Therapy Health and Medicine*. Jan-Feb 17(1): 40-8.

Li F, Harmer P. (2015) Economic evaluation of a Tai Ji Quan intervention to reduce falls in people with Parkinson Disease, Oregon, 2008-2011. *Preventing Chronic Disease*, 30(12): E120.

Lystad RP, Pollard H, Graham PL. (2009) Epidemiology of injuries in competition taekwondo: A meta-analysis of observational studies. *Journal of Science and Medicine in Sport*, 12: 614–621.

Mbubaegbu CE, Perry AJ. (1994) Femoral osteochondral fracture – a non-contact injury in martial arts? A case report. *British Journal of Sports Medicine*, 28(3): 203-205.

McLatchie GR. (1976). Analysis of karate injuries sustained in 295 contests. *Injury*, 8(2): 132-134.

McLatchie GR, Morris EW. (1977) Prevention of karate injuries—a progress report. *British Journal of Sports Medicine*, 11: 78–82.

McLatchie G. (1981) Karate and karate injuries. *British Journal of Sports Medicine*, 15: 84-86.

Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 6(6): e1000097.

Nicholl JP, Coleman P, Williams BT. (1995) The epidemiology of sports and exercise related injury in the United Kingdom. *British Journal of Sports Medicine*, 29(4): 232-238.

OCEBM Levels of Evidence Working Group*. "The Oxford 2011 Levels of Evidence". Oxford Centre for Evidence-Based Medicine. www.cebm.net/index.aspx?o=5653

Oler M, Tomson W, Pepe H, Yoon D, Branoff R, Branch J. (1991) Morbidity and mortality in the martial arts: a warning. *Journal of Trauma*, 31: 251-253.

Pacei F, Valvassori L, Bet L. (2014) Vertebral artery dissection during Kung-Fu training. *Neurological Sciences*. Feb 35(2): 331-2.

Pappas E. (2007) Boxing, Wrestling, and Martial Arts Related Injuries Treated in Emergency Departments in the United States, 2002-2005. *Journal of Sports Science & Medicine*; 6(CSSI-2): 58-61.

Pieter W, Bercades LT, Heijmans J. (1998) Competition injuries in Olympic taekwondo. *Kinesiology*, 30(1): 22-30.

Pieter W, Fife GP, O'Sullivan DM. (2012) Competition injuries in taekwondo: a literature review and suggestions for prevention and surveillance. *British journal of sports medicine*, 46(7): 485-491.

Porr J, Laframboise M, Kazemi M. (2012) Traumatic hyoid bone fracture - a case report and review of the literature. *Journal of the Canadian Chiropractic Association*. Dec 56(4): 269-74.

Serina ER, Lieu DK. (1991) Thoracic injury potential of basic competition taekwondo kicks. *Journal of Biomechanics*, 24: 951-960.

Schmid L, Hájek E, Votipka F, et al. (1969) Experience with head- gear in boxing. *Journal of Sports Medicine and Physical Fitness*, 8: 171-176.

Schwartz M, Hudson A, Fernie G, et al. (1986) Biomechanical study of full-contact karate contrasted with boxing. *Journal of Neurosurgery*, 64: 248-252.

Scoggin JF, Brusovanik G, PI M, et al. (2010). Assessment of injuries sustained in mixed martial arts competition. *American journal of orthopedics*, 39(5): 247-251.

Shimoyama T, Masuda I, Numa T, Horie N. (2009) Mandibular fracture with a mouth formed mouthguard in kickboxing. *Dental Traumatology*, 25(2): 242-244.

Suzuki R, Osaki M, Endo K, Amano T, Minematsu K, Toyoda K. (2012) Common carotid artery dissection caused by a frontal thrust in Kendo (Japanese swordsmanship). *Circulation*, 125(17): e617-9.

Tabben M, Coquart J, Chaabène J, Franchini E, Ghoul N, Tourny C. (2015) Time-motion, tactical and technical analysis in top-level karatekas according to gender, match outcome and weight categories *Journal of Sports Sciences*, 33(8): 841–849.

Velin P, Four R, Matta T, Dupont D. (1994) Evaluation of sports injuries, 1982-1988. *Archives of Paediatrics*, 1: 202-207.

Weir EC, Carline TE. (1997) Lower limb injuries in karate - an incidence survey. *Journal of British Podiatric Medicine*, 52(1), 6-8.

Wilkerson LA. (1997) Martial arts injuries. *Journal of the American Osteopathic Association*, 97: 221–6.

Yiemsiri P, Wanawan A. (2014). Prevalence of injuries in Wushu competition during the 1st Asian Martial Arts Games 2009. *Journal of the Medical Association of Thailand*, 97(Suppl 2): S9-S13.

Zazryn TR, Finch CF, McRory P. (2003) A 16 year study of injuries to professional kickboxers in the state of Victoria, Australia. *British Journal of Sports Medicine*, 37: 448-451.

Zemper ED, Pieter ED. (1989) Injury rates during the 1988 US Olympic Team Trials for taekwondo. *British journal of sports medicine*, 23(3): 161-164.

Zetaruk MN, Violán ML, Zurakowski D, Micheli LJ. (2005) Injuries in martial arts: a comparison of five styles. *British Journal of Sports Medicine*. 39: 29-33.

Ziaee V, Rahmani S, Rostami M. (2010) Injury Rates in Iranian Taekwondo Athletes; a Prospective Study. *Asian Journal of Sports Medicine*, 1(1): 23-28.

APPENDIX 1

SYSTEMATIC REVIEW PROTOCOL

Methodological Rationale

There are two phases to this work. This systematic review is the first part, followed by a survey. The aim of Phase one is to identify the prevalence and incidence reported of orthopaedic martial arts injuries. These will be stratified per martial art, the level and setting in which the injury was sustained (i.e. novice or expert level; sustained at competition, grading or during training).

The results of this review will also aim to identify prevalence and incidence of orthopaedic martial arts injuries if possible. It will support the development of a survey that should more clearly identify the prevalence of orthopaedic martial arts injuries across settings. This constitutes the second phase of the research.

Study Objectives

1. Identify the reported prevalence of these injuries.
2. Identify the reported incidence of these injuries.
3. Identify the common orthopaedic injuries in contact martial arts reported in academic literature.

Study methods

Selection Criteria

Principal study measures

- Incidence of orthopaedic injuries in contact martial arts.
- Prevalence of orthopaedic injuries in contact martial arts.
- Reported orthopaedic injuries in contact martial arts.
- Level of participation at which injury was sustained.
- Setting where the injury was sustained i.e. class, grading or competition.

Population/Participants

- Athletes aged 16+ engaged in contact martial arts where the overriding sparring theme is striking such as kickboxing, taekwondo, kung fu and karate.

Injuries of interest

- Orthopaedic injuries sustained in the practice of contact martial arts excluding head and maxillofacial injuries.

Settings

- Injuries sustained in martial arts class, grading or competition during training or sparring.

