A musculoskeletal injury profile of league tennis players in the northern eThekwini region

By

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This work is submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at the Durban University of Technology

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

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Dedication

I dedicate this to my parents Craig and Pam. You have provided me with everything I have ever needed. You have always been there to motivate and to drive me to better myself and grow as a person. You have sculpted me into the man I have become today and I hope that I will continue to make you proud.

Acknowledgements

I would like to thank my parents, all my aunts and uncles and especially my grand parents Minnie and Digs. The love and support I have received from all of you has helped me get through this.

To my girlfriend Jamie. I am so grateful to have had you share this journey with me. Thank you for putting up with me through all the ups and downs.

To my supervisor, Dr. Garrick Haswell, thank you all your time and effort in helping me complete this dissertation. Thank you for being a great mentor during my earlier years, for always having some great stories and for always being such a “good oke”.

To Dr. Charmaine Korporaal, what you do for this profession is immeasurable. Thank you for all your help and guidance through the years.

To Mrs Avenal Finlayson, thank you for your help in the library and the Research Commons.

To the Clinic staff, Pat, Linda, Mrs Drake and the lecturers, thank you for all the work you put in behind the scenes to help this department run the way it does.

To Bronwyn Jones, my proof-reader. Thank you for working so fast and efficiently. I really appreciate your help.

To Mrs Tonya Esterhuizen for her time and help with the data analysis and interpretation of the statistics.

Lastly to all my classmates, the “original ones” and the ones we gained along the way, we’ve made some awesome memories. Thank you for all the good times.

Abstract

Background: Tennis is one of the most popular sports globally with over 75 million players around the world. Most studies have focused on junior or elite level players although the majority of players around the world are presumed to be recreational/non-professional players. To date, limited research is available pertaining to the epidemiology of tennis related musculoskeletal in non-professional league tennis players in South Africa. This study aimed to determine the profile of musculoskeletal injuries amongst league tennis players in the northern eThekwini region.

Methods: This was a quantitative, cross-sectional, descriptive study utilizing a self-administered questionnaire, developed specifically for this research utilizing an expert group and pilot study. The questionnaire contained sections on demographics, tennis history, training and nutrition, court surface and equipment as well as a section on tennis related musculoskeletal injuries. Risk factors for injury were first tested using chi square tests in the case of categorical variables, and t-tests in the case of continuous variables. In order to assess the relationship between injury and potential risk factors for injury, a binary logistic regression using backward selection based on likelihood ratios was used. Odds ratios and 95% confidence intervals of the variables remaining in the model at the end were reported. A p value <0.05 was used to indicate statistical significance.

Results: Eighty league tennis players responded giving a response rate of 70.16%. The period prevalence, and the point prevalence of tennis related musculoskeletal injury was 68.75% and 36.25% respectively. A predominance of injuries to the upper extremity were recorded (49%) compared to the lower extremity (27.5%) and the back and trunk (23.5%). The elbow was the most common anatomical site of injury (21.4%) followed by the shoulder (19.4%), the lumbar spine (17.3%) and the knee (8.2%). Age was considered to be a risk factor for injury (p=0.049) as older players in the study (49.32 (17.547) years of age) were less likely to contract an injury than younger players (48.38

(13.210) years of age). The likelihood of injury decreased with a higher Body Mass Index (*p*=0.042). The relationship between consumption of spirit alcohol and injury was significant (*p*=0.043). Ex-smokers had a higher chance of contracting an injury (*p*=0.013). It was also found that those who cycled weekly were less likely to contract an injury (*p*=0.040).

Conclusion: The results concur with other studies on recreational/non-professional tennis players and add insight into risk factors predisposing this population to injury. Health care practitioners need to understand the risk factors for injury in this population so that players can be better managed. Using the results of the study, an injury prevention strategy such as a strength and conditioning program, needs to be implemented with the goal to reduce or prevent common injuries in this population of players.

Key terms: Tennis, musculoskeletal, injury profile, musculoskeletal injuries, chiropractic, prevalence

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Definitions

Acute injury	It is a short-term injury that occurs due to a single traumatic event (Dorland 2007).
Amateur	A person who engages in a sport on an unpaid basis (Oxford Dictionaries 2015a).
Anatomy	The branch of science concerned with the bodily structure of humans (Oxford Dictionaries 2015b).
Anterior	Referring to the front of the body or a position closer to the front than another (Lippert 2006).
Backhand	A stroke played across the body with the back of the hand facing the direction of the strike (Sports Definitions 2011).
Baseline	The line marking the back of the court (Sports Definitions 2011).
Biomechanical	Relating to the application of mechanical principles to living structures (Dorland 2007).
Chronic	See Overuse injury.
Confidentiality	Confidentiality is the inability of other people to associate individual people with specific questionnaire responses (Salant and Dillman 1994).
Eccentric muscle contraction	Occurs when there is joint movement, but the muscle appears to lengthen, and the muscle attachments separate (Lippert 2006).

Forehand The forehand is played with the palm of the hand facing the direction of the strike (Sports Definitions 2011).

Incidence This term describes the “occurrence of new cases of disease, injury, or other medical conditions over a specified time period, typically calculated as a rate or proportion” (Encyclopaedia Britannica 2014).

Injury rate Number of injuries per unit of exposure time (Hopkins *et al.* 2007).

Instability Inability of a joint to maintain support (Dorland 2007).

Kwa-Zulu Natal Kwa-Zulu Natal is one of nine provinces in South Africa.

Management The management plan includes the treatment of the area of complaint / injury (within the designated scope of practice of the practitioner) as well as addressing the overall health care of the athlete in order to ensure appropriate healing, recovery, rehabilitation and return to sport performance (Hyde and Gengenbach 2007).

Novice See Amateur.

Odds of injury Probability injury will occur divided by probability injury will not occur (Hopkins *et al.* 2007).

Overuse Injury An injury that was not initiated by a specific traumatic incident, but causing symptoms of pain or swelling (Beachy *et al.* 1997). It usually persists over a long period of time (Dorland 2007).

Participant Any individual who voluntarily chose to take part in this study.

Posterior	Referring to the back of the body or to a position closer to the back then another (Lippert 2006).
Prevalence	The number of cases of a specific disease in a given population at a specific time (Dorland 2007).
Professional player	For the purpose of this study it is a highly skilled player who earns a salary from competing in tennis tournaments (Oxford Dictionaries 2015c)
Recreational player	See Amateur.
Service	Every point is started with a serve. Both feet must be behind the baseline when the serve is struck. The ball is tossed into the air and is struck in a similar manner to an overhead smash (Sports Definitions 2011).
Smash	A powerful attacking shot played when the ball is above the head (Sports Definitions 2011).
Traumatic injury	See Acute injury.
Treatment	The treatment includes the combination of directed therapies or Interventions (within the designated scope of practice of the practitioner) utilised to address a particular injury / area of complaint in a patient (Hyde and Gengenbach 2007).

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Abbreviations

ATP	The Association of Tennis Professionals
BAC	Blood Alcohol Concentration
CI	Confidence interval
cm	centimeter
DUT	Durban University of Technology
GP	General practitioner
IREC	Institutional Research Ethics Committee
kg	Kilogram
KZN	Kwa-Zulu Natal
lbs.	Pounds
m	Meter
n/a	Not applicable
NTRP	National Tennis Rating Program
OR	Odds ratio
Q	Question
sig.	Significance
sq.in	Square inches
VMS	Vitamins Minerals and Supplements
WTA	Women's Tennis Association

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Tennis is one of the most popular sports globally with over 75 million players around the world (Pluim *et al.* 2007). Tennis is an Olympic sport, but it can also be played by any person, at any age who are able to hold a tennis racket (including people who are wheelchair dependent) (Baker 1988).

Tennis is either played individually against a single opponent, which is known as “singles”, or it can be played in teams of two against a team of two opponents, which is known as “doubles” (Baker 1988). The game is played on a rectangular court, which is 23.77m long and 8.23m wide for singles matches, and 10.97m wide for doubles matches. A net, which is 0.914m high at the centre, passes over two net posts on the side of the court that are 1.07m high (International Tennis Federation 2014). The object of the game is for the individual, to strike a felt covered hollow ball using a tennis racket, over the net and into the opponent’s court so that they are unable to return the ball back into court (Baker 1988).

Playing tennis, whether as a beginner as a recreational hobby or at a professional level places players at risk of injury (Pluim *et al.* 2006). Tennis players are required to repetitively generate high velocity arm movements in order to strike the tennis ball, therefore predisposing the upper extremity to overuse injuries (Abrams, Renstrom and Safran 2012). Due to the physical demands of the sport, musculoskeletal injuries can occur in nearly all anatomical regions (Pluim *et al.* 2006). In order to reach the ball during play, players are required to accelerate, decelerate, pivot and jump, which places repeated rotational sheer and loading forces on the joints of the lower extremity (Kibler and Safran 2005).

The purpose of the review by Pluim *et al.* (2006) was to identify gaps in the literature and to encourage further epidemiological research in the field of tennis injuries. Abrams, Renstrom and Safran (2012) also stated that further studies on the epidemiology of tennis injuries are needed. Ellenbecker *et al.* (2009) stated that common injuries, and risk factors for injury in tennis players need to be identified so that a specific strength and conditioning program can be put in place to prevent these injuries from occurring.

Thus, this study aimed to investigate the musculoskeletal injury profile of league tennis players in the northern eThekwini region. The primary objective outcomes were to describe the demographic profile as well as to determine the prevalence of musculoskeletal injuries and then finally describe the association between selected risk factors and the prevalence of injury amongst league tennis players in the northern eThekwini region.

1.2 Research aim and objectives

The aim of the study was to determine the profile of musculoskeletal injuries amongst league tennis players in the northern eThekwini region.

The First Objective was to describe the demographic profile of league tennis players in the northern eThekwini region.

The Second Objective was to determine the prevalence of musculoskeletal injuries amongst league tennis players in the northern eThekwini region.

The Third Objective was to describe the association between risk factors and prevalence of injury amongst league tennis players in the northern eThekwini region.

1.3 Rationale for the study

The majority of tennis players around the world are neither elite nor professional players and are presumed to be recreational players, however most epidemiologic studies regarding tennis have focused on junior and elite tennis players (Jayanthi *et al.* 2005). To the researcher's knowledge, there is paucity of literature on the epidemiology of injuries in league tennis players in South Africa.

Tennis racket technology has improved since the 1980s when rackets were made out of wood (Miller 2006). They were heavy, flexible and had a small racket head size (Miller 2006). Therefore it was only possible for players to generate slow swing speeds, using their body weight to initiate the stroke (Tanprasert and Tanprasert 2013). According to Elliott (2006), the heavy, flexible wooden rackets as well as the type of technique used to strike a tennis ball, meant that players were less frequently injured. Modern day rackets are light-weight, stiff and made out of composite materials (Miller 2006). This allows players to generate faster swing speeds (Tanprasert and Tanprasert 2013). There is a higher chance of injury using modern tennis rackets because the increased stiffness of the racket, combined with the player's ability to generate faster swing speeds, results in more shock being transferred to the upper limb (Elliott 2006). By investigating these injuries and contributing factors, it will assist in furthering the knowledge of how such injuries occur. This information will help non-professional tennis players improve their technique and as such prevent further injuries.

According to Jayanthi *et al.* (2005), the majority of tennis players around the world are to non-professional. It can therefore be stated that the majority of tennis players in South Africa play for recreational purposes and do not earn a salary from competing in tournaments. It is vital that as health care practitioners in South Africa, chiropractors can use the results of this study as a guide to understand which anatomical sites are most frequently injured in this population. This knowledge may enable a cost effective treatment to be developed with a view to reduce and prevent future injury

1.4 Limitations of the study

As this study is a questionnaire based study, it was assumed that the participants understood the questions and answered the study's questionnaire openly and honestly, to reflect their past injuries as well as their injuries at that point in time when they completed the questionnaire (Mouton 1996; Dyer 1997; Mouton 2001). Additionally, the outcomes of this study only includes information from league tennis players that accepted the invitation to participate in this study, therefore the results may only be generalised to a similar population group (This is discussed in Chapter Four, which discusses response rates).

1.5 Outline of chapters

This chapter provided an introduction to the study, presenting the study's context and setting, the aim and objectives as well as the limitations and benefits of the study are also described. Chapter Two which follows reviews the literature behind the game of tennis and risk factors associated with participation in the sport. Chapter Three looks at the methods and tools used to obtain the information to meet the aims and objectives of the study. The results are then presented and in Chapter Four. In Chapter Five, the results of the study are discussed. Chapter Six concludes the study and offers recommendations for future studies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter Two is an overview of the current literature. The aim is to enhance the readers' understanding about tennis, and selected risk factors that have been identified as predisposing tennis players to injury.

It is estimated that there are about 75 million tennis players around the world, making it one of the most popular sports (Pluim *et al.* 2007). The sport can be played by anyone who is able to hold a racket (including people who are wheelchair dependent) (Baker 1988).

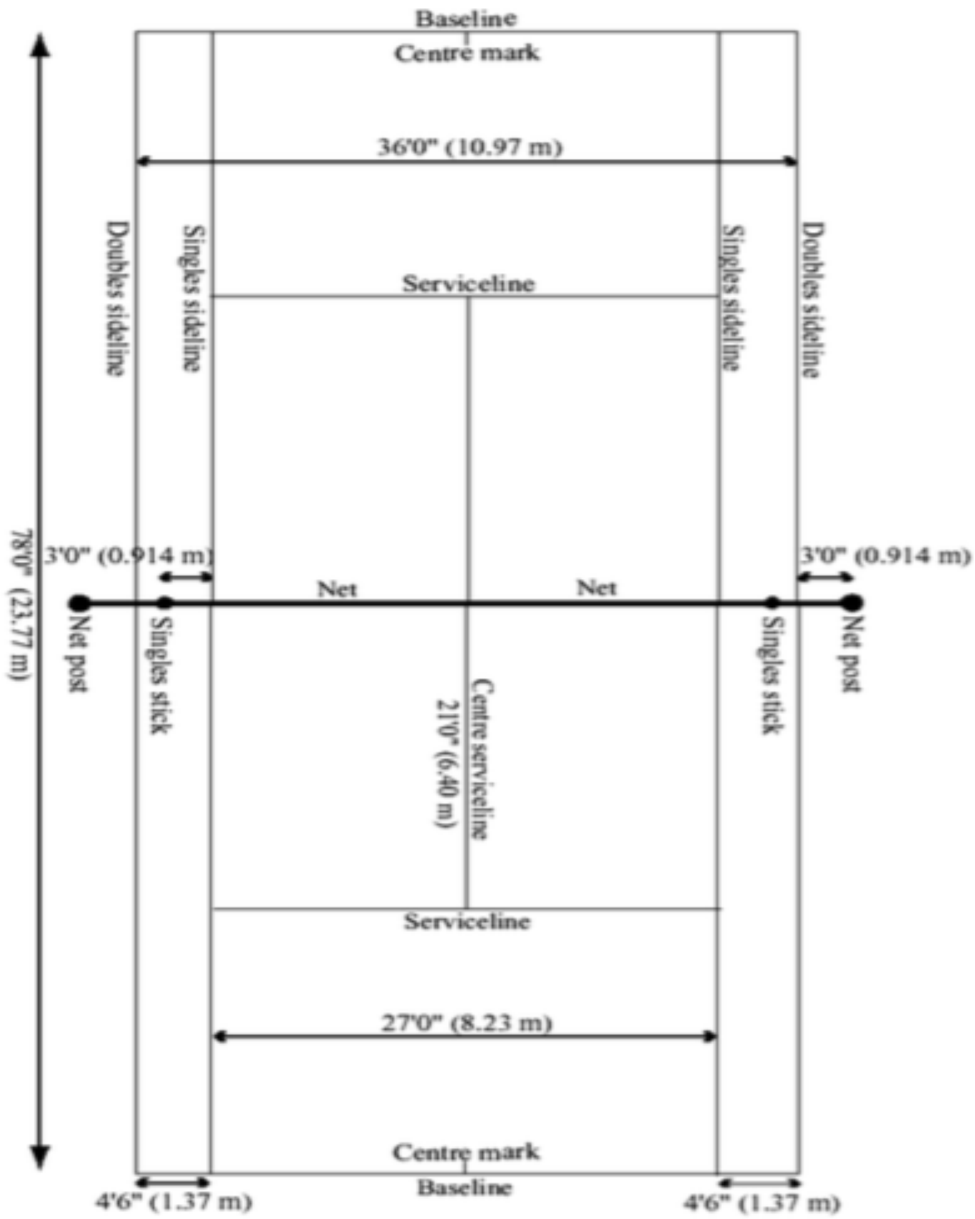
2.2 Background of tennis

2.2.1 The origin of tennis

The game of tennis is thought to have originated in the monasteries of northern France in the 12th century (Gillmeister 1998). Back then, players would strike the ball by hand and it was named “jeu de paume” (game of the palm) (Gillmeister 1998). Rackets were introduced into the game in the 16th century and from then on the game was known as “tennis” (Crego 2003).

2.2.2 Plan of the tennis court

Figure 2.1: Plan of the court (International Tennis Federation 2014).



The game is played on a rectangular court, which is 23.77m long and 8.23m wide for singles matches, and 10.97m wide for doubles matches. A net, which is 0.914m high at the centre, passes over two net posts on the side of the court that are 1.07m high (figure 2.1). The court surface can be made from clay, grass, carpet or a hard acrylic substance (known as a hard court) (International Tennis Federation 2014). Different court surfaces alter the “pace” of the game, clay courts have the slowest “pace” because of the high amount of friction between the ball and the court surface (Miller 2006). On the other hand, due to the low amount of friction between the ball and the surface, combined with low rebound of the tennis ball, players perceive grass courts to be the fastest of the different surfaces (Miller 2006).

2.2.3 Tennis rackets

Tennis rackets consist of a frame and strings. Until the 1970’s, rackets were made from wood (Miller 2006). Tennis racket technology has developed considerably and modern tennis racket frames are now made out of materials such as graphite and carbon fibre (Miller 2006; Tagliafico *et al.* 2009). According to the International Tennis Federation (2014) a tennis racket may not exceed 73.7cm in length and 31.7cm in width.

2.2.4 Tennis balls

A tennis ball is a round, fabric covered hollow ball that is either yellow or white in colour. The International Tennis Federation (2014) specified that a tennis ball must weigh between 56.0g and 59.4g and have a diameter that ranges between 6.54 and 6.86cm.

2.2.5 The object of the game

Tennis is either played individually against a single opponent, which is known as “singles”, or it can be played in teams of two against a team of two opponents, which is known as “doubles” (Baker 1988). The object of the game is for the individual, to strike the ball over the net using a tennis racket and into the opponent’s court so that they are unable to return the ball back into court (Baker 1988).

2.3 The prevalence of tennis related musculoskeletal injury

The demands of tennis put a lot of physical strain on players, and as a result, they may develop musculoskeletal injuries in nearly all of their anatomical regions (Pluim *et al.* 2006). Tennis players are required to repetitively generate high velocity arm movements to strike the tennis ball, which predisposes their upper extremities to a variety of overuse injuries (Abrams, Renstrom and Safran 2012). Similarly, in order to reach the ball during a game, players are required to accelerate, decelerate, pivot and jump, which places repeated rotational sheer and loading forces on the joints of the lower extremities (Kibler and Safran 2005).

In a systematic review of the tennis literature, Pluim *et al.* (2006) investigated twenty-eight published epidemiological studies on tennis and reported that most injuries occurred in the lower extremities (31-67%) followed by the upper extremities (20-49%) and the trunk (3-21%).

Similarly, Kibler and Safran (2005) reviewed the injury patterns in elite junior tennis players and found similar outcomes to those found by Pluim *et al.* (2006), but with a slightly higher prevalence of back and trunk injuries (11-30% of all injuries).

Statistics on injury location by Pluim *et al.* (2006) are similar to those found by Ellenbecker *et al.* (2009). After reviewing the literature it was found that most injuries occur in the lower extremity (39-63.6%), followed by the upper extremity (24.9-45.8%) and then lastly the head and trunk being the least affected (10-22%) (Table 2.1). Veijgen (2007) found that the lower leg was the most frequently injured (18%) (Table 2.1). Khune, Zettl and Nast-Kolb (2004) reported that the pelvis/hip was the most frequently injured part of the body (27.1%) (Table 2.1). Winge, Jorgensen and Lassen Nielson (1989) and Jayanthi *et al.* (2005) found there to be a predominance of injuries in the upper extremity with the shoulder (17.4%) and elbow (20%) being the most frequently injured body parts respectively (Table 2.1).

Table 2.1: Analysis of injury location in tennis players. Adapted from (Ellenbecker *et al.* 2009)

Study type	Prospective	Prospective	Prospective	Prospective	Prospective	Prospective	Retrospective
Author	(Veijgen)	(Khune, Zettl and Nast-Kolb)	(Safran *et al.*)	(Hutchinson *et al.*)	(Winge, Jorgensen and Lassen Nielson)	(Jayanthi *et al.*)	(Chard and Lachmann)
"n"	283	335	233	304	46	299	131
Head/Trunk	**10**	**11.3**	**19.9**	**22**	**11**	**10**	**20**
Head/Neck	1.1	0	4.2	7	0	0	2
Back	0	0	12.1	12	0	10	0
Upper back/chest	1.1	11.3	0	0	11	0	16
Lower back	7.8	0	0	0	0	0	0
Abdomen	0	0	3.6	3	0	0	0
Upper Extremity	**36.7**	**24.9**	**27.7**	**27**	**45.8**	**41**	**35**
Shoulder	12	11.8	10.7	9	17.4	15	9
Arm	2.8	0	5.0	0	4.4	0	0
Elbow	13.1	4.4	8.5	8	10.9	20	14.5
Forearm	2.8	5.1	0	0	2.2	0	0
Wrist/hand	6	3.6	3.5	10	10.9	6	7
Lower Extremity	**53.3**	**63.6**	**52.5**	**51**	**39**	**39**	**45**
Pelvis/Hip	3.5	27.1	6.4	8	0	0	0
Thigh/Groin	8.5	0	9.9	21	4.3	5	0
Knee	12.7	7.8	5.0	2	6.5	12	19
Lower Leg	18	14.6	0	2	4.3	1	0
Calf/Achilles	0	0	9.2	0	4.3	5	4
Ankle	8.5	6.9	8.5	7	10.9	8	5.5
Foot/toes	2.1	7.2	13.5	11	8.7	8	4
Other	0	0	0	0	4.3	3	(19)*
Total	**100**	**99.8**	**100.1**	**100**	**100.1**	**93**	**100**

All values are expressed in percentage

Abrams, Renstrom and Safran (2012) performed a recent systematic review of the epidemiology of tennis related musculoskeletal injuries. Their findings concur with those of Pluim *et al.* (2006) and Ellenbecker *et al.* (2009) in that the majority of injuries occur in the lower extremity (31%-67%), the upper extremity (20%-49%) and lastly the back and trunk (3%-21%). The ankle and the thigh were the most frequent anatomical sites of injury in the lower extremity while the elbow was the most frequently injured anatomical site in the upper extremity.