Outcomes

- Types of injury sustained during sparring in contact martial arts reported in the literature.
- Prevalence of orthopaedic martial arts injuries in contact martial arts by type of injury and overall.
- Incidence of orthopaedic martial arts injuries in contact martial arts by type of injury and overall.

Types of studies

- Objective 1
 - All studies including case series and case studies that identify orthopaedic injuries in contact martial arts.
- Objective 2
 - Surveys giving prevalence will also be included.
 - Studies where prevalence may be calculated from their results.
- Objectives 3
 - Longitudinal and cohort studies pertaining to incidence of orthopaedic injuries sustained in martial arts.
 - Randomised controlled trials, though unlikely to be encountered in this study setting, will only include the control arm of the study to give incidence.
 - Studies where incidence may be calculated from their results.
- Exclusions
 - Reports of meetings

- Abstracts
- PhD theses
- Grey literature
- Periodicals
- eBooks

Search Strategy

The search will be conducted with no restriction on date of publication. Selection will be restricted to peer reviewed publications in the English language only. Studies related to non-contact martial arts, abstracts of meetings and expert opinion articles will be excluded. The example given below is for a Medline search strategy.

Databases to be searched

- AMED
- Medline
- SportDiscus

MeSH Headings

- Injury
 - Athletic Injury
 - Sports Injury
- Martial Arts
- Musculoskeletal system
- Orthopedic (no MeSH terms returned with 'orthopaedic')

Search terms

Group 1 (Intervention/exposure)	Group 2 (Outcome)	Group 3 (Outcome subtype)	Group 3 (Study)
Martial Art	Injury	Ligament	Prevalence

Martial Arts	Injuries	Ligamentous	Incidence
Martial Artist		Muscular	
Martial Artists	Dislocation	Muscle	Epidemiology
Karate	Subluxation	Musculoskeletal	Epidemiologic
Kickboxing		Musculo-skeletal	Epidemiological
Kung Fu	Fracture	Orthopaedic	
Gong Fu		Orthopedic	
Gung Fu	Trauma	Skeletal	
Taekwondo		Tendon	
Tae Kwon Do		Tendinous	
Tae Kwan Do			

NB: There is no MeSH term for the British spelling of orthopaedic, hence in the search terms it is 'orthopedic'.

Search Terms	
#1	Search martial art*
#2	Search "martial arts"[MeSH]
#3	Search exp "martial arts"[MeSH]
#4	Search karate
#5	Search kickboxing
#6	Search "kung fu" OR "gong fu" OR "gung fu"
#7	Search taekwondo OR "tae kwan do" OR "tae kwon do"
#8	Search #1 OR #2 OR #3
#9	Search #8 OR #4 OR #5 OR #6 OR #7
#10	Search injur*
#11	Search 'Wounds and Injuries' [MeSH] OR exp 'Wounds and Injuries'[MeSH]
#12	Search #10 OR #11
#13	Search dislocat*
#14	Search sublux*
#15	Search fractur*

#16	Search fracture[MeSH]
	MeSH search for fracture brings up several terms. Those selected are: Fractures, Stress; Hip fractures; shoulder fractures; periprosthetic fractures; intra-articular fractures; fractures, open; fractures, closed; ulna fractures.
#17	Search exp fracture[MeSH]
	The exploded MeSH terms for fractures included exploding all the above MeSH terms in Search #16, however only 'hip fractures' and 'ulna fractures' could be exploded.
#18	Search #15 OR #16 OR #17
#19	Search traum*
#20	Search trauma[MeSH]
#21	Search exp trauma[MeSH]
#22	Search #19 OR #20 OR #21
#23	Search #12 OR #13 OR #14 OR #18 OR #22
#24	Search ligament*
#25	Search musc*
#26	Search "musculoskeletal pain"[MeSH]
#27	Search exp "musculoskeletal pain"[MeSH]
#28	Search #25 OR #26 OR #27
	There is no MeSH term for musculoskeletal system, there is one for musculoskeletal pain so this was changed.
#29	Search orthop*
#30	Search orthopedics [MeSH]
#31	Search orthopedics [MeSH Major Concept]
#32	Search #29 OR #30 OR #31
#33	Search skele*
#34	Search tendon
#35	Search tendin*
#36	Search #34 OR #35
#37	Search #24 OR#28 OR #32 OR #33 OR #36

#38	Search prevalence
#39	Search incidence
#40	Search rate
#41	Search #38 OR #39 OR #40
#42	Search #9 AND #23
#43	Search #9 AND #12
#44	Search #43 AND #37
#45	Search #43 AND #32
#46	Search #43 AND #36
#47	Search #9 AND #22
#48	Search #47 AND #37
#49	Search #43 AND #41
#50	Search #42 AND #41

Screening & Eligibility

Studies will be reviewed by title and abstract. Those eligible will be reviewed to select full text articles to assess for inclusion. Duplicates will be recorded. This will be in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)¹⁵ (Appendix 2). The principal and second reviewers will undertake this process at the same time though independently. If discrepancies arise these will have to be discussed between the reviewers and recorded. Both will review the full article. If between the two reviewers a resolution cannot be reached a third reviewer will be consulted.

Title and Abstract Review

- Titles will be reviewed for relevance. The abstract will be reviewed to identify studies that describe contact martial arts injuries or incidence or prevalence.

Full article review

- Those articles identified will be requested and assessed for inclusion eligibility by both reviewers. This will be based on the data provided in that they must provide the setting, a description of the injury, demographics and style of martial art.

Duplicated studies

- Articles published in more than one journal will be counted as one article and only the most recent publication will be included
- Studies publishing series of data that incorporates data from their previous publication – in this case only the most recent data will be used and the old study included.
- Articles that return on more than one database will count as one study.

Other resources that will be utilised will be the references provided in the articles selected for inclusion.

Limitations

One of the limitations to this search strategy is in restricting studies to the English language. This will exclude many studies, as it would be beyond the remit of this study to translate all languages. A further limitation is that it is not possible to search every database and as such some studies may be missed, however the engines utilised in this study should cover the vast majority of the available data. Finally, there are well over a thousand styles of martial arts and it is not possible to perform a search for each one individually with their alternative spelling thus only the most popular have been selected.

Data Extraction

Two reviewers will undertake data extraction independently. If any differences are found these will be discussed. If these cannot be resolved a third reviewer will be consulted.

- The following will be recorded for each study
 - Study type/level of evidence

- Martial art type
- Setting (class, grading, competition)
- Demographics (age, sex)
- Injury sustained
 - Injuries will be categorised into upper or lower limb and trunk.
 - Upper limb is defined from the glenohumeral joint up to and including the structures of the hand.
 - Lower limb is defined from the hip joint up to and including the structures of the foot.
 - The trunk comprises the cervical spine down to and including the pelvis.
 - Injuries will be further categorised into sprain/strain/fracture or dislocation.
- Mechanism of injury (e.g. fall from a throw or trip, direct trauma from kick, punch or lock)
- Grade at which the injury was sustained. As different martial arts will employ a variety of grading systems, for simplicity the grades will be divided thusly:
 - Junior grade – anyone with a rank less than black belt.
 - Senior grade – black belt and above.
 - Elite level – if specifically stipulated by the study, otherwise they will be classed as senior grade.
- Prevalence
 - Data on the injuries sustained in a single tournament or season will be collected and presented as a percentage of total competitors per event/season. Essentially the proportion of people who have an injury at the event/ number of people at risk (which in this case would be all participants at a particular event)
- Incidence
 - Data on the type and number of each new injury sustained at each event will be collected. The numerator will be the

overall number of injuries and the denominator will be the number of the competitors. This will be sub-classified into incidence of injuries occurring to the upper limb, lower limb and trunk.

Quality Assessment

- Epidemiological studies will be assessed for bias using validated tools.
- Risk of bias will be assessed using the bias risk assessment tool in prevalence studies developed by Hoy et al (2012).¹⁶
- The Newcastle-Ottawa scale will be used to assess the quality of cohort and case-control studies.¹⁷

Data Synthesis

Data items will be tabulated to facilitate evaluation. The first table will stratify the injuries per body part and present the epidemiological data that is identified.

E.G. TABLE 1 – PREVALENCE OF INJURIES

	Study	Martial art	Grade/Level of participants	Setting	Injuries	Prevalence
UPPER LIMB						
LOWER LIMB						
TRUNK						

The second table summarises the incidence.

E.G. TABLE 2 – INCIDENCE OF INJURIES

	Study	Martial art	Grade/Level of participants	Setting	Injuries	Incidence
UPPER LIMB						
LOWER LIMB						
TRUNK						

Reported overall prevalence and incidence will be tabulated separately. The data will be used to illustrate the spread of reported prevalence and incidence. If enough data with a homogenous population is found, a meta-analysis will be undertaken.

The demographics of the populations may vary as will style of martial art. The heterogeneity of the population will be assessed statistically.

Conflicts of Interest

The author certifies that I have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

APPENDIX 2
SEARCH STRATEGIES

SportDiscus and AMED Search Strategies	
#1	Search martial art*
#2	Search karate
#3	Search kickboxing
#4	Search “kung fu” OR “gong fu” OR “gung fu”
#5	Search taekwando OR “tae kwan do” OR “tae kwon do”
#6	Search #1 OR #2 OR #3 OR #4 OR #5
#7	Search injur*
#8	Search dislocat*
#9	Search sublux*
#10	Search fractur*
#11	Search traum*
#12	Search #7 OR #8 OR #9 OR #10 OR #11
#13	Search #6 AND #12 (Final search)

APPENDIX 3

PREVALENCE STUDY ASSESSMENT TOOL

The following is the tool used to assess the prevalence studies. It is from Hoy et al 2012.

Name of paper/study:-

This tool is designed to assess the risk of bias in population-based prevalence studies. Please read the additional notes for each item when initially using the tool. Note: If there is insufficient information in the article to permit a judgement for a particular item, please answer **No (HIGH RISK)** for that particular item.

Risk of bias item	Criteria for answers (please circle one option)	Additional notes and examples
External Validity		
1. Was the study's target population a close representation of the national population in relation to relevant variables, e.g. age, sex, occupation?	<ul style="list-style-type: none"> • Yes (LOW RISK): The study's target population was a close representation of the national population. • No (HIGH RISK): The study's target population was clearly NOT representative of the national population. 	<p>The target population refers to the group of people or entities to which the results of the study will be generalised. Examples:</p> <ul style="list-style-type: none"> • The study was a national health survey of people 15 years and over and the sample was drawn from a list that included all individuals in the population aged 15 years and over. The answer is: Yes (LOW RISK). • The study was conducted in one province only, and it is not clear if this was representative of the national population. The answer is: No (HIGH RISK). • The study was undertaken in one village only and it is clear this was not representative of the national population. The answer is: No (HIGH RISK).
2. Was the sampling frame a true or close representation of the target population?	<ul style="list-style-type: none"> • Yes (LOW RISK): The sampling frame was a true or close representation of the target population. • No (HIGH RISK): The sampling frame was NOT a true or close representation of the target population. 	<p>The sampling frame is a list of the sampling units in the target population and the study sample is drawn from this list. Examples:</p> <ul style="list-style-type: none"> • The sampling frame was a list of almost every individual within the target population. The answer is: Yes (LOW RISK). • The cluster sampling method was used and the sample of clusters/villages was drawn from a list of all villages in the target population. The answer is: Yes (LOW RISK). • The sampling frame was a list of just one particular ethnic group within the overall target population, which comprised many groups. The answer is: No (HIGH RISK).
3. Was some form of random selection used to select the sample, OR, was a census undertaken?	<ul style="list-style-type: none"> • Yes (LOW RISK): A census was undertaken, OR, some form of random selection was used to select the sample (e.g. simple random sampling, stratified random sampling, cluster sampling, systematic sampling). • No (HIGH RISK): A census was NOT undertaken, AND some form of random selection was NOT used to select the sample. 	<p>A census collects information from every unit in the sampling frame. In a survey, only part of the sampling frame is sampled. In these instances, random selection of the sample helps minimise study bias. Examples:</p> <ul style="list-style-type: none"> • The sample was selected using simple random sampling. The answer is: Yes (LOW RISK). • The target population was the village and every person in the village was sampled. The answer is: Yes (LOW RISK). • The nearest villages to the capital city were selected in order to save on the cost of fuel. The answer is: No (HIGH RISK).
4. Was the likelihood of non-response bias minimal ?	<ul style="list-style-type: none"> • Yes (LOW RISK): The response rate for the study was $\geq 75\%$, OR, an analysis was performed that showed no significant difference in relevant demographic characteristics between responders and non-responders • No (HIGH RISK): The response rate was $< 75\%$, and if any analysis comparing responders and non-responders was done, it showed a significant difference in relevant demographic characteristics between responders and non-responders. 	<p>Examples:</p> <ul style="list-style-type: none"> • The response rate was 68%; however, the researchers did an analysis and found no significant difference between responders and non-responders in terms of age, sex, occupation and socio-economic status. The answer is: Yes (LOW RISK). • The response rate was 65% and the researchers did NOT carry out an analysis to compare relevant demographic characteristics between responders and non-responders. The answer is: No (HIGH RISK). • The response rate was 69% and the researchers did an analysis and found a significant difference in age, sex and socio-economic status between responders and non-responders. The answer is: No (HIGH RISK).