The prevalence of shoulder pain has been shown to range from 4% to 17% (Winge, Jorgensen and Lassen Nielson 1989; Hutchinson *et al.* 1995; Sallis *et al.* 2001; Khune, Zettl and Nast-Kolb 2004). In young, elite players aged 12 to 19 prevalence of shoulder pain was reported to be 24% and in middle aged players the prevalence of shoulder pain is as high as 50% (Lehman 1988).

2.4 Injuries

2.4.1 Acute and chronic

Acute injuries are those which occur suddenly during activity, e.g. a traumatic event such as slipping or falling (Eustice 2014) which can cause ligament sprains, muscle tears, joint dislocations and bone fractures (Cluett 2014). A chronic injury is the result of overuse of a body part or a long standing condition (Eustice 2014). Some common chronic musculoskeletal injuries include overuse syndromes, tendonitis, tendinosis, bursitis and arthritis (Cluett 2014). According to findings from previous studies, it has been stated that acute musculoskeletal injuries occur more often in the lower extremities, whereas chronic or overuse injuries occur more frequently in the upper extremity (Pluim *et al.* 2006; Abrams, Renstrom and Safran 2012)

2.4.2 Commonly injured structures

2.4.2.1 Muscles and fascia

Injuries to muscle and fasciae are as a result of neuromuscular dysfunction (Simons, Travell and Simons 1999). Muscles are required to contract and relax repeatedly in the upper extremity so that the player can strike the tennis ball, as well as in the lower extremity so the player is able to run on the tennis court. However, according to Hyde and Gengenbach (2007) fatigue eventually sets in due to the repetitive nature of the game, which results in musculoskeletal pain. Overused muscles can develop trigger points which may cause referred pain in a pattern specific to the affected muscle (Simons, Travell and Simons 1999). Biomechanical abnormalities can lead to problems with the muscle and the overlying fascia, which can also affect the spinal segments resulting in dysfunction and pain (Brown 2002).

2.4.2.2 Tendons

The function of a tendon is to attach muscle to bone (Lippert 2006; Comfort and Abrahamson 2010). Tendonitis is defined as inflammation of the tendon resulting in mild pain (Khan, Cook and Taunton 2000; Lippert 2006). Untreated tendon pathologies such as tendonitis will eventually undergo degenerative changes within the tendon, resulting in increased pain. When microscopic degenerative changes have occurred in a tendon, the condition becomes known as tendinosis (Khan, Cook and Taunton 2000). According to Brown (2002), the use of performance enhancing substances, such as anabolic steroids, have been linked to an increased likelihood of injury to tendons.

2.4.2.3 Bursae

Bursae form between joint surfaces and tendons or areas where surfaces tend to contact and rub over one another. They are potential spaces and their function is to reduce friction between these surfaces that are contact with one another. When inflammation or irritation of bursae occurs it is known as bursitis (Brown 2002).

2.4.2.4 Nerves

The nervous system can be divided into the Central Nervous System (CNS) and Peripheral Nervous System (PNS). The CNS is made up of the brain and spinal cord (Lippert 2006). The PNS consists of nerves that extend from the brain and spinal cord known as spinal nerves. Their function is to carry sensory impulses to the spinal cord upwards into the brain and carry motor impulses from the brain, down the spinal cord to muscles and organs (Lippert 2006). Compression or stretching of spinal nerves may lead to spinal/peripheral nerve dysfunction which can cause muscle weakness and pain (Brown 2002; Lippert 2006).

2.4.3 Common tennis injuries

2.4.3.1 The upper extremity

Chronic injuries in the upper extremity develop due to repetitive nature of the tennis (Pluim *et al.* 2006; Abrams, Renstrom and Safran 2012). The rotator cuff muscles and the biceps tendon maintain the stability of the glenohumeral joint during tennis strokes (Ryu *et al.* 1988). Over time tennis players usually develop glenohumeral instability, which results in rotator cuff tendonitis, biceps tendonitis and/or glenoid labrum pathology (van der Hoeven and Kibler 2006).

"Tennis elbow" or lateral epicondylitis is one of the most common injuries, especially in recreational tennis players (De Smedt *et al.* 2007). De Smedt *et al.* (2007) further stated that pain in the elbow region is caused due to tendinopathy of the extensor carpi radialis brevis (ECRB) tendon, which inserts into the lateral epicondyle of the elbow.

According to Tagliafico *et al.* (2009), wrist injuries are not as common as other injuries in the upper extremity. According to the literature, injuries such as extensor or flexor tendonitis, ligament tears, triangular fibrocartilage injuries, ulnar carpal impingement and fractures of the hook of hamate are prevalent in the hand and wrist (Jacobson, Miller and Morag 2005; Tagliafico *et al.* 2007).

2.4.3.2 The lower extremity

Injuries in the lower extremity are usually more acute in nature, but the lower extremity is prone to overuse injuries as well (Pluim *et al.* 2006; Abrams, Renstrom and Safran 2012). Knee are common in tennis players because they are required to make sudden changes in direction in order to reach the ball (Gecha and Torg 1988) Overuse injuries affecting the knee include conditions such as; patellar tendonitis, bursitis and patellofemoral pain, especially in females (Perkins and Davis 2006). Some examples of acute injury in the knee are; medial collateral, lateral collateral and a cruciate ligament tears as well as meniscal tears (Gecha and Torg 1988).

According to Perkins and Davis (2006), injuries to the lower leg are common in tennis players. A condition known as "tennis leg" is caused by a small tear of the medial head of the gastrocnemius muscle, at the musculotendinous junction (Zecher and Leach 1995). Other common conditions that occur in the lower leg include achilles tendonitis, and medial tibial stress syndrome, which is also known as "shin splints" (Zecher and Leach 1995).

Ankle sprains have been reported to be one of the most common acute injuries in the lower extremity (Hjelm, Werner and Renstrom 2010). According to Zecher and Leach (1995) the most common type of ankle sprain is an inversion ankle sprain which affects the anterior talofibular, calcaneofibular and posterior talofibular ligaments. Other conditions affecting the foot and ankle include conditions such as plantar fasciitis and "tennis toe", which is degeneration of the first metacarpal phalangeal joint (Zecher and Leach 1995).

2.4.3.3 The trunk and back

An acute lumbar strain is the most common injury affecting the lower back of tennis players (Perkins and Davis 2006). The multifidus and erector spinae muscles are at risk of injury due to repetitive rotation and extension of the players trunk (Hainline 1995). The serve places the most amount of stress on the structures in the lower back, especially the lumbar intervertebral disks (Chard and Lachmann 1987). A player is required to hyper-extend and rotate their trunk and this can lead to tears in the annular fibrosis, which increases their chances of herniating an intervertebral disk at a later stage (Hainline 1995).

2.5 Risk factors associated with injury

2.5.1 Age

Due to the repetitive nature of tennis, older players are generally more susceptible to injury because of muscle degeneration (Von Kramer and Schmitz-Beuting 1979). In a review by Jayanthi *et al.* (2005), where data was collected from 528 recreational league tennis players across all skill levels, it was found that there was a correlation between increasing age of players and injury rates. However, a group of players aged 55 years and older, reported that their injury rates were lower than that of players younger than 55 years of age (Jayanthi *et al.* 2005).

2.5.2 Gender

According to Bylak and Hutchinson (1998), males and females competing in the same sporting code tend to present with similar injury patterns. Sallis *et al.* (2001) studied the injury rates of almost 4 000 male and female college athletes over a 15-year period and found that during this time 1 800 injuries had been reported. But, the overall difference in injury rates between them was considered to be insignificant when sub-group analysis took place.

However, according to Silva *et al.* (2003), females were more frequently injured than males. This result is contradicted by Hjelm, Werner and Renstrom (2010) where it was found that more males were more frequently injured than females.

2.5.3 Weight, Height and Body Mass Index (BMI)

Players' height and weight measurements of players reflect their growth and development and could even reflect their general level of fitness, for example, obesity (Saglimbini 2007). Saglimbini (2007) further states that these measurements are valuable in screening athletes for risk of injury.

Body mass index, or BMI, is a ratio of weight to height (Prentice 2006). It is calculated by dividing a person's weight by their height squared (weight/height^2). The Centers for Disease Control and Prevention (2015) have classified the following BMI ranges for adults as follows:

- Below 18.5: Underweight
- 18.5 – 24.9: Normal or Healthy weight
- 25.0 – 29.9: Over weight
- 30.0 and above: Obese

BMI may be used to evaluate a tennis player's general fitness and risks for competing in league tennis. Health risks are associated to a BMI of more than 25 (Prentice 2006). Research by Prentice (2006) and Saglimbini (2007) suggested that BMI can influence injury rates.

According to Prentice and Jebb (2001), it is well known that BMI gives a poor representation of body fat in individuals with developed musculature, which results from prolonged periods of physical training.

Nielsen *et al.* (2013) found that the incidence of running-related injuries (RRI) in novice runners is significantly associated with a high BMI. These results are in agreement with findings by Buist and Bredeweg (2010) who found a significant difference in RRI (p=0.03) between runners with a BMI over 25, and those with a BMI of less than 25.

2.5.4 Handedness

Studies have shown that in the general population, around 70-90% of people are right-handed (Holder 1997; Cardwell, Clark and Meldrum 2000). The results of this study fall within the above-mentioned percentage. A report by Raymond *et al.* (1996) estimate that only 10% to 13% of the western world are left handed and are predominantly male (Papadatou-Pastou *et al.* 2008).

2.5.5 Hours of play versus injury

According to Abrams, Renstrom and Safran (2012), there is a positive correlation between increased hours of play and rate of injury. Similarly, Pluim and Staal (2009) found an overall increase in injury rates in people who played tennis for more than 3 hours per week.

In the systematic review by Abrams, Renstrom and Safran (2012) there were two studies identified, by Gruchow and Pelletier (1979) and Kitai *et al.* (1986), that examine the relationship between hours of play and the development of lateral epicondylitis. Kitai *et al.* (1986) found that amateur players who presented with symptoms of lateral epicondylitis, played tennis for 8 or more hours per week, and those players who played an average of 5.5 hours or less per week did not present with symptoms. According to the study by Gruchow and Pelletier (1979), players who played tennis more than 2 hours per day reported more frequent elbow pain than those who played for less than 2 hours per day.

2.5.6 Skill level

The United States Tennis Association developed the National Tennis Rating Program (NTRP) as a means of classifying the skill levels of players to allow more compatible matches, lessons, league play and tournaments between players of similar ability (United States Tennis Association 2014). Jayanthi *et al.* (2005) published a study which documents the association between risk of tennis related musculoskeletal injuries and skill level in recreational players. Players in the study were required to self-rate their skill level based on the criteria set out by the NTRP. The results of this study did not show any statistical difference in injury rates between players with different NTRP ratings.

According to Henning, Rosenbaum and Milani (1992), less experienced players were more prone to striking the tennis ball “off-centre” compared to more experienced players. When a player strikes a tennis ball off-centre it causes the tennis racket to vibrate more than it would for a shot that was struck off the “sweet spot” on the racket strings. Therefore higher vibration loads would be transferred through the racket and into the players’ wrist and elbow. This was confirmed by Wei *et al.* (2006), that experienced players were able to reduce racket vibration (due to impact with the tennis ball) transferred to the wrist and arm by 89% by loosening their grip on the racket during the follow through phase of the backhand, whereas novice players could only reduce the impact vibration by 62% because they maintained a tight grip on the racket during the follow through. The authors of that study believed that novice players unintentionally had an inconsistent point of contact between the racket and ball upon the racket strings.

Similarly, Henning, Rosenbaum and Milani (1992) also stated that experienced players do not tend to hold a tennis racket as tightly as less experienced players. This means that holding a racket with less force decreases the vibration load that transfers from the racket to the players arm and this in turn leads to fewer injuries in the upper extremity. However, professional or experienced players might have a better stroke technique compared to less experienced players, but due to their increased volume of play, similar rates of injury are found between the two groups (Abrams, Renstrom and Safran 2012).

2.5.7 Cigarette smoking

Cigarette smoking has been reported to be an independent risk factor for developing musculoskeletal pathologies (Jones *et al.* 1993; Reynolds *et al.* 1994; Altarac *et al.* 2000; Kapnik *et al.* 2001). Studies have shown that skeletal muscle is damaged due to the presence of free radicals which results in impaired muscle metabolism, increased inflammation and oxidative damage (Rom *et al.* 2012). Cigarette smoking has also been shown to suppress the immune system, cause micro-vascular damage to blood vessels and reduce blood flow by producing carbon monoxide; all of which may cause injury or delay the healing of bones, ligaments and muscles. (Gu *et al.* 1993; Huie 1996). Smoking has also been associated with recurrent shoulder pain, rotator cuff tendinopathy (Bodin *et al.* 2012) and back pain (Ernst 1993).

2.5.8 Alcohol consumption

According to (Maughan and Burke 2008) alcohol and sport are closely associated through advertising and sponsorships, and now days consuming alcohol training or post-competition has become a social ritual. Dietary surveys of athletes have shown that they may only consume alcohol on a few separate occasions during the month, but when they consume alcohol, it is usually in excessive amounts. Alcohol causes dilation of blood vessels that can lead to excessive swelling in an injured area resulting in an increased recovery time (Maughan and Burke 2008). It is also believed that an intoxicated athlete may not follow correct nutritional guidelines to improve their recovery after competing (Maughan and Burke 2008).

The rate of absorption of alcohol from wine, beer and spirits was studied by Mitchell, Teigen and Ramchandani (2014). On three separate occasion's they measured the blood alcohol concentration (BAC) in 15 healthy men after they consumed 0.5g of alcohol from beer, wine and spirits/tonic per kg of body weight. Their results showed that peak BAC was significantly higher (p=0.001) after the men consumed the wine and spirit/tonic mix than after consuming beer (p=0.001) than the peak BAC after consuming beer.

2.5.9 Nutrition

2.5.9.1 Nutrition for sport

Carbohydrates are a good source of energy and are stored in the body as glycogen in the liver, and skeletal muscles. Glycogen is an important source of fuel for an athlete. Periods of intense training and inadequate glycogen replacement will lead to chronic glycogen depletion resulting in impaired performance and fatigue. It is vital that an athlete replenishes glycogen stores after intense training. This can be achieved by an athlete following a diet that is high in complex carbohydrates (Brunker and Khan 2008).

Protein can be used as another source of energy in the body by the conversion of amino acids to glucose (Brunker and Khan 2008). Adequate protein in an athletes diet is vital as it helps to prevent muscle break down and is used to repair and rebuild damaged muscle tissue (Shamus and Shamus 2001; Brunker and Khan 2008).

Proper hydration is extremely important for any athlete (Shamus and Shamus 2001). Adult players generally lose between 1 and 2.5 liters of sweat per hour of competitive tennis in warm to hot temperatures (Bergeron, Armstrong and Maresh 1995). Athletes who are not hydrated adequately can suffer from heat cramps, which can be caused by depletion of electrolytes and fluids (Bergeron 2003). Therefore, athletes should replace lost fluids with a sports drink containing enough fluids, carbohydrates and electrolytes needed for proper rehydration (Shamus and Shamus 2001; Bergeron 2003).

Some guidelines for tennis nutrition/supplementation were formulated by Ranchordas *et al.* (2013). It is recommended that tennis players aim to consume the following amounts of carbohydrates, protein and fats daily:

- 6-10g of carbohydrates per kilogram body weight
- 1.6g of protein per kilogram body weight
- 2g of fat per kilogram body weight

Ranchordas *et al.* (2013) also recommended that tennis players consume the following during match play situations:

- 30-60 g per hour of carbohydrate in match play exceeding 2 hours
- 200 ml of fluid containing electrolytes per changeover, when ambient temperatures are below 27 degrees Celsius, or 400ml of fluid and electrolytes if over 27 degrees Celsius.

These amounts will vary slightly depending on the intensity of training/match play (Ranchordas *et al.* 2013). Amounts will be slightly less for women as their energy expenditure is less than males (Ranchordas *et al.* 2013).

Brunker and Khan (2008) stated player's risk of injury may be increased if their current diet does not offer the nutrients needed for proper recovery. The correct nutrition can positively affect an athletes recovery post-competition by helping to reduce muscle or joint soreness (Carpentier 2006).

2.5.9.2 Nutritional Supplements

According to Maughan, Depiesse and Geyer (2007), many athletes believe that their diet alone does not supply them with all the necessary nutrients needed to perform at an optimum level, they then turn to nutritional supplements in the hope that it will give them the competitive edge. The increased use of nutritional supplements among athletes has resulted in the Vitamins, Minerals and Supplements (VMS) industry becoming one of the fastest growing industries world wide, with an estimated revenue of $32 billion for supplements alone (Lariviere 2013). The target market supplement companies market their products to are men and women in the 18-40 year age group (Lariviere 2013).

Athletes categorise nutritional supplements according to the function of the supplement (Maughan, Depiesse and Geyer 2007). Table 2.2 shows some examples of popular nutritional supplements:

Table 2.2: Popular nutritional supplements used by athletes. Adapted from (Maughan, Depiesse and Geyer 2007)

Function of the supplement	Examples
Muscle growth and repair:	Protein powder; essential amino acids
Fat reduction:	Caffeine
Exercise metabolism:	Carbohydrate; caffeine
Promoting recovery:	Protein powders; carbohydrate bars
Joint health:	Glucosamine; chondroitin sulphate
General health:	Vitamins; minerals; omega oils
CNS stimulants:	Taurine; caffeine, guarana
Meal replacements:	Liquid meals; sports bars, carbohydrate gels
Fluid and electrolytes:	Sports drinks; electrolyte supplements

Maughan, Depiesse and Geyer (2007) stated that a balanced diet containing a variety of foods that are eaten in sufficient should provide all the nutrients required by the athlete. They further stated that supplements should not be used to substitute whole foods.

2.6 Facilities and Equipment

2.6.1 Court surface

Cross (2006) performed a retrospective study and collected statistics on the percentages of incomplete matches at all four tennis grand slam events. He found that the lowest percentage of incomplete matches were matches that were played on grass courts whereas the highest percentage of incomplete matches were matches played on hard courts. Kulund (1979) found that senior players who spent their careers playing on softer clay courts reported fewer knee problems compared to those players who spent their careers playing on hard courts. Nigg and Segesser (1988) suggested that there is a lower risk of playing on clay courts as opposed to hard courts.

2.6.2 Tennis racket design

Modern tennis rackets have been designed using materials such as graphite and carbon fiber, to make them lighter, bigger and stiffer than traditional wooden rackets (Miller 2006; Tagliafico *et al.* 2009). This new racket technology gives players more power and control (Tagliafico *et al.* 2009). This has allowed non-professional players, for example, league players to play a more aggressive game, not unlike that of a professional player (Browne and Helms 1998). However, this may lead to negative adaptive changes and an increase in overuse injuries in the non-professional player because they simply do not have the physical strength, flexibility, coordination or skills of a professional player (Tagliafico *et al.* 2007).

Tennis rackets with an oversize head (106-130sq.in) and weight range of 225g-280g are designed for beginners, or older players with shorter, slower swing speeds, who require more power from a racket as they are unable to generate the power on their own (Tennis Warehouse 2015). Intermediate to advanced players will often choose a racket with a head size of 96-105 sq.in. and a weight range of 281g-300g. These rackets offer a balance of power and control and therefore appeal to the majority of tennis players (Tennis Warehouse 2015). Professional, elite and high level club players will choose a heavier racket (301g and over) with a small head size (85-95 sq.in.). This racket appeals to these high-level players because they are able to generate their own power and therefore require a racket that offers them more control than power (Tennis Warehouse 2015).

Due to the changes in modern tennis rackets there is increased shock transmission from the racket into the tissues of the upper extremity (i.e. wrist, elbow, shoulder). Over time, prolonged exposure to vibrations in the upper extremity has the potential to lead to fatigue and tissue degeneration (Reynolds, Standlee and Angevine 1977; Nordin and Frankel 2001). Henning, Rosenbaum and Milani (1992) found that tennis rackets with a larger head diameter have a bigger "sweet spot", which means that players are less likely to contact the ball off-centre. Similarly, Kaimen (1990) found that that tennis rackets with a larger head size absorb vibrations better than smaller rackets. This may mean that less vibration would be transferred from the racket to the wrist and elbow therefore resulting in a lower risk of injury. However, oversize rackets also have the potential to cause more torque injuries from off-centre shots (Kaimen 1990).

According to Hyde and Gengenbach (2007), tennis rackets with a higher string tension will transmit more shock through the upper limb, which would cause tissue injury over time. Nirschl (1974) believed that heavier rackets, or rackets strung at a higher tension and rackets with an incorrect grip size may be associated with the development of conditions such as lateral epicondylitis because of increased forearm muscle activity placing strain on the extensor tendons in the elbow. A method for determining the correct grip size for a player was devised by Nirschl (1974), this involved measuring the distance from the tip of the players ring finder to their proximal palmar crease on their hand. It was believed that when using the correct grip size that the player wouldn't need to hold the racket with as much force, therefore decreasing the potential for the development of overuse injuries. However, Hatch, Pink and Mohr (2006) fount that there was no statistical difference in forearm muscle electromyography activity when over-sizing or under-sizing the recommended size of the racket grip by 6.25mm (1/4 inch).

It has been hypothesized by De Smedt *et al.* (2007) that grip size and the use of vibration dampeners would have an impact on the development of elbow pain, specifically lateral epicondylitis. Vibration dampeners have been used by players with the goal to reduce vibration loads transferred to the upper extremity (Li, Fewtrell and Jenkins 2004). Stroede, Noble and Walker (1999) found there to be no difference in discomfort experienced by players with and without vibration dampeners on their racket strings. This finding is supported by (Li, Fewtrell and Jenkins 2004), who found there to be no significant variations in vibrations transferred to the wrist between those players who used a vibration dampener and those players who did not use one.

2.6.3 Footwear

Hard tennis courts are extremely abrasive and will cause cross-trainers or running shoes to wear out much faster than tennis shoes because tennis shoes are purpose built and are made of abrasion resistant materials on the internal and external linings and sole (Wilson 2010).
The ability of a shoe to grip the court surface is vital to the player as it allows them to move around the court confidently, too little grip will mean that the player will tend to slip and fall, whereas, too much grip may increase the risk of injury (Miller 2006). Nigg and Segesser (1988) proposed that the magnitude of repetitive forces on the lower limb is directly related to the development of overuse injuries, therefore it can be concluded that poor / incorrect footwear has a link to injury. Similarly, Kibler and Safran (2005) stated that footwear

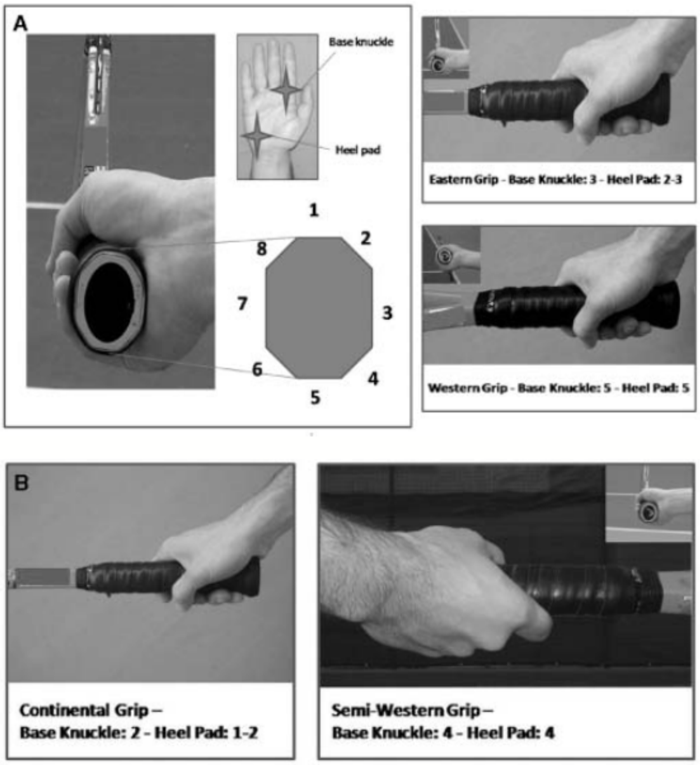
with poor cushioning or medial arch support may increase a players chances of developing plantar fasciitis or they may even rupture the plantar fascia.