Internal Validity		
5. Were data collected <u>directly from the subjects</u> (as opposed to a proxy)?	<ul style="list-style-type: none"> • Yes (LOW RISK): All data were collected directly from the subjects. • No (HIGH RISK): In some instances, data were collected from a proxy. 	<p>A proxy is a representative of the subject. Examples:</p> <ul style="list-style-type: none"> • All eligible subjects in the household were interviewed separately. The answer is: Yes (LOW RISK). • A representative of the household was interviewed and questioned about the presence of low back pain in each household member. The answer is: No (HIGH RISK).
6. Was an acceptable case definition used in the study?	<ul style="list-style-type: none"> • Yes (LOW RISK): An acceptable case definition was used. • No (HIGH RISK): An acceptable case definition was <u>NOT</u> used. 	<ul style="list-style-type: none"> • For a study on low back pain, the following case definition was used: "Low back pain is defined as activity-limiting pain lasting more than one day in the area on the posterior aspect of the body from the bottom of the 12th rib to the lower gluteal folds." The answer is: Yes (LOW RISK). • For a study on back pain, there was no description of the specific anatomical location 'back' referred to. The answer is: No (HIGH RISK). • For a study on osteoarthritis, the following case definition was used: "Symptomatic osteoarthritis of the hip or knee, radiologically confirmed as Kellgren-Lawrence grade 2-4". The answer is: LOW RISK.
7. Was the study instrument that measured the parameter of interest (e.g. prevalence of low back pain) shown to have <u>reliability and validity (if necessary)</u> ?	<ul style="list-style-type: none"> • Yes (LOW RISK): The study instrument had been shown to have reliability and validity (if this was necessary), e.g. test-re-test, piloting, validation in a previous study, etc. • No (HIGH RISK): The study instrument had <u>NOT</u> been shown to have reliability or validity (if this was necessary). 	<ul style="list-style-type: none"> • The authors used the COPCORD questionnaire, which had previously been validated. They also tested the inter-rater reliability of the questionnaire. The answer is: Yes (LOW RISK). • The authors developed their own questionnaire and did not test this for validity or reliability. The answer is: No (HIGH RISK).
8. Was the <u>same mode of data collection</u> used for all subjects?	<ul style="list-style-type: none"> • Yes (LOW RISK): The same mode of data collection was used for all subjects. • No (HIGH RISK): The same mode of data collection was <u>NOT</u> used for all subjects. 	<p>The mode of data collection is the method used for collecting information from the subjects. The most common modes are face-to-face interviews, telephone interviews and self-administered questionnaires. Examples:</p> <ul style="list-style-type: none"> • All eligible subjects had a face-to-face interview. The answer is: Yes (LOW RISK). • Some subjects were interviewed over the telephone and some filled in postal questionnaires. The answer is: No (HIGH RISK).
9. Was the <u>length of the shortest prevalence period</u> for the parameter of interest appropriate?	<ul style="list-style-type: none"> • Yes (LOW RISK): The shortest prevalence period for the parameter of interest was appropriate (e.g. point prevalence, one-week prevalence, one-year prevalence). • No (HIGH RISK): The shortest prevalence period for the parameter of interest was not appropriate (e.g. lifetime prevalence) 	<p>The prevalence period is the period that the subject is asked about e.g. "Have you experienced low back pain over the previous year?" In this example, the prevalence period is one year. The longer the prevalence period, the greater the likelihood of the subject forgetting if they experienced the symptom of interest (e.g. low back pain). Examples:</p> <ul style="list-style-type: none"> • Subjects were asked about pain over the past week. The answer is: Yes (LOW RISK). • Subjects were only asked about pain over the past three years. The answer is: No (HIGH RISK).
10. Were the <u>numerator(s) and denominator(s)</u> for the parameter of interest appropriate?	<ul style="list-style-type: none"> • Yes (LOW RISK): The paper presented appropriate numerator(s) AND denominator(s) for the parameter of interest (e.g. the prevalence of low back pain). • No (HIGH RISK): The paper did present numerator(s) AND denominator(s) for the parameter of interest but one or more of these were inappropriate. 	<p>There may be errors in the calculation and/or reporting of the numerator and/or denominator. Examples:</p> <ul style="list-style-type: none"> • There were no errors in the reporting of the numerator(s) AND denominator(s) for the prevalence of low back pain. The answer is: Yes (LOW RISK). • In reporting the overall prevalence of low back pain (in both men and women), the authors accidentally used the population of women as the denominator rather than the combined population. The answer is: No (HIGH RISK).
11. Summary item on the overall risk of study bias		
<ul style="list-style-type: none"> • LOW RISK OF BIAS: Further research is <u>very unlikely</u> to change our confidence in the estimate. • MODERATE RISK OF BIAS: Further research is <u>likely</u> to have an important impact on our confidence in the estimate and may change the estimate. 		

APPENDIX 4

EVENT RATE STUDY ASSESSEMENT TOOL

The following is the tool used to assess the validity of the event rate studies by Nguyen et al 2009.

Study Design		Score
A	Objective description	4
B	Description of population	4
C	Selection Criteria	4
D	Description of potential confounders	6
E	Pre-investigation sample size estimation	2
F	Sample size	4
G	Type of study (10 maximum, items cannot be randomly combined)	
	• Longitudinal	6
	• Mixed-longitudinal	4
	• Case-control	2
	• Cross-sectional	2
	• Follow-up time	4
	• Subgroup comparability	4
Study Conduct		
H	Mentioning of dropouts	2
I	Method of measurement described	8
J	Blind measurement	6
K	Number of examiners	4
L	Intra- and inter-examiner reliability described	4
M	Level of agreement intra- and inter-examiner	6

Statistical analysis		Score
N	Dropouts included in data analysis	6
O	Statistical method correct	12
P	Confounders analysed	6
Q	Presentation of data	6
 Conclusion		
R	Statement referred to statistical procedure used and appropriate to objective	6

APPENDIX 5

SURVEY PROTOCOL

Why this research is important & Methodological rationale

Phase 1 of this research, a systematic review, demonstrated little research into prevalence of orthopaedic injuries in striking contact MA. The majority of studies looked at injury rates at single events at elite level competition. No studies compared prevalence of orthopaedic injury according to setting or level of experience.

Patterns of injury may vary according to level of experience and setting (class, grading and competition). This survey, the second stage of this research, will identify the one-year period prevalence of orthopaedic injuries in striking contact MA. A secondary objective is to identify the health-seeking behaviour of MA athletes.

Understanding the more prevalent injuries may guide clinical examination and to look for specific injuries. Stratification into setting may help inform ringside physicians what injuries may be encountered. They can therefore plan the best management and what stock is required at each event.

Study methods

Principle study measures

- One-year period prevalence of orthopaedic injuries in contact striking MA – overall and according to body region (upper limb, lower limb, trunk including the cervical spine and pelvis).
- Orthopaedic injuries in contact striking martial arts
- Level of participation at which injury was sustained e.g. professional, amateur or beginner.
- Setting where the injury was sustained i.e. class, grading or competition.
- Whom MA athletes seek advice from regarding injuries.

Population/Participants

- Athletes aged 16+ engaged in contact martial arts where the overriding sparring theme is striking such as kickboxing, taekwondo, kung fu and karate.
- MA athletes attending grading and competition in WSK and SSK will be given the survey.

Injuries of interest and settings

- Orthopaedic injuries sustained in the practice of contact striking martial arts either in class, grading or competition.
- Orthopaedic injuries refer to any injury to the muscles or skeleton and their supporting structures including: cartilage, tendon, ligaments and nerves.

Exclusion Criteria

- Head injuries e.g. brain injury or concussion.
- Maxillofacial injuries e.g. mandibular and orbital fractures
- Visceral injuries (organ injuries such as splenic or kidney injury)
- Contusions, abrasions and lacerations.
- Injuries sustained outside of the MA setting such as a street fight/assault.
- Returned forms with personal identifying information.

Sample Size

As we have limited information on the prevalence of injury in this group, we have assumed a rate of 50%, as the worst-case scenario. We estimate that we need at least 96 respondents for the prevalence rate to be estimated to within no more than +/- 10% with 95% confidence.

Data Collection

The data will be collected through a survey (see Appendix 2) from individuals attending grading and classes in January and February 2016. At least one week prior to data collection I will inform each instructor that I will attend the class, grading or competition so that their students are aware and have time to think about whether they would like to participate. I will also provide them with a sample questionnaire so that they may look at this and read the accompanying

information sheet detailing who I am, the purpose of this research and that their participation is voluntary.

Two organizations have been contacted regarding permission to attend gradings to disseminate and collect the data. Approval in principle has been granted from the following:

- Grand Master C K Chang Wu Shu Kwan
- Senior Master P Kennedy San Shou Kwan

The principle researcher will hand the survey out to all athletes attending the class, grading or competition, as this will allow the response rate to be calculated. They will be issued with an envelope and pen. The survey will be returned in the sealed envelope into a drop box that will be emptied by the principle researcher at the end of the event.

I undertook a small group discussion with some martial artists. One of their concerns was regarding confidentiality in that some had attended competitions outside of their martial art. If this information were to be passed on to their school they may be suspended for this. For this reason, I will hand out and collect the data in sealed envelopes in the drop box so that no one individual may be identified.

Data Protection

To comply with the Data Protection Act (1998), no personal details will be collected, as no further contact is required for this research following the primary data collection. The survey is voluntary and participants will complete this only with their consent and aware that all data provided is anonymous and only used for the purpose of this research and subsequent publications.

All data will be kept in a single file with the principle researcher in a locked filing cabinet. The anonymous data will be uploaded onto the university system in the form of an MS-excel spread sheet that is password protected. This data will be

transferred to the DoS at the end of the MSc and kept for five years. All hard copies will be destroyed in NHS confidentiality waste when they are no longer required. Only the principle researcher will have access to the raw data.

University ethical approval will be sought prior to data collection.

It will be clear from the information sheet provided that no personal details should be divulged. If any such information is received, it will be destroyed through confidential waste disposal and not included in the study.

Data Required

The data to be collected is as follows:

- Age
- Sex
- Martial Art
- Grade if applicable
- Years of experience
- Level (Professional/Amateur competitive/Amateur non-competition/Beginner)
- Number of training sessions per week/month
- Number of injuries sustained in the last 12 months as a result of their MA
- Injuries
 - List injuries and for each describe:
 - Mechanism
 - Setting sustained e.g. class/grading/competition
 - How was this managed?
 - If help/advice was sought, who was this from?
 - Did the injury resolve?
 - Did they take any time out of training, if so, how long?
 - Are any of these re-injuries or are they new?

Data Analysis

- Data will be stratified as follows and if possible the one-year period prevalence for each stratum will be calculated:
 - Upper limb is defined from the glenohumeral joint up to and including the structures of the hand.
 - Lower limb is defined from the hip joint up to and including the structures of the foot.
 - The trunk comprises the cervical spine down to and including the pelvis.
 - Years of experience will be subdivided into
 - 1-6 month 6-12 month 1-2 years 2-5 years >5years
 - Level will be divided into the following groups:
 - Professional
 - Amateur engages in competition
 - Amateur non-competitive
 - Beginner
 - Grade will be divided into:
 - Junior (anyone less than black belt)
 - Senior (Black belt and above)
- Statistical analysis will compare whether there are significant differences in overall orthopaedic injury prevalence exists across years of experience (grade) and setting.

Data will also be presented on the injuries sustained and their mechanism.

APPENDIX 6

ETHICAL APPROVAL LETTER



8th April 2016

Paola Dey/Nasri Zreik
School of Medicine
University of Central Lancashire

Dear Paola/Nasri,

Re: STEMH Ethics Committee Application
Unique Reference Number: STEMH 446

The STEMH ethics committee has granted approval of your proposal application 'Orthopaedic Injuries in Martial Arts'. Approval is granted up to the end of project date* or for 5 years from the date of this letter, whichever is the longer.

It is your responsibility to ensure that:

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use [e-Ethics Closure Report Proforma](#)).

Yours sincerely,

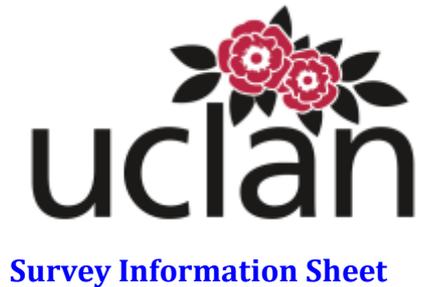
A handwritten signature in black ink, appearing to read 'Colin Thain', is written over a light grey rectangular background.

Colin Thain
Chair
STEMH Ethics Committee

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals as a result of gained.

**APPENDIX 7
COVER LETTER**



Dear Participant:

My name is Nasri Zreik and I am a graduate student at the University of Central Lancashire. For my thesis, I am examining orthopaedic injuries in martial arts. Orthopaedics is a field of medicine that studies the bones, muscles and connective structures in the body. Because you are a martial arts athlete over the age of 16, I am inviting you to participate in this research study by completing the attached survey.

The aim of the survey is to give an idea of the common orthopaedic injuries that occur in the practice of martial art. We aim to looking at whether the type of injury is related to the years of experience in adult (16-years-old and over) martial artists. We are also looking at how many new injuries are picked up in the course of a year and if the injury is related to the level of sparring and setting (competition, grading or class) in which it occurred. Your participation in this survey will help us to answer these questions and will hopefully translate into better knowledge for clinicians treating martial arts injuries in the future.

The following survey will require approximately 10-15 minutes to complete. The following symbols are used to guide you in what the question requires:



Write



List



Tick

In order to ensure that all information will remain confidential, please do not include your name or other information that would identify you personally. Copies of the project will be provided to my UCLAN supervisors. No personal data will be stored.

If you choose to participate in this project, please answer all questions as honestly as possible and return the completed questionnaires in the supplied envelope and place it in the box labelled 'Questionnaires' at the end of class or grading. Participation is strictly voluntary and you may refuse to participate. As this is an anonymous survey, I am unable to withdraw your data once it is collected.

Thank you for taking the time to assist me in my educational endeavours. The anonymous data collected will provide useful information regarding injuries in martial arts and may help to develop the knowledge and skills of clinicians treating martial arts athletes such as you. It will be used for my thesis, subsequent publication in peer reviewed medical journals and presentations.

If you would like a summary copy of this study please inform your instructor and I will provide a copy through them to maintain your anonymity. Completion and return of the questionnaire will indicate your willingness to participate in this study. If you require additional information or have questions, please contact me at the number listed below.