2.7 Playing style

2.7.1 Forehand grip

According to Tagliafico *et al.* (2009) there are four basic single-handed grips used by players to hit the forehand, they are: continental, eastern, semi-western and full western grips. The difference between the four grips is the players positioning of the heel pad of their palm, and the base knuckle of their index finger on one of the 8 faces of the racket handle (Figure 2.2).

Figure 2.2: Four basic forehand grips (Tagliafico *et al.* 2009)



The eastern grip is a popular grip because it can suit a wide variety of playing styles. Beginners favour the eastern grip as it easy for them to hit the ball with power. However, players using an eastern grip will struggle to hit balls that bounce very high (Tagliafico *et al.* 2009)

The continental grip used to be the preferred grip to play almost all the strokes: forehands, backhands, serves and volleys. It gained popularity on the clay courts of Europe, which were soft, low-bouncing courts. Now-a-days, the continental grip is used most often for serves and volleys. (Tagliafico *et al.* 2009)

The semi-western grip is a popular grip amongst tennis players of all levels as it offers the player power and control. Users also feel more comfortable with this grip because the palm of the hand supports the racket, which provides more racket stability when the ball contacts the strings. The player is able to hit powerful top-spin forehands with this grip but they would have to change their grip in order to play a low-bouncing ball (Tagliafico *et al.* 2009).

The full-western grip originated on the high-bouncing hard courts of the western United States of America. This grip gives the user control when hitting a high-bouncing ball. Similar to players using a semi-western grip, those players who use a full-western grip will also have to change their grip in order to play a low bouncing balls (Tagliafico *et al.* 2009).

Tagliafico *et al.* (2009) studied the relationship between the four different forehand grips and wrist injuries in non-professional players. Their results show that radial side wrist injuries were significantly associated with the eastern grip and ulnar side injuries were significantly associated with the semi-western and full-western grips ($p<0.001$). The overall prevalence of wrist injuries in that study was 13%.

2.7.2 Backhand preference

According to Steinberger (2014), players at all levels used a one-handed backhand fifty years ago, whereas now-a-days, the one-handed backhand is slowly losing popularity among players. Only 24 of the top 100 ranked men, and 3 of the top 100 women currently use a one-handed backhand (Garber 2012).

It is hypothesized that players who use a two-handed backhand instead of a single-handed backhand are less likely to develop elbow pain (De Smedt *et al.* 2007). The non-dominant hand in a two-handed backhand is thought to absorb some of the forces transferred from the racket and corrects faulty biomechanics of a flexed wrist of the dominant hand (Leach and Miller 1987). Giangarra *et al.* (1993) studied the difference in EMG activity of the extensor carpi radialis brevis (ECRB) between one and two-handed backhands and found there to be decreased activity in the wrist extensor group in players using a two-handed backhand.

Research by Blackwell and Cole (1994) has shown that experienced players strike a one-handed backhand with a hyper-extended wrist and extend the hand through the point of impact maintaining correct biomechanics of their wrist during the stroke. However, an inexperienced player tends to lead with the elbow and strike the ball with the wrist joint in flexion and the forearm extensors eccentrically contract as contact is made. Eccentric contraction of the wrist extensor muscles during a one-handed backhand is believed to be one of the key mechanisms of injury for lateral epicondylitis (Blackwell and Cole 1994).

2.8 Conclusion

After reviewing the literature it can be seen that a higher percentage of injuries occur in the lower extremity compared to the upper extremity and the back and trunk (Pluim *et al.* 2006; Abrams, Renstrom and Safran 2012). Although there is variability in the most prevalent anatomical site of injury, it has been shown the most frequent sites of injury in the lower extremity are the ankle and thigh and in the upper extremity, the most frequently injures sites are the elbow and shoulder (Pluim *et al.* 2006; Abrams, Renstrom and Safran 2012).

There has been a great improvement in tennis racket technology since the 1970's when tennis rackets used to be made out of wood (Miller 2006). This has allowed novice players to generate faster swing speeds and play a more aggressive game similar to that of an elite tennis player, but they lack the physical conditioning of elite tennis players, and as a result, they have an increased risk of injury (Tagliafico *et al.* 2007).

This literature review described the background of tennis, the prevalence of tennis related musculoskeletal injuries, common injuries as well as the risk factors that have been associated with injury in tennis players.

Chapter Three follows and analyses the methods and materials used in the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the study design is described as well as the methodology, sampling procedure, inclusion and exclusion criteria, what methods as well as the data analysis.

3.2 Methods

3.2.1 Research study design

This research was a quantitative, cross-sectional, descriptive study in the form of a self-administered questionnaire (Fink and Kosekoff 1985) (Appendix O), which documented tennis related musculoskeletal injuries in league tennis players in the northern eThekwini region. Participation was by voluntary Informed Consent (Appendix N).

Data was obtained from league tennis players who volunteered to participate in the study and completed a self-administered questionnaire (Appendix O) documenting tennis-related musculoskeletal injuries (Salant and Dillman 1994).

Based on the above study design, ethical clearance was provisionally given subject to piloting of the data collection tool (Appendix A). Permission to start data collection was given by the Durban University of Technology's Institutional Research and Ethics Committee (IREC) (Appendix B). Amendments to the original title of the study and methodology were approved by IREC (Appendix C). This clearance indicated that the current study complied with the principals stated in the Declarations of Helsinki, Nuremburg and Belmont of 1975 (Johnson 2005).

3.2.2 Advertising/ recruitment

Permission was obtained from the chairpersons of the selected tennis clubs prior to ethics approval. As a result, no formal advertising was required as participants were informed through the chairpersons of their respective tennis clubs. This allowed the researcher to personally address and recruit the potential participants.

3.2.3 Participant sampling

3.2.3.1 Population size

There are six tennis clubs in the northern eThekwini region; Durban North Tennis Club, Prospect Tennis Club, Glenashley Tennis Club, Mount Edgecombe Tennis Club, La Lucia Tennis Club and Umhlanga Tennis Club (eThekwini Tennis Association 2014). However, only Durban North, Prospect,, Glenashley and Mount Edgecombe Tennis Clubs enter teams of players into the various divisions' of the eThekwini tennis Association league. At the time of the proposal approval, there were 114 active league tennis players registered with the four (out of six) clubs that participate in the inter-club league. A letter was given to the club chairpersons (Appendix M), requesting permission to have access to the players at the respective clubs and conduct a research study.

A maximum response rate was attempted. However, there was a need for some league tennis players to participate in the expert group and pilot study. Therefore, a minimum sample size of 70% (80 league players of the total sample) was chosen as the baseline for this study to complete data collection (Esterhuizen 2014).

3.2.3.2 Allocation

Participants were not allocated into groups, as this is an investigation of an entire population group. Sub grouping only occurred during the data analysis (Esterhuizen 2014).

3.2.3.3 Method

All league tennis players meeting the inclusion and exclusion criteria were invited to participate. Participation in this study was voluntary and a method of self-selection was used to participate in the study (Mouton 1996). Participants who agreed to participate were required to complete a self-administered questionnaire (Appendix O).

3.2.3.4 Sample characteristics

In order for the league tennis players to participate in this study, they were required to meet the following criteria:

3.2.3.4.1 Inclusion criteria

Inclusion criteria for the expert group:

- At least one league tennis player.
- At least one Master's student.
- At least two people with experience of utilizing questionnaires for research purposes.
- The researcher.
- The researcher's supervisor.
- All of the above would be required to voluntarily read the Letter of Information (Appendix D) and sign an Informed Consent form (Appendix E) as well as a Code of Conduct (Appendix F) and Confidentiality Statement (Appendix G).

Inclusion criteria for the pilot study group:

- Males and females who represented their club in the eThekwini Tennis Association League.
- Participants who read the Letter of Information and signed the Informed Consent form (Appendix J).

Inclusion criteria for the research procedure:

- Males and females who represented their club in the eThekwini Tennis Association League.
- Participants who read the Letter of Information and signed the Informed Consent form (Appendix N).

3.2.3.4.2 Exclusion criteria

Exclusion criteria for the expert group:

- Any person invited that declined the invitation to participate.
- Any person who did not voluntarily read the Letter of Information (Appendix D) or sign the Informed Consent form (Appendix E), Code of Conduct form (Appendix F) or Confidentiality Statement (Appendix G), would not be allowed to participate in the expert group.

Exclusion criteria for the pilot study group:

- Players under 18 years of age whose parents or legal guardian did not sign the Informed Consent form.
- Players who represented a club that is outside of the northern eThekwini region.
- Players who currently earn a salary from tennis competitions (professional players).
- Any player approached by the researcher who declined the invitation to participate.
- Players who refused to read the pilot study Letter of Information and sign the Informed Consent form (Appendix J).

- Any person that participated in the expert group.
- Any person approached by the researcher who declined the invitation to participate.

Exclusion criteria for the research procedure:

- Players under 18 years of age whose parents or legal guardian did not sign the Informed Consent form.
- Players who represented a club that is outside of the northern eThekwini region.
- Players who currently earn a salary from tennis competitions (professional players).
- Players who declined to participate in the study.
- Players who refused to read the Letter of Information and sign the Informed Consent form (Appendix N).
- Players who formed part of the expert group and pilot study to prevent any form of bias from the participants in the main study (Morgan 1998) (Brink 2007).

3.2.4 Research tools/ instruments

3.2.4.1 **Questionnaire** (Appendix O)

3.2.4.1.1 Questionnaire development

The main sections of the final questionnaire (Appendix O) and their questions were developed after consulting:

- Existing questionnaires on injury profiles (Sutherland 2008; Tychsen 2009)

- Peer reviewed articles (Kulund 1979; Henning, Rosenbaum and Milani 1992; Jayanthi *et al.* 2005; Kibler and Safran 2005; Elliott 2006; Pluim *et al.* 2006; Girard and Millet 2009; Tagliafico *et al.*

2009; Hjelm, Werner and Renstrom 2010; Abrams, Renstrom and Safran 2012) and

- Books (Nordin and Frankel 2001; Whiting and Zernicke 2008).

3.2.4.1.2 Expert group procedure

Before IREC granted provisional approval of the proposal (Appendix A) and later approval of the Final Questionnaire (Appendix B), the Pre-Expert Group Questionnaire (Appendix H) was carefully scrutinized and refined through an expert group discussion.

An expert group enables a group of individuals to discuss the questionnaire (Salant and Dillman 1994). These members critically assess the relevance of questions presented in a questionnaire. They also have the authority to suggest additional or the deletion of questions, or request clarification of any questions with the goal of strengthening the validity of the questionnaire.

An expert group had been chosen based on the fact that within a questionnaire one needs to address issues such as; the face validity, construction and the validity of criteria in the questionnaire.

The following procedures were utilized to confirm if the interested party would be interested in participating in the expert group (Seymour (2004):

- The individuals were approached personally or contacted telephonically by the researcher

- Once the expert group had been established, arrangements were then made to host the expert group meeting. These arrangements included: determining a date and time that suited all members, making a booking for the boardroom, arranging snacks, refreshments and stationery and setting up equipment to record the expert group meeting

Once everyone had arrived, the meeting commenced. The researcher opened the meeting by welcoming all participants and explaining the procedure for the expert group meeting. All the participants were required to read the Letter of Information (Appendix D) and sign the Informed Consent form (Appendix E), Code of Conduct (Appendix F) and Confidentiality Statement (Appendix G) before the questionnaires were handed out. The questionnaire was discussed one question at a time. Members of the expert group voiced their advice/concerns about each question (or confirmed acceptance of each question) and the researcher noted the changes, if required. During this meeting, snacks, refreshments and stationery was provided. A DVD containing the audiovisual recording of the expert group proceedings was made (Appendix Q) for the examiners' use only due to the confidentiality agreement.

The changes that were made as per the expert group are indicated in Appendix I.

3.2.4.1.3 Pilot study procedure

After provisional approval of the proposal, ethical clearance was granted to allow for piloting of the data collection tool (Appendix A). A pilot study involved taking a small sample of the population for which the questionnaire is intended. The questionnaire was administered exactly as it would be administered to the research sample. The purpose of the pilot study was to determine the average time taken and if there were any problematic areas in the questionnaire (Fink and Kosekoff 1985).

Participants of the pilot study were required to read the Letter of Information and sign the Informed Consent form (Appendix J). The Pilot Study Questionnaire (Appendix K) was delivered to a pilot study group. These were hand-delivered in person by the researcher to the league tennis players who volunteered to participate in the pilot study. Feedback from members of the pilot study group was used to make changes to the pilot study questionnaire, and the changes are shown in Appendix L. The resulting questionnaire became the Final Questionnaire (Appendix O).

3.2.4.2 Data collection procedure for the main study

All participants meeting inclusion/exclusion criteria were invited to participate. The researcher personally visited each tennis club on their club practice/training day to access the largest number of participants. The researcher addressed the participants and explained the aims and objectives of the study and the contents of the Final Questionnaire (Appendix O). The participants were required to read the Letter of Information and sign the Informed Consent form (Appendix N) and place it into a sealed ballot box. Thereafter, the researcher handed the participants the Final Questionnaire (Appendix O). Once the questionnaire had been completed, participants were required to place it inside another separate sealed ballot box.

For those players not present at the club on the day of data collection, the questionnaire was emailed to them along with the Letter of Information and Informed Consent form (Appendix N). A follow-up email was sent after 2 weeks, and another after 4 weeks to remind participants to complete the questionnaire. The researcher allowed up to 6 weeks for a response, after which the participants who failed to return the questionnaire to the researcher were excluded from the study.

No names or identifying information were on the questionnaire thus ensuring confidentiality of the participants (Brink 2007). The questionnaires were kept safe by the researcher until all data had been collected how kept safe. The questionnaires will be stored in the Department of Chiropractic and Somatology for 15 years, after such time they will be destroyed. Only the researcher and the researcher's supervisor will have access to the completed questionnaires.

3.3 Statistical methodology

IBM SPSS version 22 was used for the analysis. A p value < 0.05 was used to indicate statistical significance. Associations between the demographic variables and the prevalence of injury were first tested using chi square tests in the case of categorical variables, and t-tests in the case of continuous variables. Those variables that were associated at the 0.1 level of significance were entered into a binary logistic regression to analyse the risk factors of injury. A backward selection method was used using likelihood ratios. Odds ratios and 95% confidence intervals of the variables remaining in the model at the end were reported.

3.4 Conclusion

This chapter described the methodology used to conduct this study. It also described the initial questionnaire development, amendments made to the original title and methodology (as reflected in the appropriate appendices) and the procedure for the expert group meeting, pilot study and final research procedure. The statistical methods that were used in the study were also presented.

CHAPTER FOUR
RESULTS

4.1 Introduction

This chapter reveals the results obtained from the statistical analysis of the data collected. Bar graphs and charts are used to illustrate the results, with a short description accompanying each bar graph or table. The results are organized as they relate to the respective objectives (Objectives One to Three) of this study.

4.2 Objectives

The first objective was to describe the demographic profile of league tennis players in the northern eThekwini region. The second objective was to determine the prevalence of musculoskeletal injuries amongst league tennis players in the northern eThekwini region. Finally, the third objective was to describe the association between risk factors and prevalence of injury amongst league tennis players in the northern eThekwini region.

4.3 Data

4.3.1 Primary data

In this study, information was collected by the means of a self-administered questionnaire (Appendix H1) This enabled the gathered data to be quantified and analysed (Mouton 1996).

4.3.2 Secondary data

Secondary data was collected from the following sources: journal articles, books, expert group and pilot study participants as well as through personal communication with relevant people.

4.4 Abbreviations used in Chapter Four

The following abbreviations appeared in this chapter:

CI	Confidence interval
cm	Centimetre
GP	General practitioner
IQR	Inter Quartile Range
kg	Kilogram
km	Kilometre
m	Meter
n	number
n/a	Not applicable
OR	Odds ratio
Q	Question
sig.	Significance

4.5 Response rate for this study

The sample consisted of the entire population of competitive league tennis players who are affiliated with various tennis clubs in the northern eThekwini region. There were 114 active league players (eThekwini Tennis Associationnn 2014). The recommendation from a statistician was that a response rate of 70% was required for statistical significance (Esterhuizen 2014).

The data was collected in person by the researcher, over a period of five months between November 2014 to March 2015. This method of data collection was chosen over that of other methods, such as posted questionnaires or questionnaires that were delivered via a neutral third party. The reasons for this included the decreased return rate of questionnaires in studies where they were sent via post (Lapane, Quilliam and Hughes 2007) which would affect the feasibility of the sample and bias the results (Brink 2007). Seventy seven completed questionnaires were returned to the researcher at the time of the study, while 3 completed questionnaires were scanned and emailed to him. As a result, a total of 80 questionnaires were retuned (n=80), making the response rate 70.16%. This met the requirement of a 70% response rate set by the Faculty of Health Sciences Research and Ethics Committee (Chapter 3, Section 3.2.3.1).

4.6 Results

It should be noted that not all the questions in this chapter reflected 80 responses in that some participants were not currently injured or had been injured during the previous 12-months, and as such, those questions were not applicable to them. Conversely, if the results added up to more than 80, it meant that participants were given the option to select more than one answer for the given question.

4.6.2 Player demographics

4.6.2.1 Age, gender and ethnicity

The youngest participant was 18 years of age and the oldest was 81 years of age. The average age of all participants was 49.04 years. Three quarters (75%) of the sample were male, and the remaining quarter (25%) were female. The majority (91.3%) of participants were White, 5% were Indian, 1.3% were African, Coloured and Other ethnic groups made up 1.3% of the total.

Table 4.1: Age, gender and ethnicity

		Count	Column N %
Age (years)	Minimum	18	n/a
	Maximum	81	
	Mean	49.04	
	Median	48	
Gender	Female	20	25.0%
	Male	60	75.0%
Ethnicity	African	1	1.3%
	Coloured	1	1.3%
	Indian	4	5.0%
	White	73	91.3%
	Other	1	1.3%

4.6.2.2 Height, weight and BMI

The participants were asked to state their height and weight. The researcher calculated the BMI of each player by taking their weight in kilograms (kg) and dividing by their height in meters squared (m^2). Table 4.2 shows that the tallest tennis player was 1.95m while the shortest was 1.30m (mean 1.75m). The participants' weight ranged from 50kg to 120kg (mean 76.4kg). Their BMI scores ranged from 17.5 to 35.1 (mean 24.8) (Table 4.2).

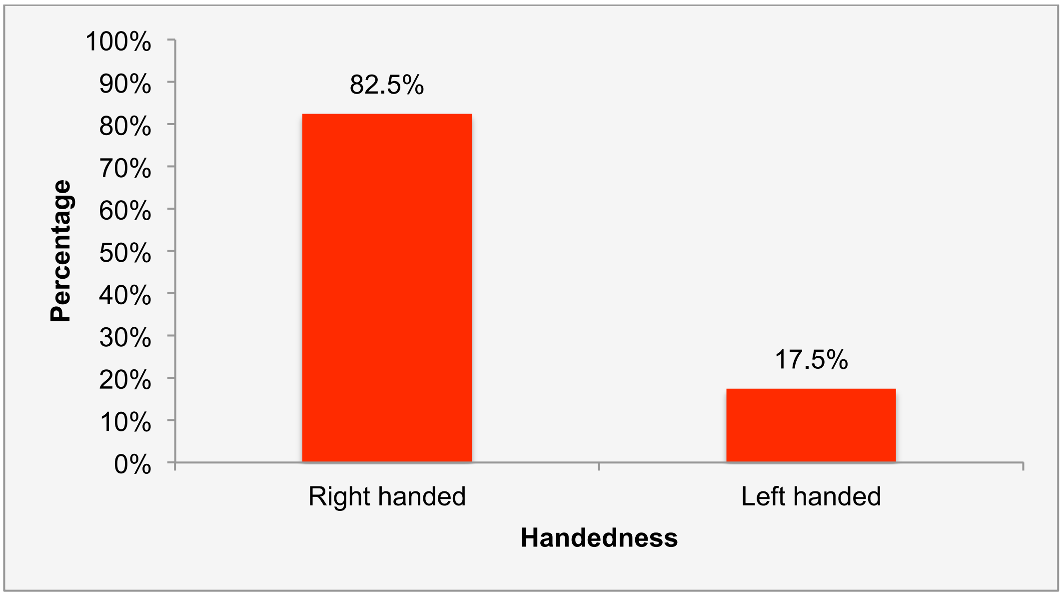
Table 4. 2 Height, weight and BMI

	Mean	Standard Deviation	Minimum	Maximum
Height (m)	1.75	0.103	1.30	1.95
Weight (kg)	76.4	14.53	50.0	120.0
BMI	24.8	3.46	17.5	35.1

4.6.2.3 Handedness

It was found that 82.5% of participants were right-handed, and the remaining 17.5% were left-handed.

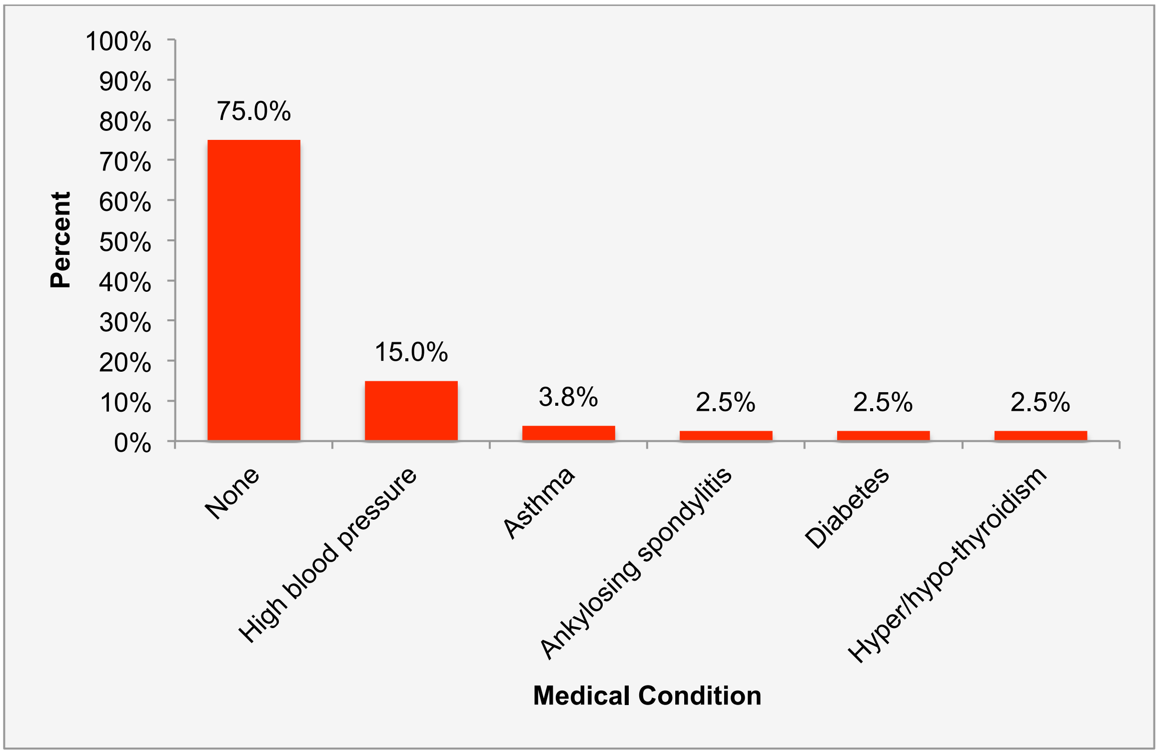
Figure 4.1: Handedness



4.6.2.4 Medical conditions

The participants were asked to report any medical condition(s) with which they had been previously diagnosed. Figure 4.2 shows that 75% of the participants did not report any medical conditions, whereas 15% reported with high blood pressure, and 3.8% reported as suffering from Asthma. Figure 4.2 also shows that 2.5% of the sample reported that they had previously been diagnosed with Diabetes and another 2.5% of the sample reported that they had hyper/hypo-thyrodism. The responses for "Other" were: ankylosing spondylitis, heart attack and Meniere's syndrome.

Figure 4.2: Medical conditions



4.6.2.5 Alcohol Consumption

Almost three quarters (74%) of the participants consumed alcohol and that the remaining 26% did not consume alcohol. Table 4.3 shows that the minimum number of units per alcohol consumed per week is 0 units, the maximum is 30 units and the median (not including the 21 participants who do not consume alcohol, i.e. 0 units per week) is 4.5 units with an interquartile range (IQR) from 0-11.5 units.

Figure 4.3: Alcohol consumption

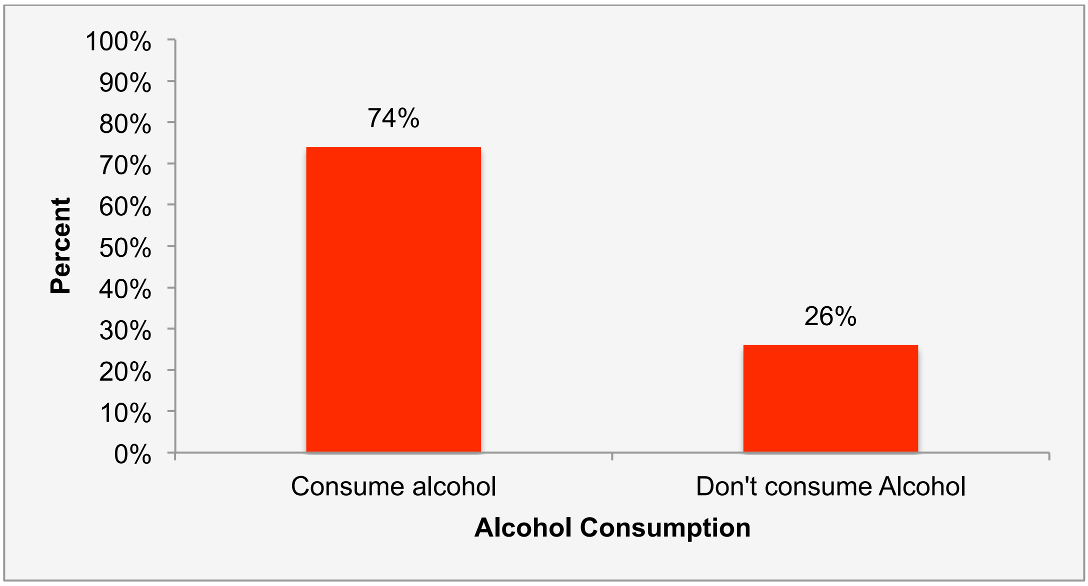


Table 4.3: Units of alcohol consumed per week

		Units
Minimum		0
Maximum		30
Median		7
Percentiles	25	0.00
	50	4.50
	75	11.50

4.6.2.6 Cigarette Smoking

As shown in Figure 4.4, 80% of the sample reported that they did not smoke, whereas 10% stated they were ex-smokers. Only 10% of participants were current smokers. Table 4.4 shows the total pack years of smoking for ex-smokers and current smokers. The researcher calculated total pack years smoking by multiplying the packs/boxes of cigarettes smoked per day by the number of years the person has smoked. The minimum pack years recorded was 4, while the maximum was 55.5. The median pack years for smokers and ex-smokers was 15 and the IQR was from 8.25 to 20 pack years (Table 4.4).

Figure 4.4: Non-smokers, ex-smokers and current smokers

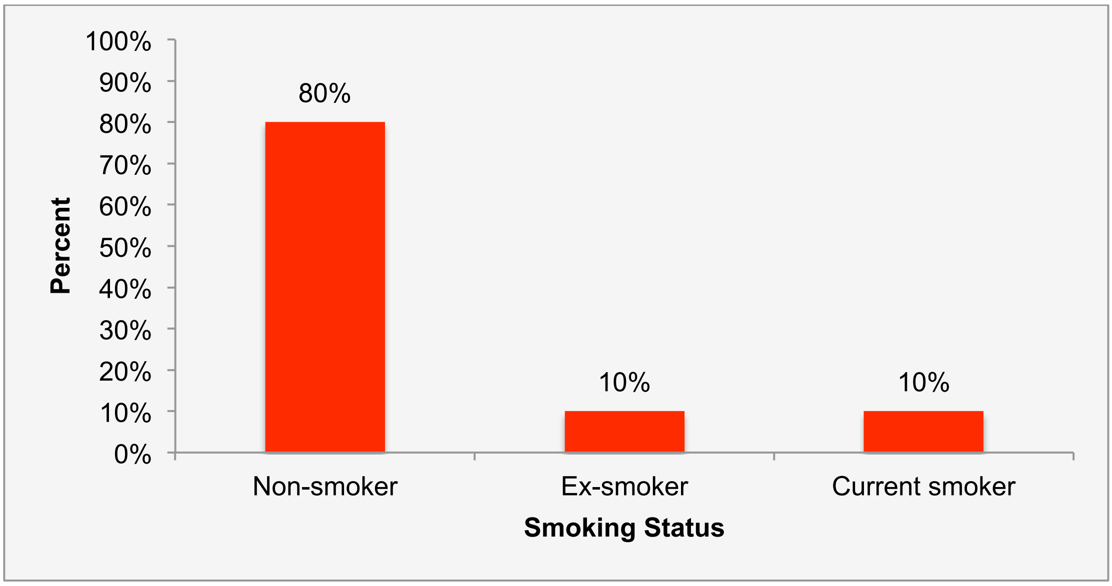


Table 4.4: Pack years for ex-smokers and current smokers

		Pack years
Minimum		4
Maximum		55.5
Median		15
Percentiles	25	8.25
	50	15.00
	75	20.00

4.6.3 Tennis history, training and nutrition

4.6.3.1 Duration of tennis career, and duration of tennis played per week.

Table 4.5 reflects that the median number of years participants played tennis is 30 years and the mean number of years is 27.5 years. The minimum is 1 year and the maximum is 65 years. The IQR is from 13.25 to 38 years. The median number of hours that a league tennis player played per week is 7 hours, and the mean number of hours is 7.4 hours. The minimum number of hours is 2 and the maximum is 19 hours per week. The IQR ranges from 5.125 to 8.00 hours (Table 4.6).

Table 4.5: Duration of tennis career

		Years playing tennis
Minimum		1
Maximum		65
Median		30
Mean		27.5
Percentiles	25	13.25
	50	30.00
	75	38.00

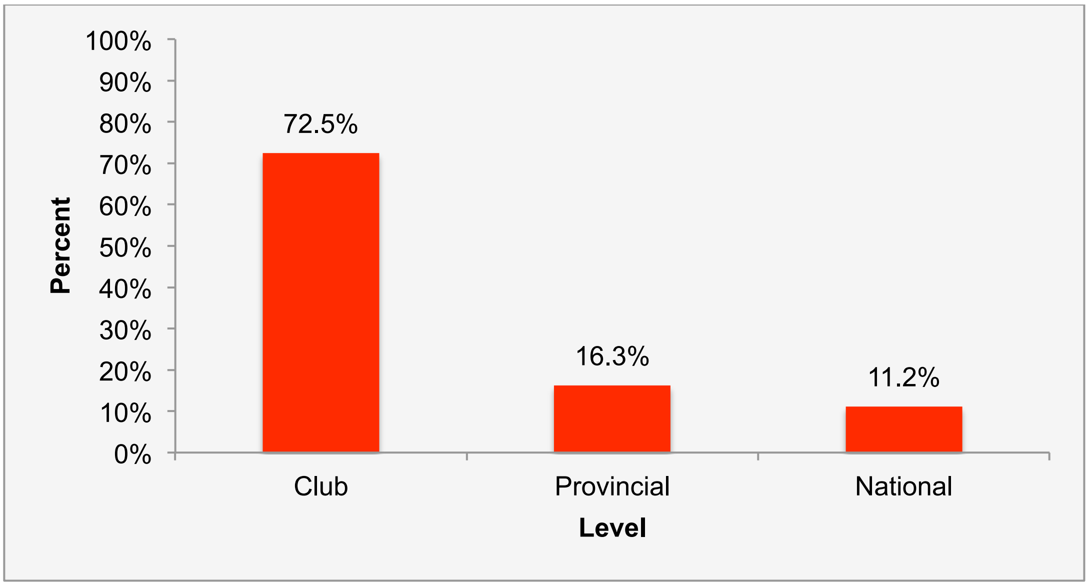
Table 4.6: Duration of tennis played per week

		Hours playing tennis
Minimum		2.0
Maximum		19.0
Median		7
Mean		7.4
Percentiles	25	5.125
	50	7.00
	75	8.00

4.6.3.2 Highest level in which a player participated

Figure 4.5 shows that 11.2% of the sample represented their country or they had turned professional at a point in their tennis career. Figure 4.5 also shows that 16.3% represented their province in inter-provincial tournaments. The remaining 72.5% of the sample had only competed at a club league level.

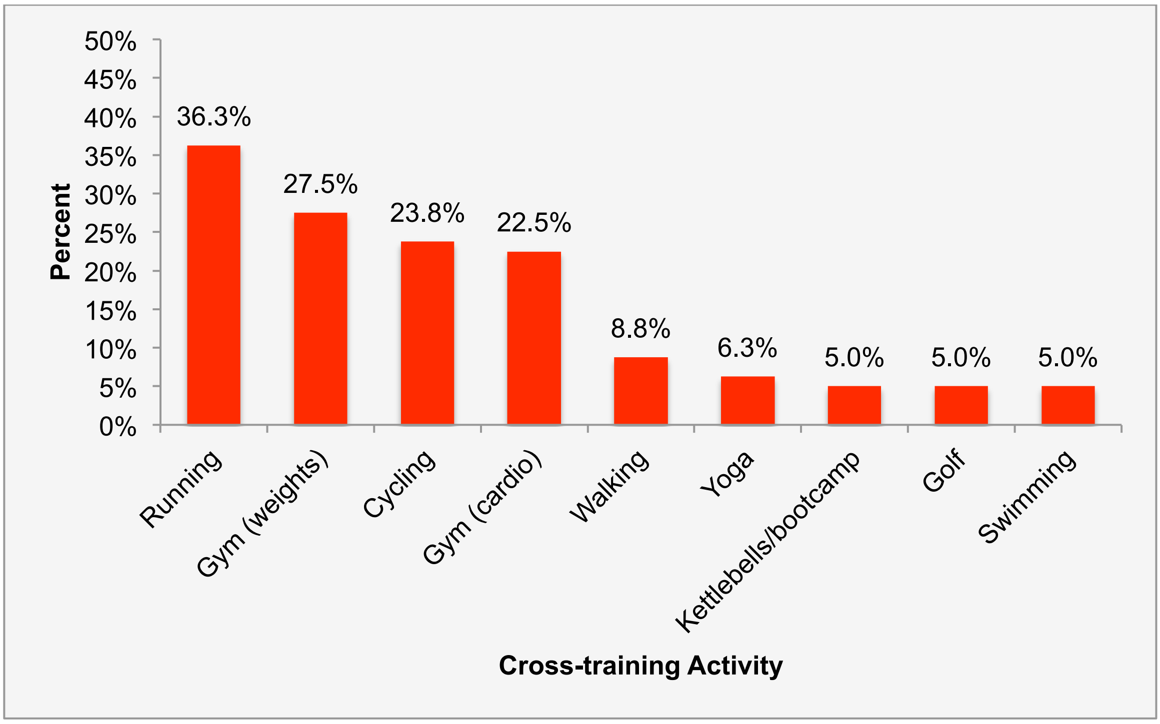
Figure 4.5: Highest level in which a player participated



4.6.3.3 Cross-training activities

Running was the most popular cross-training activity with 36.6% of the sample running on a weekly basis (Figure 4.6). Gym (weights) was the second most popular with 27.5% participating weekly and cycling was the third most popular cross-training activity with 23.8% of the sample participating weekly. "Other" was chosen by 23.8% of responses. Responses for Other activities were: walking, swimming, golf, bowls, squash, soccer and deep-sea fishing. Figure 4.6 also shows that 16.3% of the participants did not take part in any cross-training activities.

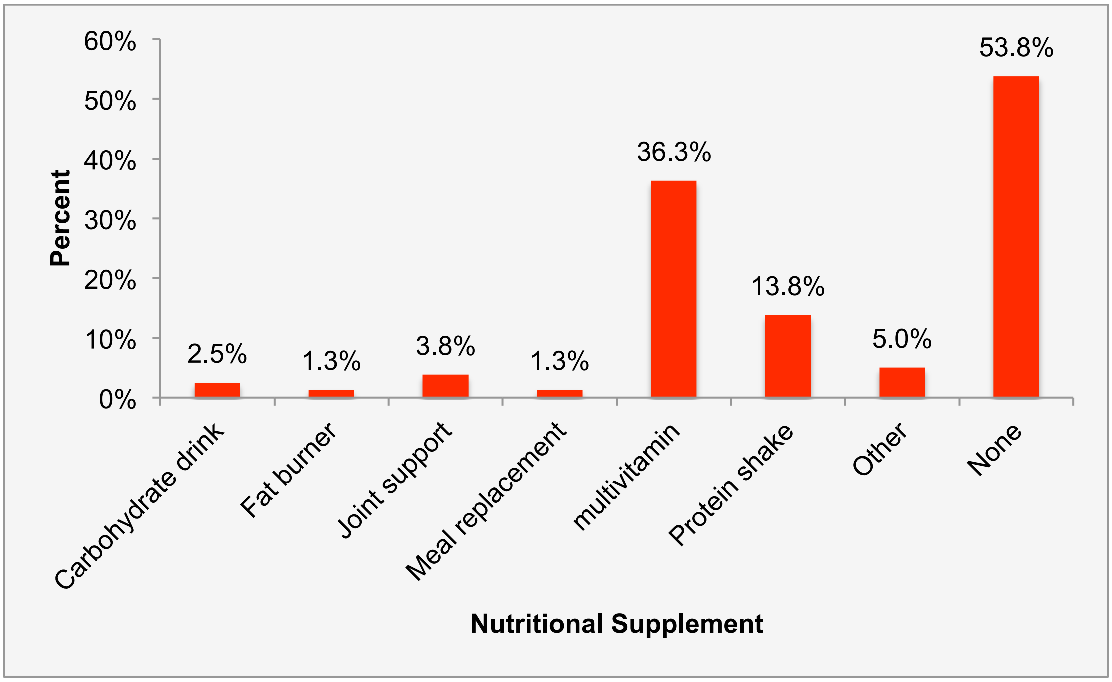
Figure 4.6: Cross-training activities



4.6.3.4 Nutritional supplements

Over half (53.8%) of participants did not use any nutritional supplement(s). However, of the remaining 36.3% of the participants, the most popular nutritional supplement was a Multivitamin used by 36.3%. The second most popular what was a protein shake (13.8%). Joint support supplements were used by 3.8% of the sample, and only 2.5% of the sample used a carbohydrate supplement. Fat burner and meal replacement supplements equaled 1.3% each. Other nutritional supplements equaled 5%. Some responses for Other were: “GU energy gel”, “Nu Skin”, “Omega 3” and “Vitamin C”.

Figure 4.7: Nutritional supplements

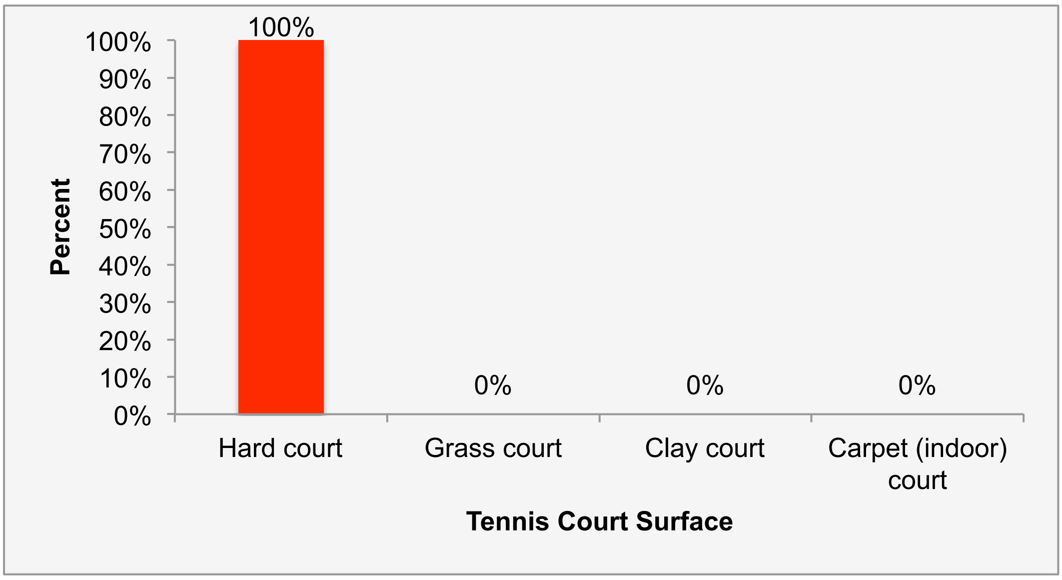


4.6.4 Court surface and equipment

4.6.4.1 Court surface

All of the participants in this study (100%) played on hard courts (Figure 4.8).

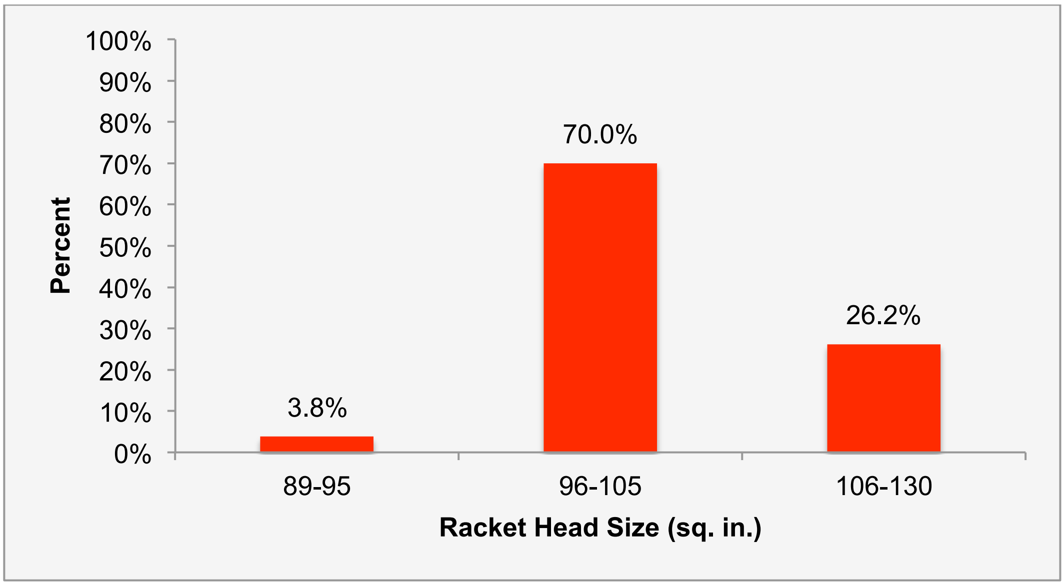
Figure 4.8: Tennis court surface



4.6.4.2 Racket head size

Figure 4.9 highlights that the most popular racket head size, used by 70.0% of the sample, is a 96-105 square inch (sq. in.) racket. The least popular racket is 89-95 sq. in. used by 3.8% of the sample. An oversize racket head (106-130 sq. in.) is used by 26.2% of the participants.

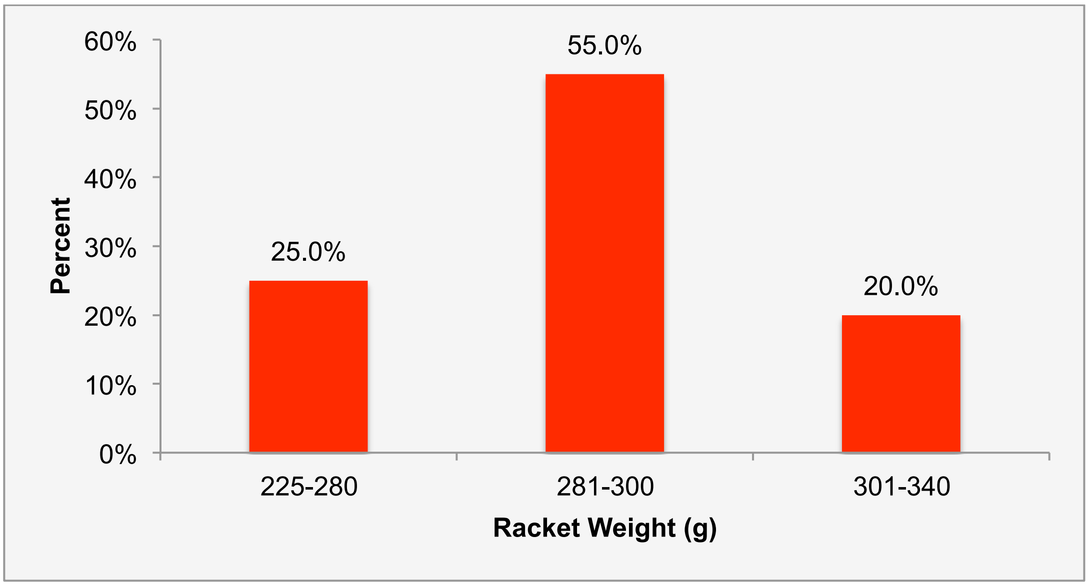
Figure 4.9: Racket head size



4.6.4.3 Racket weight

Figure 4.10 shows that 55.0% of the sample used medium weight rackets that weighed between 281g-300g. Lightweight rackets that weighed between 225g-280g were used by 25% of the sample and 20% used heavy rackets that weighed between 301g-340g.