If you are not satisfied with the manner in which this study is being conducted, you may report (anonymously if you so choose) any complaints to my supervisors (listed below).

Sincerely,

Dr. Nasri Zreik

MB ChB(Hons) BSc(Hons) MRCS MCSP

nzreik@uclan.ac.uk

Supervisors: Professor MP Dey & Professor C Charalambous

(mpdey@uclan.ac.uk) (ccharalambous@uclan.ac.uk)

APPENDIX 8

QUESTIONNAIRE

The following appendix gives the questionnaires through their design from first draft to the final version.

SURVEY VERSION 1



Dear Sir or Madam:

My name is Nasri Zreik and I am conducting a survey into orthopaedic injuries in martial arts. Orthopaedics is a field of medicine that studies the bones, muscles and connective structures in the body. This survey is part of a Masters project undertaken at the University of Central Lancashire (UCLAN). Your participation is optional and greatly appreciated. Please only complete this survey if you are 16 years of age and above.

The data collected is designed to be anonymous and will not personally identify any individual. Please do not include any personal data that may identify you such as name, date of birth or email address.

Q1: What is your age?

Q2: What your sex?

Q3: What martial art(s) do you practice?

Q4: What is your current grade (*if applicable*)? (*If black belt, please state what dan/degree you hold*).

Q5: How many months or years experience do you have in your martial art?

Months/Years (*delete as appropriate*)

Q6: How would you describe your training level? *(Please tick)*

Beginner	
Leisure (do not compete)	
Amateur (competes but not for prize fights)	
Professional/Elite	

Q7: How often do you train for your martial art? *(Include class, gradings and competition).*

Number of classes	
	per week/month
Other activity (please list and state how often)	

Q8: In the last 12 months how many injuries have you had in training, sparring, grading or competition in your martial art? *(We consider an injury to be anything from a bruise, skin abrasion or a small cut to a broken bone.)*

Q9: For each of your injuries you counted above please list each one, how you got them. Please indicate whether these were in class, grading, competition and whether they happened during sparring or training. *(please continue on a separate sheet if necessary).*

Injury	Where did you get injured?	How did you get injured?	Did you wear protective equipment?	Did you seek any advice or treatment for this? If yes, from who?	Did you have to take time off training? If yes, how long?
<i>e.g. broken forearm</i>	<i>Grading when sparring full contact.</i>	<i>Axe kick to shoulder</i>	<i>Yes, but only gloves, headguard and gumshield.</i>	<i>Yes, from hospital, I needed a surgery</i>	<i>I had to take 3 months off training</i>
<i>e.g. sprained ankle</i>	<i>Class during drill</i>	<i>I was practicing a turning kick during the drill section and I twisted and went over on my left ankle</i>	<i>Not applicable</i>	<i>I spoke to my instructor who told me to elevate it and ice it.</i>	<i>3 weeks</i>

Q10: Were any of your injuries in those 12 months because of an old injury that you re-injured? (*If yes, please list which ones*).

Thank you for your participation in this survey. If there is anything else you wish to add please use the space below. Any feedback on the survey itself would also be greatly appreciated, especially on the language used and the content, especially if you think anything is missing or whether anything needs to be clearer. If you have any questions, please contact me at Nzreik@uclan.ac.uk

Alternatively, if you have any concerns, my tutors may also be contacted at UCLAN: Professor MP Dey & Professor C Charalambous.



SURVEY VERSION 2



Please do not include any personal data that may identify you such as name, date of birth or email address.

Q1: What is your age group? (Please tick)

16-19	20-25	25-30
30-35	35-40	40-50
50-60	>60	

Q2: What your gender? (Please tick)

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

Q3: Please list the martial art(s) you practice and circle your main one:

Q4: What is your current grade (if applicable) in each martial art? (If you are a black belt, please state what dan/degree you hold).

Q5: How many months or years' experience do you have in your martial art? (Please tick)

Less than 6 months

6-12months

1-2 years

2-4years

5-10 years

10-15 years

More than 15 years

Q6: How would you describe your training level? (Please tick)

Beginner

Leisure (do not compete)

Amateur (competes but not for prize fights)

Professional/Elite

Q7: On average, how many classes do you attend per week in your main martial art?

.....(number of sessions)

Q8: Please list any other activities you do related to your martial art and indicate how often you do these:

e.g. competition – one every three months

Q9A: In the last 12 months how many new injuries have you had in training, sparring, grading or competition in your martial art? (We consider an injury to be anything from a muscle strain to a broken bone. Please do not include injuries such as minor bruises/cuts).

.....(number of injuries)

Q9B: Please list the injuries you counted for question 9A. (Please be specific e.g. sprained ankle right side).

Q9C: For each of your injuries you listed, please explain how you got the injury, where it happened (e.g. class, grading, competition) and whether it was during sparring or training. (Please continue on a separate sheet if necessary).
e.g. broken right forearm, blocking a turning kick to chest level during sparring.

Q9D: For each of the injuries listed in question 9B above please state if you were wearing any personal protective equipment and what this was? (e.g. gum shield, headguard, gloves, shin pads). (Please specify which injury you are referring to).

Q9E: For each of the injuries listed in question 9B, please state if you sought advice or treatment for it and who the advice/treatment were from (e.g. from instructor, first aider, GP). (Please specify which injury you are referring to)

Q9F: For each of the injuries listed in question 9B, did you have to take any time off training? If so, how long was this for?

**Q10: Were any of your injuries in Q9B a result of an old injury that you re-injured? (If yes, please list which ones).
e.g. sprained ankle – I have gone over on this ankle 5 times in the last 4 years and it remains weak.**

This is the end of the survey. Thank you for your participation.



SURVEY VERSION 3

Please do not include any personal data that may identify you such as name, date of birth or email address.



Q1: What is your age group? (Please circle one)

- | | | |
|-------------|-------|-------|
| 16-19 years | 20-25 | 25-30 |
| 30-35 | 35-40 | 40-50 |
| 50-60 | >60 | |

Q2: What your gender? (Please circle one)

- | | |
|------|--------|
| Male | Female |
|------|--------|

Q3: Please list the martial art(s) you practice and circle your main one:

Q4: What is your current grade (if applicable) in each martial art? (If you are a black belt, please state what dan/degree you hold).

Q5: How many months or years of experience do you have in your martial art? (Please tick one)

Less than 6 months

6-12months

1-2 years

2-4years

5-10 years

10-15 years

More than 15 years

Q6: How would you describe your training level? (Please tick one)

Beginner

Leisure (do not compete)

Amateur (competes but not for prize fights)

Professional/Elite

Q7: On average, how many classes do you attend per week in your main martial art?

.....(number of sessions)

Q8: Please list any other activities you do related to your martial art and indicate how often you do these:

e.g. competition – one every three months

Q9A: In the last 12 months how many new injuries have you had in training, sparring, grading or competition in your martial art? (We consider an injury to be anything from a muscle strain to a broken bone. Please do not include injuries such as minor bruises/cuts).