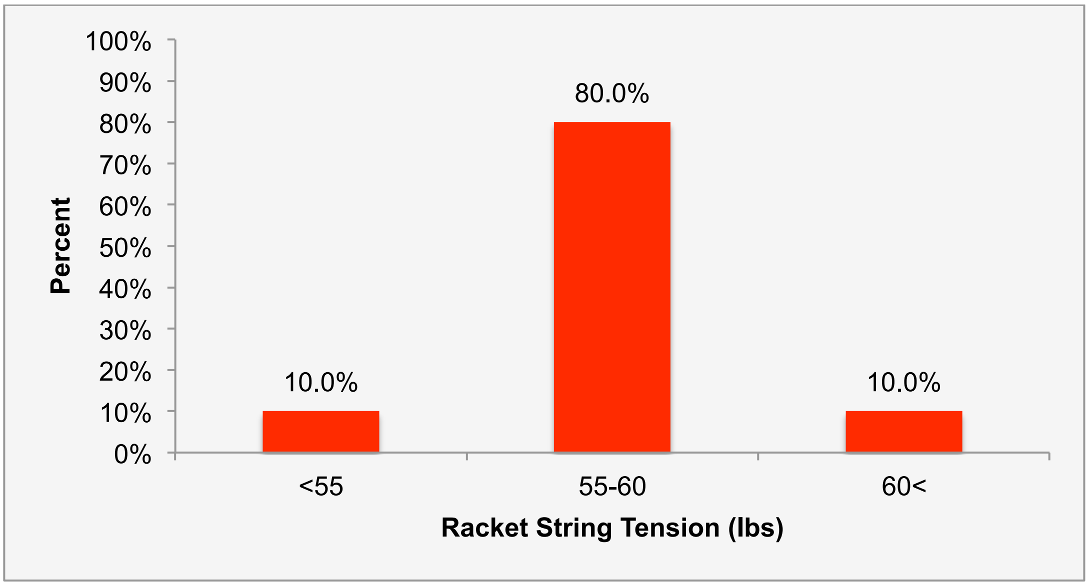
Figure 4.10: Racket weight



4.6.4.4 Racket string tension

The most popular racket string tension was 55-60 pounds (lbs) used by 80% of the sample. Only 10% used strings with a tension below 55lbs and 10% used racket strings strung over 60lbs tension (Figure 4.11).

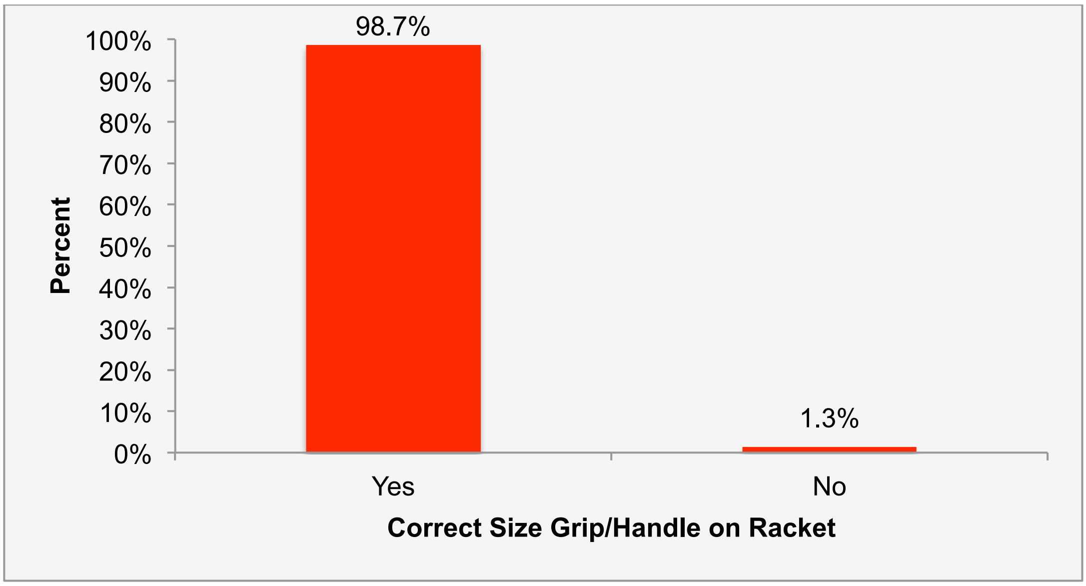
Figure 4.11: Racket string tension



4.6.4.5 Racket grip/handle size

Almost all of the participants (98.8%) used a grip that was the correct size for the size of their hand. However, 1.3% of participants used a grip that is either oversized or undersized in relation to their hand.

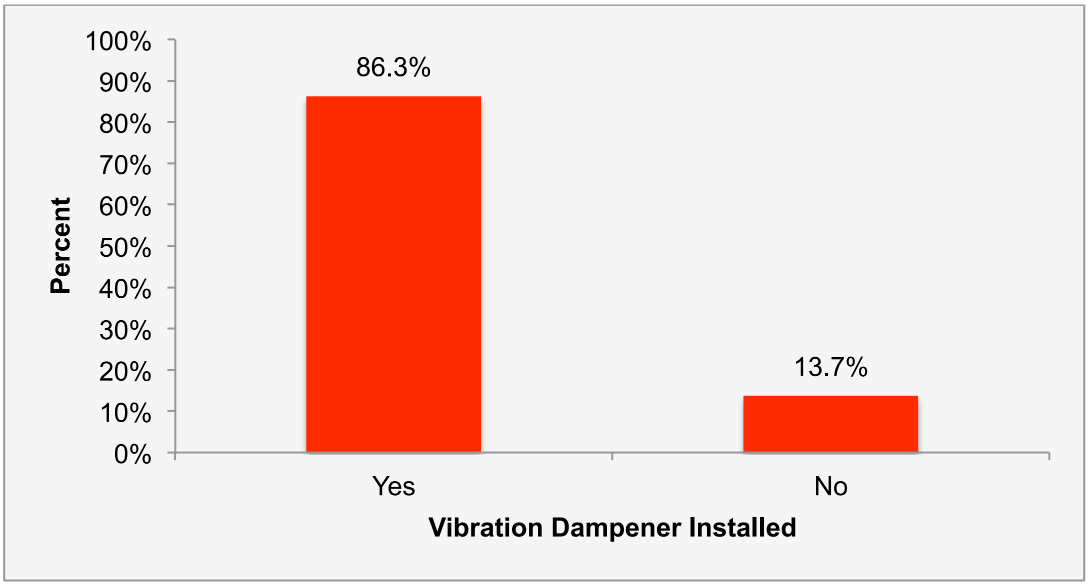
Figure 4.12: Racket grip/handle size



4.6.4.6 Vibration dampener

Figure 4.13 highlights that 86.3% of the sample used a vibration dampener either built into their rackets or installed on their strings, and 13.8% of them did not use a vibration dampener.

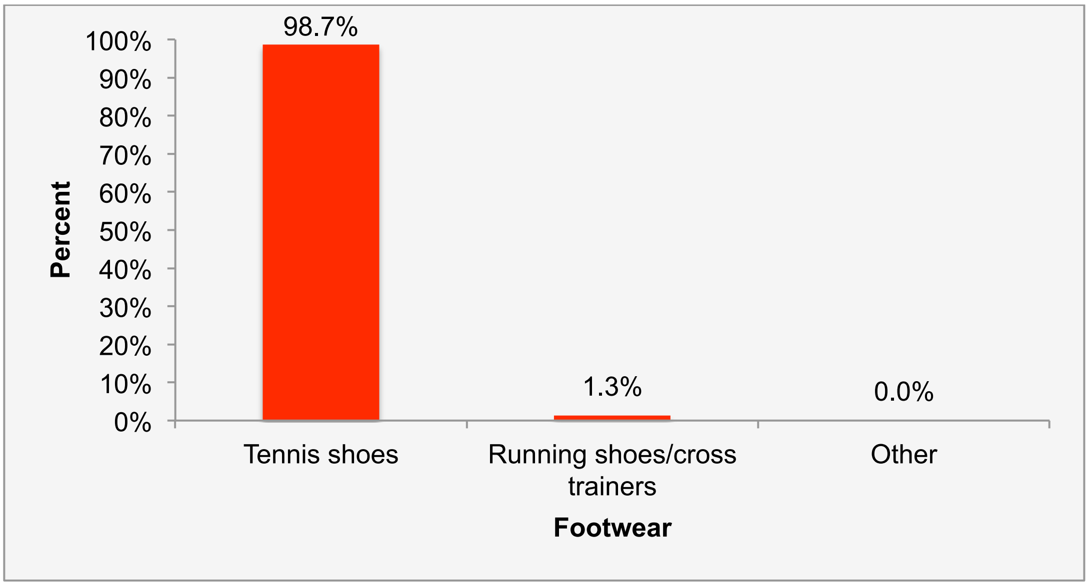
Figure 4.13: Vibration dampener



4.6.4.7 Footwear

Almost all (98.7%) of the sample chose tennis shoes as their preferred footwear, while 1.3% chose to use running shoes/cross trainers (Figure 4.14).

Figure 4.14: Footwear worn by participants

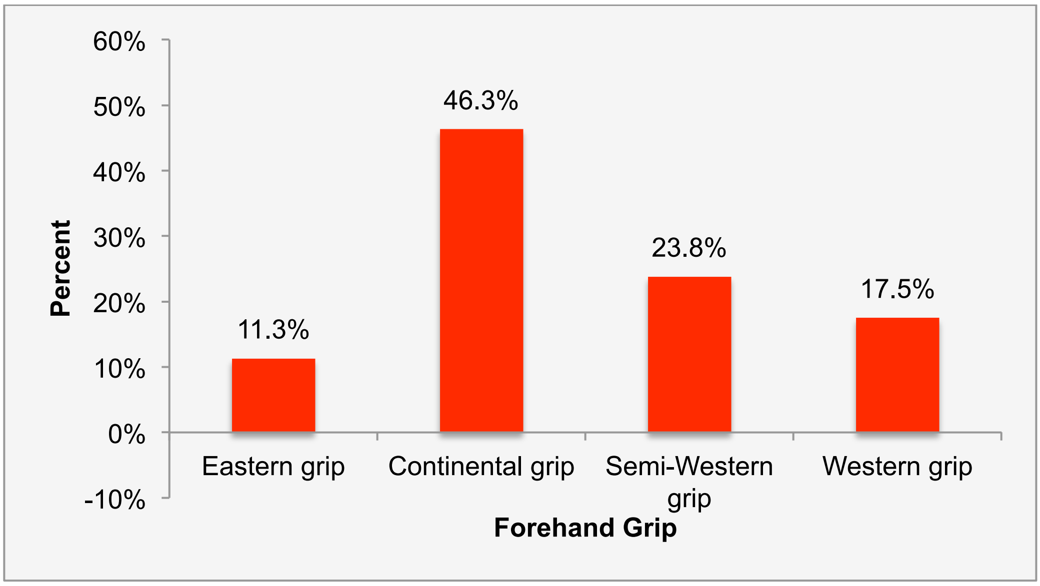


4.6.5 Playing style

4.6.5.1 Forehand grip

The most popular forehand grip was the continental grip, used by 46.3% of the participants. The least popular forehand grip was the eastern grip, used by 11.3% of participants.

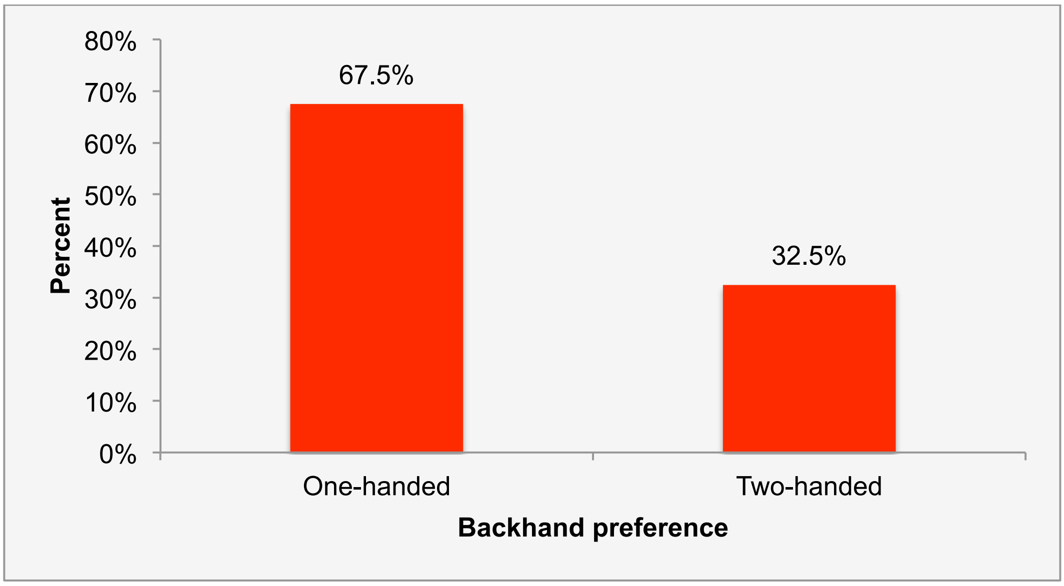
Figure 4.15: Forehand grip



4.6.5.2 Backhand preference

Over two-thirds (67.5%) of participants preferred to play a one-handed backhand while the remaining 32.5% of the participants preferred to play a two-handed backhand.

Figure 4.16: Backhand preference



4.6.6 Prevalence of tennis injuries

4.6.6.1 Period prevalence: Past 12-months

The prevalence of injuries experienced by the sample over a 12-month period was 68.75% (Table 4.8).

Table 4.8 Period prevalence of tennis injuries

	Frequency	Percent
Yes	55	68.75%
No	25	31.25%
Total	**80**	**100.0%**

4.6.6.2 Point prevalence: Current injury

The point prevalence of injury currently experienced by the sample at the time of the study was 36.25% (Table 4.9).

Table 4.9 Point prevalence of tennis injuries

	Frequency	Percent
Yes	29	36.25%
No	51	63.75%
Total	**80**	**100.0%**

4.6.7 Location of Injuries

4.6.7.1 Past 12-months

Fifty-five participants reported 98 injuries in 17 anatomical sites in the past 12-month period. The upper extremity was the most commonly affected region (49%), the lower extremity was the second (27.5%) and the trunk and back affected the least (23.5%) (Figure 4.17). The elbow (21.4%), shoulder (19.4%) and the lumbar spine (17.3%) were most common sites affected. The least common sites of injury were the hand and fingers (1.0%), abdominal musculature (1.0%) and the anterior leg (1.0%). Table 4.10 provides a summary of the injuries sustained by league tennis players over the past 12-month period.

Figure 4.17 Distribution of injuries in the past 12-months

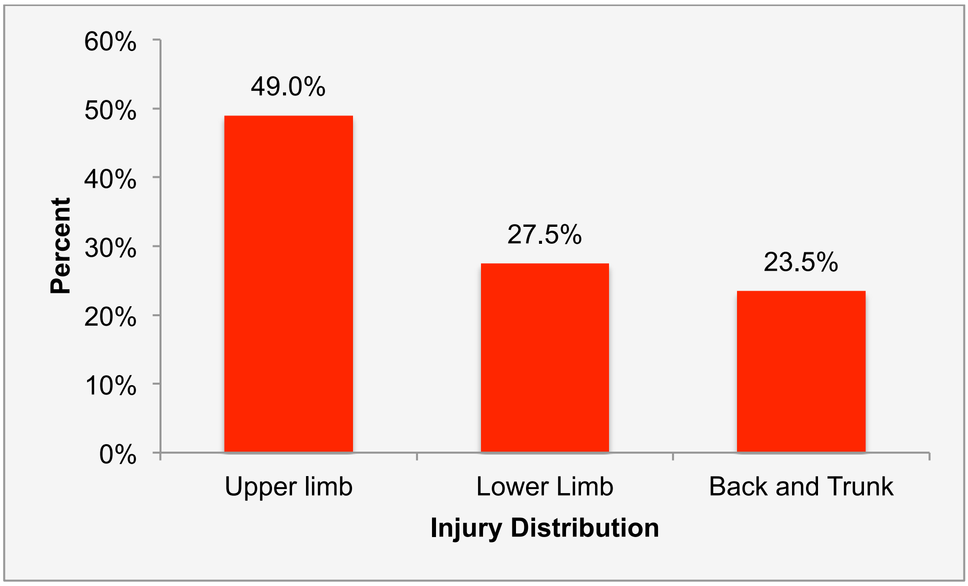


Table 4.10: Anatomical sites of injury in the past 12-months

Region	Responses	Percent %
Elbow	21	21.4%
Shoulder	19	19.4%
Lumbar spine	17	17.3%
Knee	8	8.2%
Ankle	5	5.1%
Gluteal region	4	4.1%
Posterior leg/calf	4	4.1%
Wrist	3	3.1%
Cervical spine	3	3.1%
Posterior thigh	3	3.1%
Upper arm	2	2.0%
Forearm	2	2.0%
Thoracic spine	2	2.0%
Foot	2	2.0%
Hand and fingers	1	1.0%
Abdominal	1	1.0%
Anterior leg	1	1.0%
Total	**98**	**100.0%**

4.6.7.2 Current injuries

Twenty-nine participants suffered from 44 injuries at 9 anatomical sites. In terms of current injures, the upper extremity was most commonly affected (50.0%), the lower extremity (25.0%) and the back and trunk (25.0%) were equally affected (Figure 4.18). Injuries to the shoulder were most prevalent

(25.0%) followed by the elbow (20.5%) and the lumbar spine (20.5%). Table 4.11 provides a summary of the participants' current injuries.

Figure 4.18: Distribution of current injuries

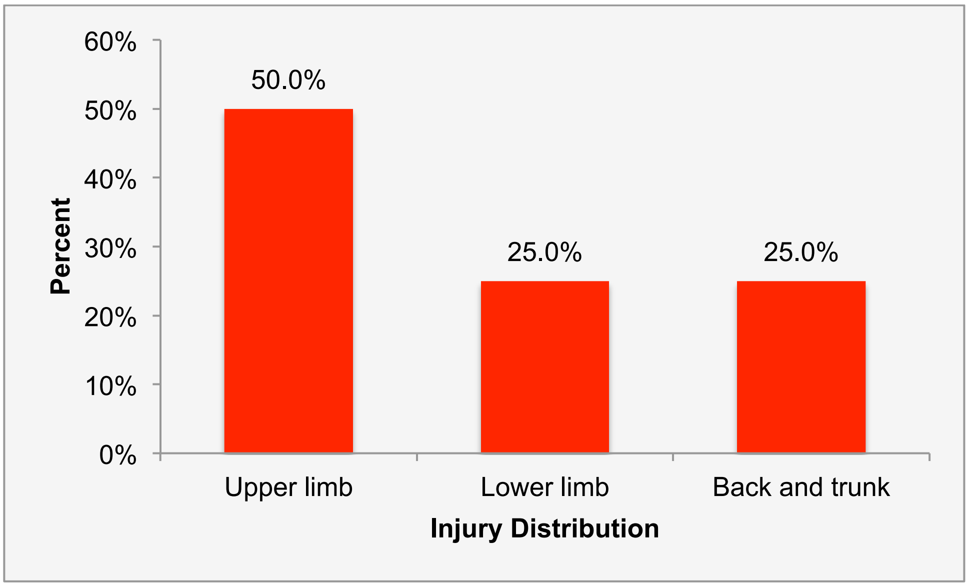


Table 4.11: Anatomical sites of current injuries

Region	Responses	Percent %
Shoulder	11	25.0%
Elbow	9	20.5%
Lumbar spine	9	20.5%
Knee	6	13.6%
Gluteal region	3	6.8%
Wrist	2	4.5%
Cervical spine	2	4.5%
Posterior thigh	1	2.3%
Foot	1	2.3%
Total	**44**	**100.0%**

4.6.8 Impact of injury on their game of tennis

4.6.8.1 Aggravating activities

4.6.8.1.1 Past 12-months

Table 4.12 highlights that serving/smashing was chosen by 32.4% of the sample as the activity that aggravated their injury the most, in the past 12-months. The backhand aggravated 23.0% of injuries, and running aggravated 20.3% of injuries (Table 4.12).

Table 4.12: Injury aggravating activities in the past 12-months

	Responses	Percent %
Serving/smash	24	32.4%
Backhand	17	23.0%
Running	15	20.3%
Forehand	11	14.9%
Other	7	9.5%
Total	**74**	**100.0%**

4.6.8.1.2 Current injury

Serving/smashing was chosen by 35.5% of the participants as the activity that aggravated their current injury the most. Running aggravated 20.6% of current injuries.

Table 4.13: Current injury aggravating activities

	Responses	Percent %
Serving/smash	12	35.3%
Running	7	20.6%
Backhand	6	17.6%
Forehand	6	17.6%
Other	3	8.8%
Total	**34**	**100.0%**

4.6.8.2 Participants that were forced to retire from a league match due to injury

4.6.8.2.1 Past 12-months

Table 4.14 shows that in the past 12-months, of the 55 participants who sustained injuries only 7.4% of injured participants were forced to retire from a league match due to injury.

Table 4.14: Retired from a match due to injury in the past 12-months

		Frequency	Valid percent %
Valid	No	50	92.6%
	Yes	4	7.4%
Missing		1	
Total		**55**	**100.0%**

4.6.8.2.2 Current injury

Table 4.15 shows that of the 29 participants were injured only 3.4% of participants were forced to retire from a league match due to their current injury.

Table 4.15: Retired from a match due to current injury

		Frequency	Valid percent %
Valid	No	28	96.6%
	Yes	1	3.4%
Total		**29**	**100%**

4.6.8.3 Number of participants, and duration that they were unable to participate in tennis due to injury

4.6.8.3.1 Past 12-months

Table 4.16 shows that in the past 12-months, 18.2% of the injured participants were unable to practice due to an injury, and 80.0% of participants did not miss a practice due to an injury. Table 4.17 shows that of those participants who were unable to fully participate in tennis due to injury, the minimum duration was 1-week and the maximum duration was 20-weeks. The mean duration of time that an injured participant was unable to participate in tennis due to an injury was 6.2 weeks.

Table 4.16: Number of participants unable to practice due to injury in past 12-months

		Frequency	Valid percent %
Valid	No	44	81.5%
	Yes	10	18.5%
Missing		1	
Total		**55**	**100.0%**

Table 4.17: The duration that participants were unable to practice due to injury in past 12-months

	Duration (weeks)
Minimum	1
Maximum	20
Mean	6.2

4.6.8.3.2 Current injury

Table 4.18 shows that of those participants who were currently injured at the time of the study, 6.9% of participants were unable to practice or play due to their injury. However, the remaining 92.3% were able to fully participate in tennis despite their current injuries. The maximum, minimum and mean duration that participants were unable to fully participate in tennis due to injury was not computed due to only one participant answering the question. This participant stated that they were unable to participate in tennis for 8 weeks due to their current injury.

Table 4.18: Number of participants unable to practice due to current injury

		Frequency	Valid percent %
Valid	No	26	92.9%
	Yes	2	7.1%
Missing		1	
Total		**29**	**100.0%**

4.6.9 Cause of injury

4.6.9.1 Past 12-months

Overuse was the most common cause of injury chosen by the participants, accounting for 36.9% of the injuries sustained. Old age was reported to be the cause of 16.9% of injuries (Table 4.19).

Table 4.19: Cause of injury in the past 12-months

	Responses	Percent %
Overuse	24	36.9%
Old age	11	16.9%
Other	11	16.9%
No warm-up	8	12.3%
Unknown	8	12.3%
Gym/cross training	2	3.1%
Incorrect equipment	1	1.5%
Total	**65**	**100.0%**

4.6.9.2 Current injury

Overuse was the most common cause of current injuries accounting for 37.1% of injuries sustained (Table 4.20).

Table 4.20: Cause of current injury

	Responses	Percent %
Overuse	13	37.1%
No warm-up	5	14.3%
Old age	5	14.3%
Unknown	5	14.1%
Other	5	14.3%
Gym/cross training	2	5.7%
Total	**35**	**100.0%**

4.6.10 Treatment

4.6.10.1 Past 12-months

Although, it was found that 24.2% of the injured participants chose not to receive treatment for their injury (Figure 4.19), the remaining 74.8% sought treatment from a variety of health practitioners. Physiotherapists were the most popular medical practitioner seen by 34.8% of the injured participants; 15.2% were treated by a chiropractor and 7.6% saw an orthopedic surgeon and GP respectively. Table 4.21 highlights that of the participants who went for treatment, 92.3% were satisfied with the treatment/advice they received from their chosen medical practitioner.

Figure 4.19: Medical practitioners consulted for injury in the past 12-months

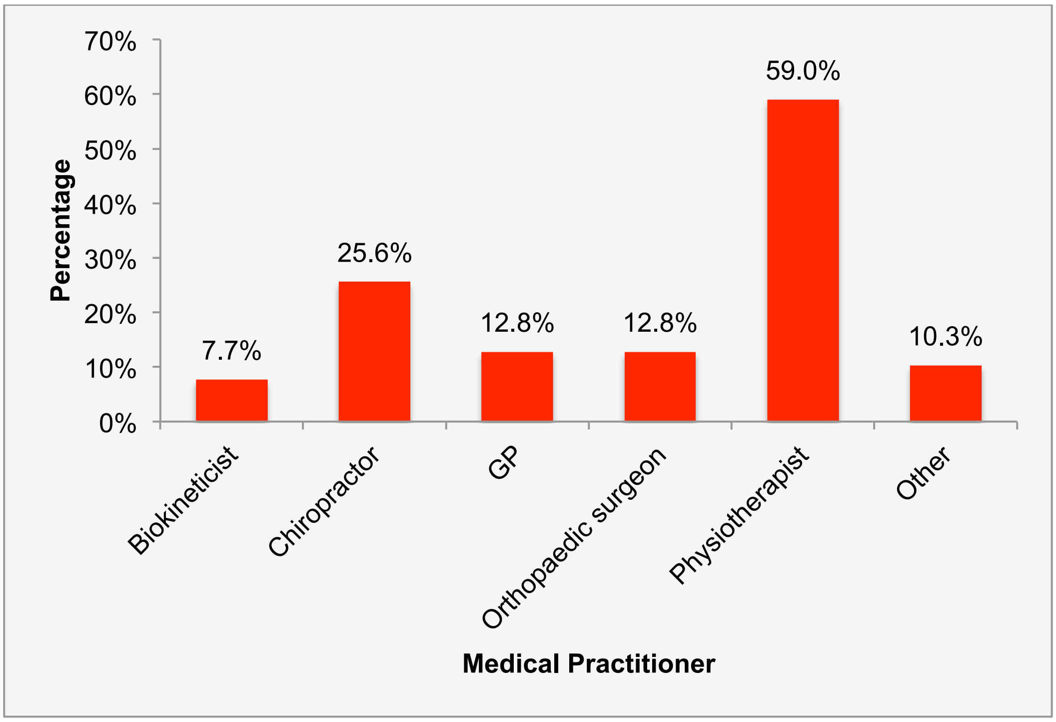


Table 4.21: Participants satisfied with treatment/advice from medical practitioners for injury in the past 12-months

		Frequency	Valid percent %
Valid	No	3	7.7%
	Yes	36	92.3%
Missing		16	
Total		55	100%

4.6.10.2 Current injury

Although, it was found that 24.2% of the currently injured participants chose not to receive treatment for their injury (Figure 4.20), the remaining 74.8% sought treatment from a variety of health practitioners. Physiotherapists were the most popular medical practitioner seen by 30.3% of the injured participants; 15.2% were treated by a chiropractor and 15.2% saw an orthopedic surgeon. Table 4.22 shows that of the participants who went for treatment, 90.5% were satisfied with the treatment/advice they received from their chosen medical practitioner.

Figure 4.20: Medical practitioners consulted for current injury

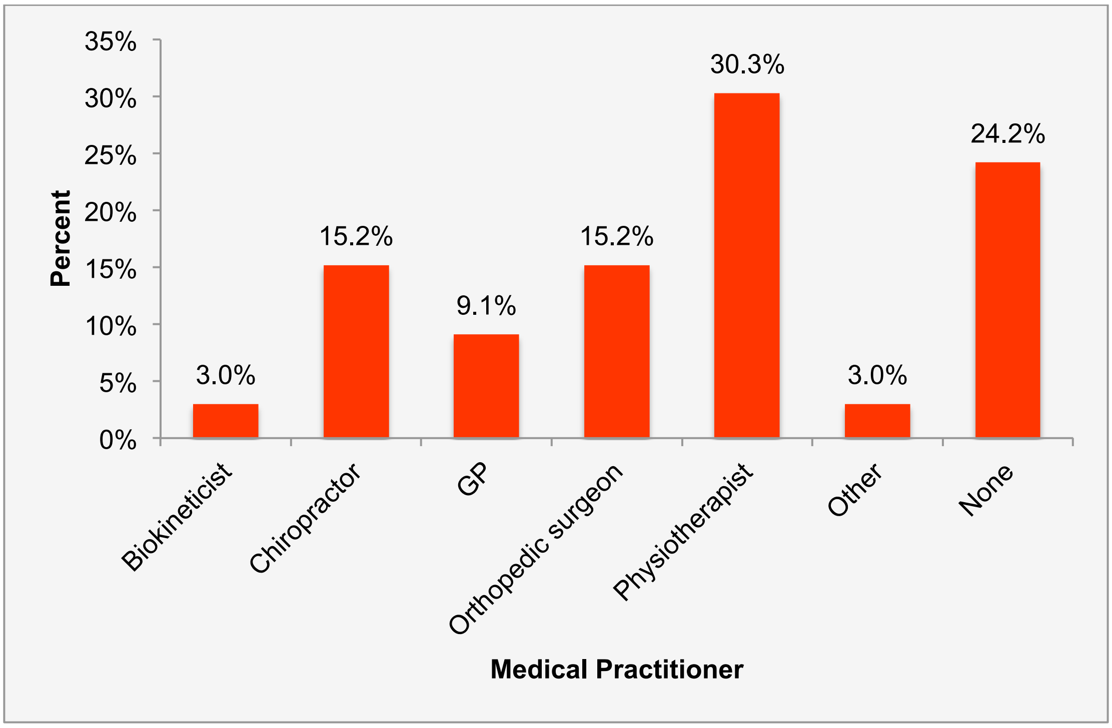


Table 4.22: Participants satisfied with treatment/advice from medical practitioners for current injury

		Frequency	Valid percent %
Valid	No	2	9.5%
	Yes	19	90.5%
Missing		8	
Total		29	100%

4.6.11 Risk factors and Injury

The following risk factors for injury were calculated against the presence of an injury that occurred in the past 12-month period (Appendix H2, Question 24). However, there were not enough current injuries at the time of the study to calculate against risk factors for injury.

4.6.11.1 Age and injury

Table 4.23: Age and injury

	Injury	n	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Age	No	25	49.32	17.547	3.509	
	Yes	55	48.38	13.210	1.781	.049

4.6.11.2 Gender and injury

Table 4.24: Gender and injury

			Injury		
			No	Yes	Total
Gender	Female	Count	4	16	20
		% within gender	20.0%	80.0%	100.0%
	Male	Count	21	39	60
		% within gender	35.0%	65.0%	100.0%
Total		Count	25	55	80
		% within gender	31.3%	68.8%	100.0%

Fischer’s Exact Test (*p*=0.165)

4.6.11.3 Ethnicity and injury

Table 4.25: Ethnicity and injury

			Injury		
			No	Yes	Total
Ethnicity	African	Count	0	1	1
		% within ethnicity	0.0%	100.0%	100.0%
	Coloured	Count	1	0	1
		% within ethnicity	100.0%	0.0%	100.0%
	Indian	Count	1	3	4
		% within ethnicity	25.0%	75.0%	100.0%
	White	Count	23	50	73
		% within ethnicity	31.5%	68.5%	100.0%
	Other	Count	0	1	1
		% within ethnicity	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within ethnicity	31.3%	68.8%	100.0%

Linear-by-linear Association (*p*=0.796)

4.6.11.4 Body Mass Index and injury

Table 4.26: Body Mass Index and injury

	Injury	n	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Age	No	24	25.225	2.9910	0.6105	
	Yes	55	24.631	3.6629	0.4939	0.327

4.6.11.5 Handedness and injury

Table 4.27: Handedness and injury

			Injury		
			No	Yes	Total
Handedness	Left	Count	7	7	14
		% within handedness	50.0%	50.0%	100.0%
	Right	Count	18	48	66
		% within handedness	27.3%	72.7%	100.0%
Total		Count	25	55	80
		% within handedness	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.091)

4.6.11.6 Medical Conditions and injury

4.6.11.6.1 Asthma

Table 4.28: Asthma and injury

			Injury		
			No	Yes	Total
Asthma	No	Count	25	52	77
		% within asthma	32.5%	67.5%	100.0%
	Yes	Count	0	3	3
		% within asthma	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within asthma	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.319)

4.6.11.6.2 Diabetes

Table 4.29: Diabetes and injury

			Injury		
			No	Yes	Total
Diabetes	No	Count	25	53	78
		% within diabetes	32.1%	67.9%	100.0%
	Yes	Count	0	2	2
		% within diabetes	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within diabetes	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.470)

4.6.11.6.3 Hyper/Hypo-thyroidism

Table 4.30: Hyper/hypo-thyroidism and injury

			Injury		
			No	Yes	Total
Hyper/hypo-thyroidism	No	Count	25	53	78
		% within hyper/hypo-thyroidism	32.1%	67.9%	100.0%
	Yes	Count	0	2	2
		% within hyper/hypo-thyroidism	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within hyper/hypo-thyroidism	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.470)

4.6.11.6.4 High blood pressure

Table 4.31: High blood pressure and injury

			Injury		
			No	Yes	Total
High blood pressure	No	Count	22	46	68
		% within high blood pressure	32.4%	67.6%	100.0%
	Yes	Count	3	9	12
		% within high blood pressure	25.0%	75.0%	100.0%
Total		Count	25	55	80
		% within high blood pressure	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.445)

4.6.11.6.5 Other

Table 4.32: Other and injury

			Injury		
			No	Yes	Total
Other	No	Count	23	53	76
		% within other	30.3%	69.7%	100.0%
	Yes	Count	2	2	4
		% within other	50.0%	50.0%	100.0%
Total		Count	25	55	80
		% within other	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.370)

4.6.11.6.6 None

Table 4.33: None and injury

			Injury		
			No	Yes	Total
None	No	Count	6	14	20
		% within none	30.0%	70.0%	100.0%
	Yes	Count	19	41	60
		% within none	31.7%	68.3%	100.0%
Total		Count	25	55	80
		% within none	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.562)

The significance could not be computed for the following medical conditions, as there were not enough reported cases:

- Epilepsy
- Osteoporosis
- Rheumatoid arthritis

4.6.11.7 Alcohol consumption and injury

4.6.11.7.1 Beer

Table 4.34: Beer consumption and injury

			Injury		
			No	Yes	Total
Beer	No	Count	11	29	40
		% within beer	27.5%	72.5%	100.0%
	Yes	Count	14	26	40
		% within beer	35.0%	65.0%	100.0%
Total		Count	25	55	80
		% within beer	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.315)

4.6.11.7.2 Wine

Table 4.35: Wine consumption and injury

			Injury		
			No	Yes	Total
Wine	No	Count	16	30	46
		% within wine	34.8%	65.2%	100.0%
	Yes	Count	9	24	33
		% within wine	27.3%	72.7%	100.0%
Total		Count	25	54	79
		% within wine	31.6%	68.4%	100.0%

Fischer's Exact Test (*p*=0.324)

4.6.11.7.3 Spirits

Table 4.36: Spirits consumption and injury

			Injury		
			No	Yes	Total
Spirits	No	Count	23	40	63
		% within spirits	36.5%	63.5%	100.0%
	Yes	Count	2	15	17
		% within spirits	11.8%	88.2%	100.0%
Total		Count	25	55	80
		% within spirits	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.043)

4.6.11.7.4 Total units of alcohol per week

Table 4.37: Total units of alcohol consumed and injury

	Injury	N	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Total units alcohol per week	No	25	6.24	7.384	1.477	
	Yes	55	6.73	6.967	0.939	0.933

4.6.11.8 Cigarette smoking and injury

4.6.11.8.1 Ex-smoker

Table 4.38: Ex-smoker and injury

	Injury	N	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Ex-smoker	No	2	20.00	0.000	0.000	
	Yes	6	13.33	5.164	2.108	0.013

4.6.11.8.2 Current smoker

Table 4.39: Current smoker and injury

	Injury	N	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Current smoker	No	3	16.33	11.846	6.839	
	Yes	5	21.00	5.477	2.449	0.095

4.6.11.8.3 Total pack years smoking, ex-smokers and current smokers

Table 4.40: Total pack years smoking and injury

	Injury	N	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Total pack years smoking	No	5	25.1000	19.15855	8.56796	
	Yes	11	15.6136	12.71778	3.83456	0.217

4.6.11.9 Duration of tennis career and injury

Table 4.41: Duration (years) of play and injury

	Injury	N	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Years playing	No	25	27.120	13.8814	2.7763	
	Yes	55	27.627	14.9682	2.0183	0.810

4.6.11.10 Duration of tennis played per week and injury

Table 4.42: Duration of tennis played per week and injury

	Injury	N	Mean	Std. Deviation	Std. Error Mean	*p*-value.
Total hours per week	No	25	7.500	3.3665	0.6733	
	Yes	55	7.282	3.2812	0.4424	0.795

4.6.11.11 Highest level in which a player participated and injury

Table 4.43: Highest level in which a player participated and injury

			Injury		
			No	Yes	Total
Level	Club	Count	19	39	58
		% within level	32.8%	67.2%	100.0%
	Provincial	Count	4	9	13
		% within level	30.8%	69.2%	100.0%
	National	Count	2	7	9
		% within level	22.2%	77.8%	100.0%
Total		Count	25	55	80
		% within level	31.3%	68.8%	100.0%

Linear-by-Linear Association (p=0.552)

4.6.11.12 Cross-training and injury

4.6.11.12.1 Cycling

Table 4.44: Cycling and injury

			Injury		
			No	Yes	Total
Cycling	No	Count	16	45	61
		% within cycling	26.2%	73.8%	100.0%
	Yes	Count	9	10	19
		% within cycling	47.4%	52.6%	100.0%
Total		Count	25	55	80
		% within cycling	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.075)

4.6.11.12.2 Gym (cardio)

Table 4.45: Gym (cardio) and injury

			Injury		
			No	Yes	Total
Gym (cardio)	No	Count	23	39	62
		% within gym (cardio)	37.1%	62.9%	100.0%
	Yes	Count	2	16	18
		% within gym (cardio)	11.1%	88.9%	100.0%
Total		Count	25	55	80
		% within gym (cardio)	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.030)

4.6.11.12.3 Gym (weights)

Table 4.46: Gym (weights) and injury

			Injury		
			No	Yes	Total
Gym (weights)	No	Count	18	39	57
		% within gym (weights)	31.6%	68.4%	100.0%
	Yes	Count	7	16	23
		% within gym (weights)	30.4%	69.6%	100.0%
Total		Count	25	55	80
		% within gym (weights)	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.718)

4.6.11.12.4 Kettle bells/boot camps

Table 4.47: Kettle bells/boot camps and injury

			Injury		
			No	Yes	Total
Kettle bells/boot camps	No	Count	23	53	76
		% within kettle bells/boot camp	30.3%	69.7%	100.0%
	Yes	Count	2	2	4
		% within kettle bells/boot camp	50.0%	50.0%	100.0%
Total		Count	25	55	80
		% within kettle bells/boot camp	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.370)

4.6.11.12.5 Pilates

Table 4.48: Pilates and injury

			Injury		
			No	Yes	Total
Pilates	No	Count	24	52	76
		% within pilates	31.6%	68.4%	100.0%
	Yes	Count	0	3	3
		% within pilates	0.0%	100.0%	100.0%
Total		Count	24	55	79
		% within pilates	30.4%	69.6%	100.0%

Fischer's Exact Test (*p*=0.332)

4.6.11.12.6 Running

Table 4.49: Running and injury

			Injury		
			No	Yes	Total
Running	No	Count	14	37	51
		% within running	27.5%	72.5%	100.0%
	Yes	Count	11	18	29
		% within running	38.0%	62.0%	100.0%
Total		Count	25	55	80
		% within running	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.386)

4.6.11.12.7 Yoga

Table 4.50: Yoga and injury

			Injury		
			No	Yes	Total
Yoga	No	Count	25	50	75
		% within yoga	33.3%	66.7%	100.0%
	Yes	Count	0	5	5
		% within yoga	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within yoga	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.145)

4.6.11.12.8 Other

Table 4.51: Other and injury

			Injury		
			No	Yes	Total
Other	No	Count	20	41	61
		% within other	32.8%	67.2%	100.0%
	Yes	Count	5	14	19
		% within other	26.3%	73.7%	100.0%
Total		Count	25	55	80
		% within other	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.409)

4.6.11.13 Nutritional Supplements and Injury

4.6.11.13.1 Carbohydrate drink

Table 4.52: Carbohydrate drink use and injury

			Injury		
			No	Yes	Total
Carbohydrate drink	No	Count	24	54	78
		% within carbohydrate drink	30.8%	69.2%	100.0%
	Yes	Count	1	1	2
		% within carbohydrate drink	50.0%	50.0%	100.0%
Total		Count	25	55	80
		% within carbohydrate drink	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.530)

4.6.11.13.2 Fat Burner

Table 4.53: Fat burner use and injury

			Injury		
			No	Yes	Total
Fat burner	No	Count	24	55	79
		% within fat burner	30.4%	69.6%	100.0%
	Yes	Count	1	0	1
		% within fat burner	100.0%	0.0%	100.0%
Total		Count	25	55	80
		% within fat burner	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.312)

4.6.11.13.3 Joint Support

Table 4.54: Joint support use and injury

			Injury		
			No	Yes	Total
Joint support	No	Count	25	52	77
		% within joint support	32.5%	67.5%	100.0%
	Yes	Count	0	3	3
		% within joint support	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within joint support	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.319)

4.6.11.13.4 Meal replacement

Table 4.55: Meal replacement use and injury

			Injury		
			No	Yes	Total
Meal replacement	No	Count	24	55	79
		% within meal replacement	30.4%	69.6%	100.0%
	Yes	Count	1	0	1
		% within meal replacement	100.0%	0.0%	100.0%
Total		Count	25	55	80
		% within meal replacement	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.312)

4.6.11.13.5 Multivitamin

Table 4.56: Multivitamin use and injury

			Injury		
			No	Yes	Total
Multivitamin	No	Count	19	32	51
		% within multivitamin	37.3%	62.7%	100.0%
	Yes	Count	6	23	29
		% within multivitamin	20.7%	79.3%	100.0%
Total		Count	25	55	80
		% within multivitamin	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.098)

4.6.11.13.6 Protein Shake

Table 4.57: Protein shake use and injury

			Injury		
			No	Yes	Total
Protein shake	No	Count	19	50	69
		% within protein shake	27.5%	72.5%	100.0%
	Yes	Count	6	5	11
		% within protein shake	54.5%	45.5%	100.0%
Total		Count	25	55	80
		% within protein shake	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.077)

4.6.11.13.7 Other

Table 4.58: Use of other supplements and injury

			Injury		
			No	Yes	Total
Other	No	Count	24	52	76
		% within other	31.6%	68.4%	100.0%
	Yes	Count	1	3	4
		% within other	25.0%	75.0%	100.0%
Total		Count	25	55	80
		% within other	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.630)

4.6.11.13.8 None

Table 4.59: Use of no supplements and injury

			Injury		
			No	Yes	Total
None	No	Count	10	27	37
		% within none	27.0%	73.0%	100.0%
	Yes	Count	15	28	43
		% within none	34.9%	65.1%	100.0%
Total		Count	25	55	80
		% within none	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.304)

4.6.11.14 Court surface and injury

The relationship between court surface and injury could not be computed as the entire sample (100%) played on hard courts.