.....(number of injuries)

Q9B: Please list the injuries you counted for question 9A. (Please be specific e.g. sprained ankle right side).

**Q9C: For each of your injuries you listed, please explain how you got the injury, where it happened (e.g. class, grading, competition) and whether it was during sparring or training. (Please continue on a separate sheet if necessary).
e.g. broken right forearm, blocking a turning kick to chest level during sparring.**

Q9D: For each of the injuries listed in question 9B above please state if you were wearing any personal protective equipment and what this was? (e.g. gum shield, headguard, gloves, shin pads). (Please specify which injury you are referring to).

Q9E: For each of the injuries listed in question 9B, please state if you sought advice or treatment for it and who the advice/treatment were from (e.g. from instructor, first aider, GP). (Please specify which injury you are referring to)

Q9F: For each of the injuries listed in question 9B, did you have to take any time off training? If so, how long was this for?

**Q10: Were any of your injuries in Q9B a result of an old injury that you re-injured? (If yes, please list which ones).
e.g. sprained ankle – I have gone over on this ankle 5 times in the last 4 years and it remains weak.**

This is the end of the survey. Thank you for your participation.



SURVEY VERSION 4

Please do not include any personal data that may identify you such as name, date of birth or email address.



Q1: What is your age group? (Please tick one)

16-19 years

20-25 years

25-30 years

30-35 years

35-40 years

40-50 years

50-60 years

>60 years

Q2: What your gender? (Please tick one)

Male

Female

Q3a: Please state your main martial art:



Q3b: Please list any other martial art(s) you practice:



Q4: What is your current grade (if applicable) in each martial art? (If you are a black belt, please state what dan/degree you hold). If your martial art does not

have a grading system please tick the appropriate box below and move on to question 5.

My martial art does not have a rank/grading system (*please tick this box*)

Q5: How many months or years of experience do you have in your main martial art? (*Please tick one*)

Less than 6 months

6-12months

1-2 years

2-4years

5-10 years

10-15 years

More than 15 years

Q6: How would you describe your training level? (*Please tick one*)

Beginner

Leisure (do not compete)

Amateur (competes but not for prize fights)

Professional/Elite

Q7: On average, how many classes do you attend per week in your main martial art? 

.....(Number of sessions)

Q8a: In the last 12 months how many new injuries have you had in training, sparring, grading or competition in your martial art? *(We consider an injury to be anything from a muscle strain to a broken bone. Please do not include injuries such as minor bruises/cuts).* 

.....(Number of injuries)

If you have had no injuries, thank you for taking part in the survey, please place it into the provided envelope and return it to the box labelled 'survey responses'.

If you have had one or more injuries, please move on to question 8b.

Q8b: Please list the injuries you counted for question 8a. *(Please be specific e.g. sprained ankle right side).* 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8c: For each of your injuries you listed in question 8b, please explain how you got the injury. (e.g. doing a turning kick and my supporting ankle twisted).



Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8d: For each of your injuries you listed in question 8b, please identify where it happened (e.g. class, grading, competition).



Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8e: For each of your injuries you listed in question 8b, please indicate what activity you were doing when you got it (e.g. it was during sparring, stretching, or drill).



Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8f: For each of the injuries listed in question 8b above please state if you were wearing any personal protective equipment and what this was? (e.g. gum shield, headguard, gloves, shin pads). (If you were not wearing any protective equipment please state NONE). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q9a: For each of the injuries listed in question 8b, did you seek any advice or treatment for the injury? (Please tick one)

Injury 1: **Yes** **No**

Injury 2: **Yes** **No**

Injury 3: **Yes** **No**

Injury 4: **Yes** **No**

Injury 5: **Yes** **No**

Please continue on a separate sheet if necessary.

Q9b: For each of the injuries listed in question 8b, if you did seek advice or treatment, please state who this was from? (E.g. from instructor, first aider, GP).



Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q9b: For each of the injuries listed in question 9b, did you have to take any time off training? If yes, please state how long this was for (e.g. six weeks)?



Injury 1: **No** **Yes** How
long?.....

Injury 2: **No** **Yes** How
long?.....

Injury 3: **No** **Yes** How
long?.....

Injury 4: **No** **Yes** How
long?.....

Injury 5: **No** **Yes** How
long?.....

Please continue on a separate sheet if necessary.

Q10: Were any of your injuries in Q8b a result of an old injury that you re-injured? (Please tick yes or no below).

Injury 1: Yes No

Injury 2: Yes No

Injury 3: Yes No

Injury 4: Yes No

Injury 5: Yes No

Please continue on a separate sheet if necessary.

This is the end of the survey. Thank you for your participation. Please seal the form in the envelope provided and drop this into the box labelled 'survey responses'.



SURVEY VERSION 5

Martial Arts Injuries Survey

Please do not include any personal data that may identify you such as name, date of birth or email address.



Q1: What is your age group? (Please tick one)

16-19 years

20-25 years

25-30 years

30-35 years

35-40 years

40-50 years

50-60 years

>60 years

Q2: What your gender? (Please tick one)

Male

Female

Q3a: Please state your main martial art:



Q3b: Please list any other martial art(s) you practice:



Q4: What is your current grade (if applicable) in each martial art? (If you are a black belt, please state what dan/degree you hold). If your martial art does not have a grading system please tick the appropriate box below and move on to question 5.

My martial art does not have a rank/grading system (please tick this box)

Q5: How many months or years of experience do you have in your main martial art? (Please tick one)

Less than 6 months

6-12months

1-2 years

2-4years

5-10 years

10-15 years

More than 15 years

Q6: How would you describe your training level? (Please tick one)



Beginner

Leisure (do not compete)

Amateur (competes but not for prize fights)

Professional/Elite

Q7: On average, how many classes do you attend per week in your main martial art? 

.....(Number of sessions)

Q8a: In the last 12 months how many new injuries have you had in training, sparring, grading or competition in your martial art? (We consider an injury to be anything from a muscle strain to a broken bone. Please do not include injuries such as minor bruises/cuts). 

.....(Number of injuries)

If you have had no injuries, thank you for taking part in the survey, please place it into the provided envelope and return it to the box labelled 'survey responses'.

If you have had one or more injuries, please move on to question 8b.

Q8b: Please list the injuries you counted for question 8a. (Please be specific e.g. sprained ankle right side). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8c: For each of your injuries you listed in question 8b, please explain how you got the injury. (e.g. doing a turning kick and my supporting ankle twisted).



Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8d: For each of your injuries you listed in question 8b, please identify where it happened (e.g. class, grading, competition). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8e: For each of your injuries you listed in question 8b, please indicate what activity you were doing when you got it (e.g. it was during sparring, stretching, or drill). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8f: For each of the injuries listed in question 8b above please state if you were wearing any relevant personal protective equipment and what this was? (e.g. gum shield, headguard, gloves, shin pads). (If you were not wearing any protective equipment please state NONE).

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q9a: For each of the injuries listed in question 8b, did you seek any advice or treatment for the injury? (Please tick one) If yes, please move on to Q9b, if not move on to Q9c.