4.6.11.15 Racket properties and injury

4.6.11.15.1 Racket head size

Table 4.60: Racket head size and injury

			Injury		
			No	Yes	Total
Head size	Small	Count	1	2	3
		% within head size	33.3%	66.7%	100.0%
	Traditional	Count	19	37	56
		% within head size	33.9%	66.1%	100.0%
	Oversize	Count	5	16	21
		% within head size	23.8%	76.2%	100.0%
Total		Count	25	55	80
		% within head size	31.3%	68.8%	100.0%

Linear-by-Linear Association (*p*=0.435)

4.6.11.15.2 Racket weight

Table 4.61: Racket weight and injury

			Injury		
			No	Yes	Total
Weight	Light	Count	7	13	20
		% within weight	35.0%	65.0%	100.0%
	Medium	Count	14	30	44
		% within weight	31.8%	68.2%	100.0%
	Heavy	Count	4	12	16
		% within weight	25.0%	75.0%	100.0%
Total		Count	25	55	80
		% within weight	31.3%	68.8%	100.0%

Linear-by-Linear Association (*p*=0.531)

4.6.11.15.3 String tension

Table 4.62: String tension and injury

			Injury		
			No	Yes	Total
Tension	Soft	Count	0	8	8
		% within string tension	0.0%	100.0%	100.0%
	Medium	Count	22	42	64
		% within string tension	34.4%	65.6%	100.0%
	Hard	Count	3	5	8
		% within string tension	37.5%	62.5%	100.0%
Total		Count	25	55	80
		% within string tension	31.3%	68.8%	100.0%

Linear-by-Linear Association (*p*=0.108)

4.6.11.15.4 Grip size

Table 4.63: Grip size and injury

			Injury		
			No	Yes	Total
Grip size	Correct	Count	1	0	1
		% within grip size	100.0%	0.0%	100.0%
	Incorrect	Count	24	55	79
		% within grip size	30.4%	69.6%	100.0%
Total		Count	25	55	80
		% within grip	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.312)

4.6.11.15.5 Vibration dampener

Table 4.64: Vibration dampener and injury

			Injury		
			No	Yes	Total
Vibration dampener	No	Count	3	8	11
		% within vibration dampener	27.3%	72.7%	100.0%
	Yes	Count	22	47	69
		% within vibration dampener	31.9%	68.1%	100.0%
Total		Count	25	55	80
		% within vibration dampener	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.531)

4.6.11.15.6 Shoes

Table 4.65: Shoes and injury

			Injury		
			No	Yes	Total
Shoes	Tennis shoes	Count	25	54	79
		% within shoes	31.6%	68.4%	100.0%
	Cross trainers	Count	0	1	1
		% within shoes	0.0%	100.0%	100.0%
Total		Count	25	55	80
		% within shoes	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.687)

4.6.11.16 Playing style

4.6.11.16.1 Forehand grip

Table 4.66: Forehand grip and injury

			Injury		
			No	Yes	Total
Forehand grip	Eastern	Count	1	9	10
		% within forehand grip	10.0%	90.0%	100.0%
	Continental	Count	10	27	37
		% within forehand grip	27.0%	73.0%	100.0%
	Semi-Western	Count	9	10	19
		% within forehand grip	47.4%	52.6%	100.0%
	Western	Count	5	9	14
		% within forehand grip	35.7%	64.3%	100.0%
Total		Count	25	55	80
		% within forehand grip	31.3%	68.8%	100.0%

Linear-by-Linear Association (*p*=0.146)

4.6.11.16.2 Backhand preference

Table 4.67: Backhand preference and injury

			Injury		
			No	Yes	Total
Backhand preference	One-handed	Count	17	37	54
		% within backhand preference	31.5%	68.5%	100.0%
	Two-handed	Count	8	18	26
		% within backhand preference	30.8%	69.2%	100.0%
Total		Count	25	55	80
		% within backhand preference	31.3%	68.8%	100.0%

Fischer's Exact Test (*p*=0.581)

4.6.11.17 Logistic regression table

Factors that were significantly associated with injury during the past 12-months (spirits, protein shake use, handedness, BMI, cycling and gym (cardio)) as well as gender and age were entered as independent variables into a logistic regression model. Using backward elimination based on likelihood ratios, after 5 steps, the following variables remained in the model, indicating that they were significantly independently associated with injury:

Table 4.68: Logistic regression table

		p-value	OR	95% CI for OR	
				Lower	Upper
Step 5[a] linear regression steps	BMI	0.042	0.823	0.682	0.993
	Alcohol (Spirits) consumption	0.020	10.443	1.439	75.768
	Cycling	0.040	0.229	0.056	0.938
	Gym (cardio)	0.011	12.283	1.794	84.110
	Constant	0.025	191.420		

The results for the logistic regression table (Table 4.68) is as follows:

- For every one unit increase in BMI, the odds of injury decreased by 18%.
- The participants who used spirits were 10.4 times more likely to have an injury than the participants who did not use spirits.
- Participants who also cycled were 77% less likely to experience an injury than participants who did not cycle.

However, the confidence intervals were wide, indicating that the results should be interpreted with caution.

4.6.11.18 Association between equipment and upper extremity injuries

A crosstab was used to determine if there were any associations between equipment use and injuries in the upper extremity in the past 12-months
Only the statistically significant associations are shown and where the statistical test is valid, i.e. where there were enough people with the type of injury to do a comparison.

Table 4.69: The association between equipment and upper extremity injuries in the past 12-months

Crosstab			Shoulder Injury No	Shoulder Injury Yes	Total
Vibration dampener	No	Count	11	0	11
		% within vibration dampener	100.0%	0.0%	100.0%
	Yes	Count	50	19	69
		% within vibration dampener	72.5%	27.5%	100.0%
Total		Count	61	19	80
		% within vibration dampener	76.3%	23.8%	100.0%

Fischer's Exact Test (*p*=0.046)

The results of table 4.69 were as follows:

- Participants with vibration dampers are more likely to have shoulder injuries.

This could be an example of reverse causality due to the fact that this was a cross sectional study and it was not clear what occurred first - the player contracting a shoulder injury then installing a vibration dampener, or visa-versa.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Introduction

In this chapter, the results of the statistical analysis presented in Chapter Four will be discussed.

5.2 Objective One

Objective One was to describe the demographic profile of league tennis players in the northern eThekwini region (using a self-administered questionnaire) (Appendix O). The demographic profile included age, gender, ethnicity, height and weight. It also profiled participants past medical and tennis history as well as their training regime.

5.2.1 Age

Three studies on non-professional players have performed; Von Kramer and Schmitz-Beuting (1979) in Germany, who found that the mean age of participants was 43 years. Khune, Zettl and Nast-Kolb (2004) also performed a study in Germany and found that the mean age of participants was 53 years of age. Most recently, Jayanthi *et al.* (2005) performed a study in the United States of America, and found that the mean age of participants was 46.9 years of age. Studies have found that the mean age or age range of elite or professional tennis players have been much lower than that of recreational or non-competitive players . Khune, Zettl and Nast-Kolb (2004) prospectively followed both competitive and recreational players and found that the mean age of the recreational players was 53 years of age, compared to the mean age of competitive players, which was 25 years of age. Similarly, the mean age of elite participants in a study by Winge, Jorgensen and Lassen Nielson (1989) was 28 years of age for male participants and the mean age for female participants was 22 years of age. More recently, a study done on professional tennis players by Kachanathu, Kumar and Malhotra (2014) found that the mean age was 22.67 (9.34) years of age.

The mean age of the participants in the current study was 49.04 years of age (Table 4.1), which is considered to be of similar age to other epidemiological studies on non-professional tennis players. It is evident from the literature that the mean age of elite or professional tennis players is much lower than that of non-professional players (Krause and Pottinger 1988; Winge, Jorgensen and Lassen Nielson 1989; Khune, Zettl and Nast-Kolb 2004; Pluim *et al.* 2006; Kachanathu, Kumar and Malhotra 2014).

The mean age of the players who experienced an injury in the past 12-month period was 48.38 years of age and was lower than that of the players who did not experience an injury in the past 12-month period (49.32 years of age) (Table 4.23). Age was considered to be statistically associated to injury (p=0.049) (Table 4.23). Similar results were found by Jayanthi *et al.* (2005) where a group of players aged 55 years and older reported less injuries than the players in the study aged who younger than 55 years of age. Jayanthi *et al.* (2005) suggested that tennis matches might be less intense between older players, resulting in fewer injuries. It has been suggested by Henning, Rosenbaum and Milani (1992) that a player's skill level is a significant factor associated with an injury, for example, a high skill level may decrease the likelihood of a player contracting injuries such as lateral epicondylitis. It is likely that the older players have spent more time perfecting their technique and learnt how to condition themselves for the tennis season so that they remain injury free.

5.2.2 Gender

The results of the current study show that 75% of the participants were male and the remaining 25% were female (Table 4.1). A possible reason for the higher percentage of male players could be that there are more male teams entered into the various inter-club leagues. Therefore, this is an accurate gender profile of the competitive, non-professional, league players. Future research studies could assess the gender profile of competitive (league players) versus non-competitive tennis players in the northern eThekwini region.

In the current study, gender was considered not to be significantly associated with injury (p=0.165) (Table 4.24). Other studies by Winge, Jorgensen and Lassen Nielson (1989); Jayanthi *et al.* (2005) support this finding. According to Bylak and Hutchinson (1998), males and females who participate in the same sporting codes tend to present with the same type of injuries.

5.2.3 Ethnicity

The ethnic makeup of the sample of tennis players from the northern eThekwini was fairly one sided. The vast majority of the participants were white (91.3%), whereas 5% were Indian, and African, Coloured and Other were each 1.3% of the sample respectively. In the current study, ethnicity was not considered to be statistically associated with injury (p=0.419) (Table 4.25).

The ethnic makeup of the eThekwini municipality is made up of 73.8% Black African, 16.7% Indian, 6.6% White, 2.5% Coloured and 0.4% for Other (Statistics South Africa 2011). No specific statistics could be found for Durban North, Glenashley, and Mount Edgecombe as these all fall within the eThekwini municipality.

The ethnic makeup of the sample is not representative of that of the general population in the eThekwini municipality. Anecdotally, it has been said that tennis is not as popular among the African communities as there is less funding being put back into the development of tennis in South Africa. Hence, the low percentage of African players in the current study. Soccer is the most widely played sport in South Africa, and has a strong following among the Black African community (South Africa.Info 2015). Organizations such as

Grass Root Soccer have launched several community-based football development programmes across South Africa (Grass Root Soccer 2015). Similar comparisons to international literature were limited as there is a paucity of information relating to variances in ethnic backgrounds.

5.2.4 Height, weight and BMI

Wong *et al.* (2014) researched the effects of body mass index and full body kinematics on tennis serve speed. They found that the mean BMI of the players in the study was 22.2. Tagliafico *et al.* (2009) researched the relationship between different forehand grips and wrist injuries in non-professional tennis players found that the mean BMI of uninjured players was 22. The BMI of injured players who used an eastern style grip was 23 and injured players who used a semi-western grip or western grip has a mean BMI of 21.

The mean BMI of the participants in the current study was 24.8, which is higher than the mean BMI of players in the studies by Tagliafico *et al.* (2009) and Wong *et al.* (2014). However, the participants in the study by Wong *et al.* (2014) were younger, elite tennis players with tournament experience which could explain why their mean BMI was lower than the mean BMI of players recorded in the current study, where the participants were older, and not as conditioned as what is expected from elite tennis players.

Research by Prentice (2006) and Saglimbini (2007) suggested that BMI (height to weight ratios) can influence injury rates. According to Prentice and Jebb (2001), it is well known that BMI gives a poor representation of body fat in individuals with developed musculature, which results from prolonged periods of physical training. In the current study, the association between BMI and injury was considered to be significant, for every one-unit increase in BMI, the odds of injury decreased by 18% (p=0.042) (Table 4.68). A reason for this could be due to the fact that players with a higher BMI score could have more lean muscle mass than those players with a lower BMI, which may help protect against injury.

5.2.5 Handedness

In the current study, it was found that 82% of the participants was right handed and the remaining 17.5% were left handed. Therefore, the results of the current study are in accordance with the findings of Holder (1997); Cardwell, Clark and Meldrum (2000). Handedness was not considered to be significantly associated with injury (*p*=0.091) (Table 4.27), however this may have been significant had the sample size been greater.

5.2.6 Medical Conditions

In the current study, none of the medical conditions listed were significantly related to injury. The following medical conditions were not significantly associated with injury:

- Asthma (*p*=0.319)
- Diabetes (*p*=0.470)
- High blood pressure (*p*=0.445)
- Hyper/Hypo- thyroidism (*p*=0.470)
- None (*p*=0.562)
- Other (*p*=0.370)

(Table 4.28 to Table 4.33)

The significance of the following medical conditions in relation to injury could not be computed, as there was insufficient numbers of these conditions in the sample:

- Epilepsy
- Osteoporosis
- Rheumatoid arthritis

Comparison to other studies was not possible as there is limited literature relating to medical conditions in tennis players. Results of the current study found that none of the above-mentioned medical conditions were significantly related to injury.

5.2.7 Alcohol Consumption

It was found the amount of alcohol that players consumed weekly was not statistically related to injury (p=0.933) (Table 4.37), but rather the type of alcohol consumed. It was found that there was no statistically significant relationship between the players who consumed beer (p=0.315) (Table 4.34) and wine (p=0.324) (Table 4.35) with an injury. However, it was found that spirit alcohol consumption was statistically significantly related to injury (p=0.043) (Table 4.36) and that they were 10.4 times more likely to be injured than those players who did not consume spirit alcohol (Table 4.68).

Alcohol intake seems to be linked with some post-competition or even post-training social rituals (Maughan and Burke 2008). Adult players generally lose between 1 and 2.5 litres of sweat per hour during competitive tennis in warm to hot ambient temperatures (Bergeron, Armstrong and Maresh 1995). Maughan and Burke (2008) proposed that it is highly likely that athletes become dehydrated after a competition or because they have eaten very little, alcohol is rapidly absorbed. Alcohol causes dilation of blood vessels, which can lead to an unwanted increase in swelling around the injured body part and affect recovery time (Maughan and Burke 2008). According to Watkins and Adler (1993), consuming food with alcohol is known to reduce peak blood alcohol concentration (BAC) and also help with the rate of alcohol elimination. Mitchell, Teigen and Ramchandani (2014) studied the rate of absorption of ethanol from beer, wine and spirits. Results showed that peak BAC was significantly higher ($p<0.001$) after consuming a spirit/tonic drink than wine or beer with the equivalent ethanol volume.

The questionnaire used in the current study asked the participants to state how much alcohol they consume on a weekly basis, however, a question was not asked on how much alcohol they consumed post-competition, post-training, with a meal or on an empty stomach. Therefore, future studies should investigate whether players consume alcohol immediately post-competition or after they have consumed a meal as this could have an effect on the relationship of BAC levels and injury.

5.2.8 Cigarette smoking

Brage and Bjerkedal (1996) performed a large cross-sectional survey (n=6 681) on the general population in Norway and found there to be a highly significant association between smoking and musculoskeletal pain. The odds ratio (OR) for pain amongst ex-smokers in relation to those who were current smokers, or those who have never smoked, was intermediary. A similar study was performed by Palmer *et al.* (2003) who explored the relationship between non-smokers, ex-smokers and current smokers (*n*=12907) and musculoskeletal pain. Their results concluded that there was a strong association between smoking and musculoskeletal pain in all anatomical regions that were investigated. The relationship also existed for ex-smokers, but the association was stronger for those who were current smokers. Therefore, according to the literature, current smokers experience more musculoskeletal pain than ex-smokers or non-smokers.

In the current study, the relationship between a players' pack history of smoking and injury was not found to be statistically significant (p=0.217) (Table 4.40), nor was the relationship between current smokers and injury considered to be significant (p=0.095) (Table 4.39). However, the relationship between ex-smokers and injury was found to be statistically significant (p=0.013) (Table 4.38). Comparison to other studies was not possible as there was limited literature available relating to the relationship of smoking and musculoskeletal injuries in tennis players.

The results of the current study do not concur with the literature. An explanation for this could have been due to the small sample size in relation to the studies by Brage and Bjerkedal (1996) and Palmer *et al.* (2003). Therefore, future studies should investigate the relationship between cigarette smoking and injury on a larger sample of league tennis players. Future studies will also need to investigate the number of years an ex-smoker has ceased smoking, as this may have an effect on the development of injuries in tennis players.

5.3 Tennis history, training and nutrition

5.3.1 Duration of tennis career, and duration of tennis played per week.

The literature suggests that increased time playing tennis as well as increased and duration of play over the years are associated with increased injury rates (Abrams, Renstrom and Safran 2012). In a study by Pluim and Staal (2009), it was found that there was an increased injury rate for those who played more than 3 hours of tennis per week. Kitai *et al.* (1986) found that those amateur players who played 8 hours or more per week showed symptoms of lateral epicondylitis whereas participants in that study who did not display symptoms of lateral epicondylitis played an average of 5.5 hours or less per week. Gruchow and Pelletier (1979) found that participants who played in tennis for longer than 2 hours per day suffered with more frequent episodes of elbow pain compared to those who played less than 2 hours per day. No specific data could be found relating to the number of years a player's career had spanned and the relationship with injury.

The results of this study do not concur with the current literature as it was demonstrated that the length of a player's tennis career (years playing tennis) (p=0.810) (Table 4.41) and the total number of hours of play per week in relation to injury (p=0.547) (Table 4.42) were considered not to be significantly associated with injury. Based on the findings of Abrams, Renstrom and

Safran (2012), one would assume that the more time a player spends playing tennis, the more likely they are to contract an injury. However, based on the results of the current study, it can be said that those who spend more time on the court are better conditioned, and have a better technique. Skill level has been shown to be a significant factor decreasing the likelihood of a player contracting injuries (Henning, Rosenbaum and Milani 1992).

5.3.2 Highest level in which a player participated

Studies on recreational or non-professional tennis players (Von Kramer and Schmitz-Beuting 1979; Henning, Rosenbaum and Milani 1992; Khune, Zettl and Nast-Kolb 2004; Jayanthi *et al.* 2005) did not question the participants regarding the highest level in which they have competed. In respect of this study, all players were required to be non-professional, meaning they did not earn an income from playing tennis which was a requirement for participation as stated under the inclusion criteria (Chapter 3, Section 3.2.3.4.1). However, at one point in their career they may have been an elite/professional player, meaning that they did earn income from playing tennis.

Coaches and players agree that in order for a player to reach an elite level, they must spend countless hours practicing and playing matches to advance their skill level (Kibler and Safran 2005). This means that they spend a far greater amount of time on court compared to an amateur player. It was suggested by Jayanthi *et al.* (2005) that more advanced players use a better technique when playing which may lead to fewer injuries. Abrams, Renstrom and Safran (2012) concur, and stated that in theory elite or professional players should have decreased risk of injury. However, it is believed that they spend more time playing tennis compared to amateur players, which is what may account for similar injury rates between amateur and professional players. This fact could account for the relationship between highest level in which a player participated and injury, being considered as not statistically significant in the current study (p=0.552) (Table 4.43).

5.3.3 Cross-training activities

In the current study, Cycling (*p*=0.040) (Table 4.68) was considered to be significantly associated with injury. It was found that participants who cycle were 77% less likely to be injured than those who did not cycle. A reason for cycling being a protective factor for injury could be that the workload on the riders' joints are almost completely unrelated to their weight. This means that a person (injured or uninjured) is able to improve both their strength and stamina in their lower limb while at the same time not exposing their joints to a high mechanical work load (Fonda and Sarabon 2010).

The relationship between the following cross-training activities and injury, were considered not to be statistically significant in the current study:

- Gym (weights) (*p*=0.718)
- Kettlebells/boot camps (*p*=0.370)
- Pilates (*p*=0.332)
- Running (*p*=0.386)
- Yoga (*p*=0.145)
- Other (*p*=0.409)

(Table 4.46 to Table 4.51)

To the best of the researchers knowledge, no other studies investigated the relationship between cross-training activities and injury in non-professional or professional tennis players and therefore comparisons could not be made.

5.3.4 Nutritional Supplements

Just over half of the participants (53.8%) did not use any nutritional supplements, however, 36.3% took a multivitamin and 2.5% used a carbohydrate supplement (Figure 4.7). The Vitamins, Minerals and Supplements (VMS) industry is one of the fastest growing industries world wide, with an estimated revenue of $32 billion for supplements alone. The target market supplement companies market their products to are men and women in the 18-40 year age group (Lariviere 2013). The mean age of the participants in this study was 49.04 years, which is older than the target market aimed for by supplement companies. It is possible that supplements were not popular when many of the players started their careers (mean number of years their careers span is 27.5 years) (Table 4.5) and therefore they did not feel the need to change their diet regime.

According to Brunker and Khan (2008), poor nutrition can increase the risk of injury in athletes because the body is not able to recover after training or competition without the required nutrients. Carbohydrates are vital for replenishing lost glycogen stores and proteins are needed to prevent muscle breakdown (Brunker and Khan 2008).

In the current study, it was found that there was no significant association between injury and the use of any of the listed nutritional supplements:

- Carbohydrate drink (p=0.530)
- Fat burner (p=0.312)
- Joint support (p=0.319)
- Meal replacement (p=0.312)
- Multivitamin (p=0.098)
- Other (p=0.630)
- Protein shake (p=0.077)
- None (p=0.304)

(Table 4.52 to Table 4.59)

Shamus and Shamus (2001) stated that poor nutrition would lead to an increase in time needed for an athlete to recover from injury. Therefore, future studies should investigate the relationship between injury and the amounts of ingested macronutrients (proteins, carbohydrates and fats) in a tennis player’s diet.

5.4 Court surface and equipment

5.4.1 Court surface

Due to the fact that the entire population of league tennis players in the northern eThekwini area plays on hard courts the relationship between different court surfaces and injury could not be computed.

5.3.2 Discussion on tennis racket properties

The results of this study found that 70% of the participants used a racket with a traditional (96-106sq.in) head diameter. The most popular weight racket, used by 55% of the participants was one that weighed between 281g and 300g. The most popular string tension, used by 80% of the participants, ranged between 55lbs and 60lbs.

In the current study, the following tennis racket properties were not considered to be significantly associated with injury:

- Racket head size (p=0.435)
- Racket weight (p=0.531)
- String tension (p=0.108)
- Grip size (p=0.312)
- Vibration dampener (p=0.531)

(Table 4.60 to Table 4.64)

Although the following authors: Reynolds, Standlee and Angevine (1977); Kaimen (1990); Miller (2006); De Smedt *et al.* (2007); Ferrara and Cohen (2013) listed tennis racket properties that were possible risk factors for pain or injury; in this study, it was found that neither the racket head size, weight, string tension nor grip size had a significant association with injury. However, it was also found that there was a significant association between the use of a vibration dampener and shoulder injuries (p=0.046) (Table 4.69). This could be an example of reverse causality due to the fact that this was a cross sectional study and it could not be confirmed what occurred first; - the player contracting a shoulder injury then installing a vibration dampener, or visa versa.

5.3.3 Footwear

The current study found that 98.7% of players chose to wear tennis shoes, while the remaining 1.3% chose to wear cross-trainers (Figure 4.14) Tennis shoes are purpose built which explains the reason why the vast majority (98.7%) chose to play in tennis shoes as opposed to cross-trainers/running shoes.

Although Kibler and Safran (2005) have said that the incorrect footwear or footwear with poor cushioning and support increase a players chance of developing an injury, in the current study, the relationship between footwear and injury was not considered to be statistically significant (p=0.687) (Table 4.65).

5.4 Playing Style

5.4.1 Forehand grip

The most popular forehand grip used by the 43.6% of the participants in this study was the continental grip. The second most popular was the semi-western grip used by 23.8% of the participants. The western grip was used by 17.5% and the eastern grip was only used by 11.3% of the participants (figure 4.15).

Tagliafico *et al.* (2009) performed a study, which compared wrist injuries in relation to forehand grip, in competitive, non-professional tennis players. They found that the most popular grip used by the participants in the study was the semi-western grip, and the least popular was the continental grip. The results of this study are in contrast to Tagliafico *et al.* (2009) findings in that the most popular grip used by participants was the continental grip and the least popular was the eastern grip. One explanation for this could have been that participants did not fully understand the classification of each grip, which caused the results to vary between studies. On the other hand, the continental grip used to be the universal grip used to hit nearly every stroke; forehand, backhand, serve and volley. Today, it is mainly used for serving and volleying (Tagliafico *et al.* 2009).