Injury 1: **Yes** **No**

Injury 2: **Yes** **No**

Injury 3: **Yes** **No**

Injury 4: **Yes** **No**

Injury 5: **Yes** **No**

Please continue on a separate sheet if necessary.

Q9b: For each of the injuries listed in question 8b, if you sought advice or treatment, please state who this was from? (E.g. from instructor, first aider, GP).



Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q9c: For each of the injuries you listed in question 8b, did you have to take any time off training? If yes, please state how long this was for (e.g. six weeks)?



Injury 1: **No** **Yes** How
long?.....

Injury 2: **No** **Yes** How
long?.....

Injury 3: **No** **Yes** How
long?.....

Injury 4: **No** **Yes** How
long?.....

Injury 5: **No** **Yes** How
long?.....

Please continue on a separate sheet if necessary.

Q10: Were any of your injuries in Q8b a result of an old injury that you re-injured? (Please tick yes or no below).

Injury 1: Yes No

Injury 2: Yes No

Injury 3: Yes No

Injury 4: Yes No

Injury 5: Yes No

Please continue on a separate sheet if necessary.

This is the end of the survey. Thank you for your participation. Please seal the form in the envelope provided and drop this into the box labelled 'survey responses'.



SURVEY FINAL VERSION

Martial Arts Injuries Survey

Please do not include any personal data that may identify you such as name, date of birth or email address.



Q1: What is your age group? (Please tick one)

16-19 years

20-24 years

25-29 years

30-34 years

35-39 years

40-49 years

50-60 years

>60 years

Q2: What your gender? (Please tick one)

Male

Female

Q3a: Please state your main martial art:

Q3b: Please list any other martial art(s) you practice:



Q4: How many months or years of experience do you have in your main martial art? (Please tick one)

- Less than 6 months
- 6-12months
- 1-2 years
- 2-4years
- 5-10 years
- 10-15 years
- More than 15 years

Q6: How would you describe your training level? (Please tick one)



- Beginner
- Leisure (do not compete)
- Amateur (competes but not for prize fights)
- Professional/Elite

Q7: On average, how many classes do you attend per week in your main martial art?

.....(Number of sessions)

Q8a: In the last 12 months how many new injuries have you had in training, sparring, grading or competition in your martial art? (We consider an injury to be anything from a muscle strain to a broken bone. Please do not include injuries such as minor bruises/cuts). 

.....(Number of injuries)

If you have had no injuries, thank you for taking part in the survey, please place it into the provided envelope and return it to the box labelled 'survey responses'.

If you have had one or more injuries, please move on to question 8b.

Q8b: Please list the injuries you counted for question 8a. (Please be specific e.g. sprained ankle right side). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8c: For each of your injuries you listed in question 8b, please explain how you got the injury. (e.g. doing a turning kick and my supporting ankle twisted). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8d: For each of your injuries you listed in question 8b, please identify where it happened (e.g. class, grading, competition). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8e: For each of your injuries you listed in question 8b, please indicate what activity you were doing when you got it (e.g. it was during sparring, stretching, or drill). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q8f: For each of the injuries listed in question 8b above please state if you were wearing any relevant personal protective equipment and what this was? (e.g. gum shield, headguard, gloves, shin pads). (If you were not wearing any protective equipment please state NONE). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q9a: For each of the injuries listed in question 8b, did you seek any advice or treatment for the injury? (Please tick one) If yes, please move on to Q9b, if not move on to Q9c.

Injury 1: **Yes** **No**

Injury 2: **Yes** **No**

Injury 3: **Yes** **No**

Injury 4: **Yes** **No**

Injury 5: **Yes** **No**

Please continue on a separate sheet if necessary.

Q9b: For each of the injuries listed in question 8b, if you sought advice or treatment, please state who this was from? (E.g. from instructor, first aider, GP). 

Injury 1:

Injury 2:

Injury 3:

Injury 4:

Injury 5:

Please continue on a separate sheet if necessary.

Q9c: For each of the injuries you listed in question 8b, did you have to take any time off training? If yes, please state how long this was for (e.g. six weeks)? 

Injury 1: No Yes How long?.....

Injury 2: No Yes How long?.....

Injury 3: No Yes How long?.....

Injury 4: No Yes How long?.....

Injury 5: No Yes How long?.....

Please continue on a separate sheet if necessary.

Q10: Were any of your injuries in Q8b a result of an old injury that you re-injured? (Please tick yes or no below).

Injury 1: Yes No

Injury 2: Yes No

Injury 3: Yes No

Injury 4: Yes No

Injury 5: Yes No

Please continue on a separate sheet if necessary.

This is the end of the survey. Thank you for your participation. Please seal the form in the envelope provided and drop this into the box labelled 'survey responses'.



APPENDIX 9
WEIGHTED ESTIMATES EXAMPLE

This appendix gives an example of the calculations used for weighted proportions and weighted 95% confidence intervals. The example used is to calculate the amateur group of participants weighted proportion and subsequent rate per 1000 athlete exposure.

n = the number of injuries

p = crude proportion of injury

w = proportion of sample

N in this situation refers to the number of athlete exposures

SE = standard error

CI = confidence interval

$$\text{Crude proportion of injury (p)} = \frac{n}{N}$$

$$\text{Proportion of sample (w)} = \frac{N}{\Sigma N}$$

Weighted injury proportion = pw

Study	Athlete Exposures (N)	Number of relevant injuries (n)	Crude injury proportion (p)	Proportion of sample (w)	Weighted injury proportion
1	295	25	0.085	0.098	0.008
2	220	12	0.055	0.073	0.004
3	2498	17	0.007	0.829	0.006
Total	3013	54	0.146	1 or 100%	0.018

$$SE = \sqrt{\sum \left(\frac{w}{\sum wN}\right)^2 \cdot np(1-p)}$$

Study	$w_i n_i$	$p(1-p)$	$\left(\frac{w}{\sum w n}\right)^2$	$np(1-p)$	$\left(\frac{w}{\sum w N}\right)^2 \cdot np(1-p)$
1	28.88	0.0776	2.14×10^{-9}	6.32×10^{-7}	4.90×10^{-8}
2	16.06	0.0516	1.19×10^{-9}	2.62×10^{-7}	1.35×10^{-8}
3	2071	0.0068	1.54×10^{-7}	3.8×10^{-4}	2.59×10^{-6}
Total	2116				2.65×10^{-6}

Therefore: $SE = \sqrt{0.00000265}$ $SE = 0.0016$

95% CI = weighted proportion +/- 1.96SE

95% CI = 0.018 +/- 1.96(0.0016)

95% CI = 0.0147 to 0.0211

To convert this to 1000 athlete exposures, multiply by 1000:

Therefore weighted proportion = 0.018 x 1000 = 18

Lower 95% CI: 0.0147 x 1000 = 14.7

Upper 95% CI: 0.0211 x 1000 = 21.1

Thus weighted proportion with 95% CI is:

18.0 injuries per 1000 AE with 95% CI of 14.7 to 21.1