The participants in the current study had a similar mean age (49.04 years) (Table 4.1) compared to Tagliafico *et al.* (2009) study who used an eastern style grip (42 years of age). But, participants who used a semi-western or western style grip had a mean age of 22 years. The relatively older players in this current study may have started their tennis careers using the continental grip or an eastern grip to play all their strokes and chose not to learn how to use the semi-western or western style grip whereas the younger players started out using a semi-western or western style grip.

The overall prevalence of wrist injuries was 13% in the study by Tagliafico *et al.* (2009). In the current study, the prevalence of wrist injuries in the past 12-months was 5.5% and 6.9% of current injuries. The relationship between forehand grip and injury was not considered to be statistically significant (p=0.146) (Table 4.66) in the current study.

5.4.2 Backhand preference

Over two thirds of the participants (67.5%) used a one-handed backhand, while the remaining 32.5% used a two-handed backhand (Figure 4.16). Players in the current study have a mean age of 49.04 years, compared to the mean age of 27.0 years of age for the current top 10 ranked male players (Garber 2012). It can be presumed that the majority of players in this study began their tennis career when the one-handed backhand was popular and decided against changing their backhand preference to a two-handed backhand. In the current study, the relationship between backhand preference and injury was not considered to be statistically significant (p=0.581) (Table 4.67).

5.5 Objective Two

Objective Two was to determine the prevalence of musculoskeletal injuries amongst league tennis players in the northern eThekwini region.

5.5.1 Prevalence of tennis injuries

The period prevalence of injury in the participants was 68.75% (Table 4.8) and the point prevalence of current injury was 36.25% (Table 4.9). The current study found that pain in the upper limb was most prevalent (49%), followed by the lower limb (27.5%) and the back and trunk (23.5%) (Figure 4.17).

The results of this current study are in accordance with those of Winge, Jorgensen and Lassen Nielson (1989); Jayanthi *et al.* (2005) who found a predominance of injuries in the upper limb of participants in their studies (41% to 45.8%) (Table 2.1). However, most of the literature on tennis injuries has shown that there is a higher prevalence of lower limb injuries compared to upper limb injuries with a prevalence ranging from 52.5% to 63.6% (Chard and Lachmann 1987; Hutchinson *et al.* 1995; Safran *et al.* 1999; Khune, Zettl and Nast-Kolb 2004; Veijgen 2007).

Elbow pain was the most prevalent anatomical site of injury in the current study (21.4%) (Figure 4.17). This result is not unsimilar to studies by Gruchow and Pelletier (1979); Carroll (1981); Kitai *et al.* (1986) in which elbow pain was also found to be more prevalent, although their results were slightly higher ranging from 35% to 51%. However, these studies were performed 24 to 36 years prior to the current study. A reason for their higher prevalent results may be because there has been great improvement in tennis racket technology over the years. Rackets are now made out of materials such as graphite and carbon fibre instead of wood (Miller 2006). It has been said that incorrect racket weight and string tension can put more strain on the tendons in the elbow (Jobe and Cioccotti 1994). Another reason for the lower prevalence of elbow pain in the current study compared to older literature could be attributed to the declining popularity of the one-handed backhand (Steinberger 2014). According to De Smedt *et al.* (2007), players who use a two-handed backhand are at lower risk for developing lateral epicondylitis than players who use a one-handed backhand.

The most commonly affected anatomical sites of injury reported in the current study were the elbow (21.4%), shoulder (19.4%), lumbar spine (17.3%) and the knee (8.2%). The results of this study are similar to those found by Jayanthi *et al.* (2005) who also performed a study on non-professional tennis players. Jayanthi *et al.* (2005) found that the elbow (20%) was most commonly affected followed by the shoulder (15%), the knee (12%) and the back (10%) (Figure 4.17). The findings of the current study are in accordance with those of Jayanthi *et al.* (2005) in that the most commonly affected anatomical site of injury was the elbow, followed by the shoulder, then the lumbar spine and the knee. Therefore, the top four most prevalent anatomical sites of injury are similar to those found in the study by (Jayanthi *et al.* 2005). More research is needed specifically on competitive, non-professional tennis players so that injury trends can be identified and intervention strategies can be put in place to try reduce the prevalence of injuries in this group (Pluim *et al.* 2006).

Although there is some variation in injury locations between studies, the shoulder, elbow, knee, back and leg are among the most commonly affected anatomical sites of injury. There have been some trends that have been identified in the tennis literature and according to Abrams, Renstrom and Safran (2012) acute injuries are common in the lower limb while overuse or chronic injuries are common in the upper limb and the back and trunk. Pluim *et al.* (2006) suggested that education of players, coaches and parents is needed to help prevent further injury, as well as musculoskeletal testing to identify weak areas before injuries occur. This has implications for further research on evidence-based prevention of tennis injuries (Pluim *et al.* 2006).

5.5.2 Impact of injury on their game of tennis

5.5.2.1 Aggravating activities

Most of the participants chose serving/smashing as the most common aggravator of pain (32.4%) (Table 4.12). The serve is considered to be the most strenuous stroke in tennis because it was found that peak muscular activity in the shoulder and forearm was at its highest during the service action compared to other strokes (Elliott *et al.* 2003). Chow, Shim and Lim (2003) found that muscles in the lower trunk contract and stabilize the lumbar spine and assist in extension/flexion and rotation of the lumbar spine during the service action.

The backhand was chosen as the second most common pain aggravating activity (23%) (Table 4.12). De Smedt *et al.* (2007) proposed that players using a two-handed backhand rarely develop elbow pain. In a study by Kachanathu, Kumar and Malhotra (2014), the backhand was found to be the most aggravating factor precipitating an injury. Over two-thirds (67.5%) (Figure 4.16) of the participants in the current study play a one-handed backhand, which is thought to be a risk factor for the development of elbow pain.

Injuries or pain to the lower limb are often aggravated by activities such as running (Kibler and Safran 2005). In the current study, 20.3% (Table 4.12) of the participants reported that running aggravated their pain or injury.

5.5.2.2 Players that were forced to retire from a league match due to injury

In the past 12-month period, 7.4% (Table 4.14) of players who contracted an injury were forced to retire from a league match due to injury. At the time of the study, 3.9% (Table

4.15) of players who were currently injured were forced to retire from a league match due to their injuries.

All the participants of this study played on hard courts (100%) (Figure 4.8) play on hard courts. According to Fernandez, Mendez-Villanueva and Pluim (2006), a hard court surface is the most high-risk surface for injury compared to grass, clay and indoor (carpet) courts. However, because participants in this study play on the same surface court, comparison of injury rates between the different court surfaces could not be computed.

Similarly, Breznik and Batagelj (2012) found there to be a higher percentage of professional male tennis players who did not complete matches played on hard courts (2.62%) and clay courts (2.78%). A lower percentage of incomplete matches was found on carpet (indoor) courts (1.86%) and the lowest percentage was found on grass courts (1.65%) (Breznik and Batagelj 2012). This study by Breznik and Batagelj (2012) looked at retirements in general. Hyperthermia and dehydration will affect the performance and health of tennis players (Kovacs 2006). Most outdoor matches are played in warm or hot ambient conditions, as opposed to a more controlled indoor environment, which will explain the increased rates of retirement on outdoor courts (hard and clay courts) compared to indoor courts (Breznik and Batagelj 2012).

There is paucity of information when it comes to retirements in non-professional players. The current study asked participants to report whether or not they had been forced to retire from a league match due to a musculoskeletal injury. It did not take into account factors such as time of year when ambient temperatures in summer will be greater than winter. Increased ambient temperatures can lead to hyperthermia, dehydration and loss of electrolytes that will result in cramping (Kovacs 2006). It is possible some players in the current study could have confused a muscle cramp for a more serious musculoskeletal pathology and therefore retired. Future studies should factor in the time of year the player retired from a league match as this may affect retirement rates.

5.5.2.3 Number of players, and duration that they were unable to participate in tennis due to injury

Of the players who contracted injuries during the past 12-month period, 18.5% contracted an injury that resulted in them being unable to practice or fully participate in a game (Table 4.17). This is referred to as a “time loss” injury (Andersen *et al.* 2006). The percentage of players at the time of study currently suffering from a time loss injury was 7.1% (Table 4.17). An explanation for this finding may be that the players who were currently suffering with a time loss injury might not have been attending the league matches or practices, hence the lower percentage of time loss injuries recorded.

In a recent epidemiological study by Kachanathu, Kumar and Malhotra (2014) that sampled 350 professional tennis players from various national tennis sports complexes, it was found that the mean time loss for injured players was 29.3 days. Winge, Jorgensen and Lassen Nielson (1989) prospectively followed 104 elite Danish tennis players and found that the average duration of time taken for a player to recover from injury was 44.5 days. The authors believed that this was longer than expected for that adult population.

The mean time loss in the current study was 46.4 days (6.2 weeks) (Table 4.17). The tennis players studied by Kachanathu, Kumar and Malhotra (2014) were much younger with a mean age of 22.67 years, compared to 49.04 years (Table 4.1) in the current study. Loeser (2010) stated that age is a risk factor for conditions such as osteoarthritis due to ageing changes in cells and tissues that make joints more susceptible to damage and less able to maintain homeostasis. This could explain the difference in recovery time between the younger professional players and the older, non-professional players of the current study. According to Kibler and Safran (2005), no meaningful conclusions can be based on existing literature regarding time loss from play because there are so few epidemiological studies that looked specifically at the relative distribution of injuries and loss of play.

5.5.3 Cause of Injury

The participants in the current study reported that Overuse (36.9%) (Table 41.9) was the most common cause of injury. These results concur with the findings of Bylak and Hutchinson (1998), who stated that muscle and ligament sprains as a result of overuse are the most common types of tennis injury in players of all ages. Jayanthi *et al.* (2005) reported that the majority of injuries in their study were caused by overuse, which affected the elbow and shoulder. According to Bylak and Hutchinson (1998), overuse injuries are less common in younger players. Therefore, taking into account that the mean age of the current sample is older than literature studies (49.04 years) (Table 4.01), injuries due to overuse are expected in this population.

The second most common cause of injury was 'Other' (16.9%). Some responses for 'Other' included non-tennis related causes of injury such as "mountain biking", "golf", "soccer" and "incorrect desk ergonomics". Out of the total of 16.9% for 'other', 6.9% were non-tennis related causes of injury, 3.1% were considered acute/traumatic injuries, and adjusting to new equipment accounted for 1.5%. The remaining 5.4% of responses were considered overuse injuries.

In the current study, 12.3% reported that a lack of, or inadequate warm-up, was the cause of their injury. According to Kibler and Safran (2005), acute musculotendinous strains occur early in practice or play and are usually associated with improper warm-up or late in play due to muscular fatigue.

Hjelm, Werner and Renstrom (2010) performed a prospective two-year study on junior club tennis players in Sweden. According to the participants in the study, 24% of injuries sustained had an unknown cause. It is believed that almost 80% of those injuries with an unclear cause were likely to be overuse injuries. In the current study, 12.3% of injuries had an unknown cause of injury. Considering that around 80% of injuries with an unclear genesis were linked to overuse injuries in the study by Hjelm, Werner and Renstrom (2010), and that the literature states that overuse injuries are common in tennis, especially in the upper limb (Abrams, Renstrom and Safran 2012), the findings of the current study are in line with the current literature. However, further studies are needed regarding the cause of injuries in older recreational/non-competitive tennis players, as literature is limited for this population.

5.5.4 Treatment of injury

Bylak and Hutchinson (1998) stated that once an injury has been accurately diagnosed, only then can the rehabilitation process begin. The majority of injured players in the sample sought medical treatment for their injuries (75.8%) (Figure 4.21), and a physiotherapist was the most popular medical practitioner whose advice was sought by 34.8% of the injured players during the past-12 month period. Chiropractors were the second most popular medical practitioner whose advice was sought by 15.2% of the injured players.

Although there is no literature relating to which medical practitioners are consulted by non-professional tennis players, there are some references relating to the professional tennis players. In the article titled “Sport science and medicine in tennis” by Pluim *et al.* (2007), they make mention of eight (four full-time and four part-time) “Sports Medicine Therapists” who provide “athletic training and physiotherapy services” to the players on tour the men’s Association of Tennis Professionals (ATP) tour. On the Women’s Tennis Association (WTA) tour, the staff of the Sport Sciences and Medicine department is made up of “primary health care providers” (physical therapists or certified athletic trainers), licensed massage therapists and advisors from various other medicine disciplines (Pluim *et al.* 2007). No specific mention is made regarding chiropractors on either the ATP or WTA tour. This shows that physiotherapy is more popular on the professional tennis circuit and the findings of the current study support that notion.

Orthopedic surgeons are medical specialists and focus on injuries and diseases of the musculoskeletal system (American Academy of Orthopaedic Surgeons 2007), however only 7.6% of the injured players consulted with one. A reason for this could be that practitioners such as GPs, physiotherapists and chiropractors would only refer an injured player to an orthopedic surgeon if they felt that the injury needed to be repaired surgically. However, studies indicated that the majority of tennis injuries were of an overuse nature (Abrams, Renstrom and Safran 2012), and as such, physiotherapists and chiropractors are well equipped to manage and treat such injuries (Hyde and Gengenbach 2007), which accounts for them being the most popular and second most popular medical practitioner being consulted.

5.6 Objective Three

Objective Three was to describe the association between risk factors and prevalence of injury amongst league tennis players in the northern eThekwini region. Associations between the demographic variables and the prevalence of injury were first tested using chi square tests in the case of categorical variables, and t-tests in the case of continuous variables. Those variables that were associated at the 0.1 level of significance were entered into a binary logistic regression to analyse the risk factors of injury. A backward selection method was used using likelihood ratios. Odds ratios and 95% confidence intervals of the variables remaining in the model at the end were reported.

In the current study, age was found to have a statistically significant association with injury in the past 12-month period (p=0.049) (Table 4.28). The mean age of the players who were more likely to experience an injury was 48.38 (13.210) years of age, whereas the mean age of players who were unlikely to be injured was 49.32 (17.547) years of age. Therefore, the older players in the sample were less likely to be injured than the younger players. Similar results were found by Jayanthi *et al.* (2005) Similar results were found by Jayanthi *et al.* (2005) where a group of players aged 55 years and older reported less injuries than the players in the study aged who younger than 55 years of age. Jayanthi *et al.* (2005) suggested that tennis matches might be less intense between older players, resulting in fewer injuries. It has been suggested by Henning, Rosenbaum and Milani (1992) that skill level has been shown to be a significant factor that decreases the likelihood of a player contracting overuse injuries such as lateral epicondylitis. It has been agreed that in order for a player to advance their skill level they require countless hours of practice and play (Kibler and Safran 2005). But, the literature suggests that increased hours of play and duration of play over the years is linked to injury (Abrams, Renstrom and Safran 2012). In a study by Pluim and Staal (2009), it was found that those players who played tennis for over 3 hours per week were at higher risk for developing an injury. Based on the findings in this study, it can be said that although the sample of participants in the current study have a mean tennis career duration of 27.5 years (Table 4.5), and play tennis for a mean of 7.4 hours (Table 4.6) per week, it is likely that they have a greater level of skill, which may be a protective factor against injury (Henning, Rosenbaum and Milani 1992).

Body mass index score was found to be statistically significantly associated with injury in this study (*p*=0.042) (Table 4.68). It was found that for every one unit increase in BMI, the likelihood of injury decreased by 18%. Prentice and Jebb (2001) have stated that BMI score gives a poor representation of body fat in those individuals with developed musculature. In the current study, individuals with a higher BMI score could have had a higher lean muscle mass compared to those people with a lower BMI. The findings of this study suggest that an increased BMI may be a protective factor against injury. However, the relationship of body fat percentage and injury in league tennis players has not been established and therefore it cannot be stated categorically that an increased BMI is protective of injury without establishing the relationship between body fat percentage and injury in this population.

In the current study, it was found that the consumption of spirit alcohol had a significant relationship with injury (*p*=0.043) (Table 4.36), whereas the relationship of injury and the consumption of beer (*p*=0.315) (Table 4.34), or wine (*p*=0.324) (Table 4.68) were considered not to be statistically significant. The consumption of alcohol post-competition or even post-training appears to be part of social rituals (Maughan and Burke 2008). Adult players generally lose between 1 and 2.5 liters of sweat per hour of competitive tennis in warm to hot ambient temperatures (Bergeron, Armstrong and Maresh 1995). Players are likely to be dehydrated after their game and have eaten very little which results in alcohol being rapidly absorbed (Maughan and Burke 2008). Alcohol consumption will result in dilation of blood vessels resulting in an unwanted increase in areas where there has been mechanical trauma, or microtrauma, and therefore delaying recovery time (Maughan and Burke 2008). Mitchell, Teigen and Ramchandani (2014) studied the rate of absorption of ethanol from beer, wine and spirits. Results showed that peak blood alcohol concentration was significantly higher (*p*<0.001) after consuming a spirit/tonic drink than wine or beer with the equivalent ethanol volume. This may explain the significant relationship between spirit consumption and injury.

A statistically significant relationship was found between injury and those players who were ex-smokers (*p*=0.013) (Table 4.38). The results of the current study do not agree fully with the literature as it has been shown by Brage and Bjerkedal (1996) and Palmer *et al.* (2003) that there is a stronger association between those who are current smokers and musculoskeletal pain compared to those who are ex-smokers. Palmer *et al.* (2003) agreed with the findings of Brage and Bjerkedal (1996) in that there are noticeable effects in those who are ex-smokers.

In the current study, cycling was found to have a significant association with injury (*p*=0.040). It was found that cyclists were 77% less likely to experience an injury compared to those who did not cycle. Cycling is said to be one of the safest of the non-contact sports because the workload through the joints of the lower limb are unrelated to their weight (Fonda and Sarabon 2010). Cycling has even been recommended in the early phases of musculoskeletal rehabilitation by Fonda and Sarabon (2010) due to the low workload on the joint combined with large activation of the muscles in the lower limb. According to McDonagh and Davies (1984), the most effective stimuli for skeletal muscle growth is producing strong contractions. In this case, peddling on a bicycle would produce strong muscle contractions (Fonda and Sarabon 2010), and over time the skeletal muscle will adapt to the stimuli, resulting in an increased muscle mass (McDonagh and Davies 1984). An increased muscle mass will result in an increase in BMI score (Prentice and Jebb 2001), which may result in a decreased likelihood of injury (*p*=0.042) (Table 4.68).

5.7 Conclusion

The age of participants in the current study ranged from 18 to 81 years of age with a mean of 49.04 years of age. Three-quarters of the participants were male and the remaining quarter were female. In terms of ethnicity, 91.3% of the participants were white. Indian players made up 5% of the participants and African, Coloured and Other ethnic groups represented 1.3% each of the participants respectively. The height of players in this study ranged from 1.30m to 1.95m, with a mean of 1.75m. Their weight ranged from 50kg to 120kg with a mean of 76.4kg. Body Mass Index scores were calculated and it was found that the mean BMI of the participants was 24.8. Most of the players in the study were right- handed (82.5%) and the remaining 17.5% were left-handed. High blood pressure was the most common medical condition affecting 15% of the participants. Two-thirds (75%) of the participants had not been previously diagnosed with any medical conditions.

Alcohol consumption was popular among the participants with 74% consuming alcohol on a weekly basis. In terms of cigarette smoking, 80% of participants were non-smokers, 10% of the participants were ex-smokers and only the remaining 10% of the participants currently smoked at the time of the study.

The study found that the mean number of years the participants had played tennis had been for 27.5 years. Their time spent playing tennis weekly, during the league season, ranged from 2 to 19 hours, with a mean of 7.4 hours of tennis per week. In respect of competition level, 72.5% of the participants had only competed at an inter-club level whereas 16.3% had competed at an inter-provincial level, and 11.2% were once professional (national) players at one point in their career.

Running was found to be the most popular cross training activity with 36.3% of the participants running for between 2 and 8 hours per week. Weight training at a gym was the second most popular cross-training activity with 27.5% of the participants training in the gym weekly. Cycling was the third most popular cross-training activity with 23.8% of the participants taking part. Those who cycled spent an average of 2 hours per week cycling. Pilates was the least popular cross-training activity with only 3.8% of the participants taking part in it weekly. The most popular nutritional supplement was a multivitamin which was used by 36.3% of the participants. The second most popular nutritional supplement used was a protein shake used by 13.8% and only 2.5% of the participants used a carbohydrate supplement. Over half (53.8%) of the participants did not use any nutritional supplements.

All the participants in this study played their tennis on hard courts. The most popular racket size used by 70.0% of the participants was one with a head diameter of 96-105 sq.in. A medium weight racket weighing between 281-300g was used by 55.0% of the participants. A string tension ranging between 55-60lbs was the most popular choice, being used by 80.0% of the participants. Almost all (98.7%) of the participants used a racket grip size that is the correct size for their hand, whereas 1.3% of the participants used a grip size that is either oversize or undersize in relation to the size of their hand. Vibration dampeners were used by 86.3% of the participants. Tennis shoes were the preferred footwear of choice with 98.7% of players choosing to wear them as opposed to the 1.3% who chose to use running shoes or cross-trainers. A continental style grip was the most commonly used forehand grip used by 46.3% the participants. An eastern style was the least popular style grip only used by 11.3%. Over two-thirds (67.5%) of the participants played a one-handed backhand as opposed to the remaining 32.5% who played a two-handed backhand.

The prevalence of injuries experienced by the participants in the past 12-month period was 68.75%. There was a predominance of injuries in the past 12-month period in the upper limb (49%) compared to the lower limb (27.5%) and the trunk and back (23.5%). The elbow was the most common anatomical site of injury (21.4%), followed by the shoulder (19.4%), the lumbar spine (17.3%) and the knee (8.2%). Overhead strokes, like serving and smashing were considered to be the most common injury-aggravating stroke (32.4%) and the backhand was the second most common injury-aggravating stroke (23.0%). Of those players in the participants who were injured in the past 12-month period, only 7.4% were forced to retire from a league match due to injury. It was found that 18.5% of the participants that had contracted an injury in the past 12- months were unable to fully participate in tennis for a period of time ranging from 1 week up to 20 weeks. The mean duration players were unable to participate in tennis due to injury was of 6.2 weeks. Overuse was considered to be the cause of 36.9% of injuries. Of the players who contracted injuries, 24.2% chose not to seek treatment from a medical practitioner. Physiotherapists were the most popular medical practitioners seen by the injured participants with 34.8% of them consulting one for an injury and only 15.2% seeing a chiropractor for treatment. A biokineticist was the least common practitioner visited with only 4.5% of the injured participants consulting with one for their injury during the past 12-month period.

The point prevalence recorded at the time of the study was found to be 36.25%. There was also a predominance of current injuries in the upper limb (50%) compared to the lower limb (25%) and the trunk and back (25%). The shoulder was the most common anatomical site of current injury (25%), followed by the elbow (20.5%), the lumbar spine (20.5%) and the knee (13.6%). Serving and smashing were also considered to be the most common injury-aggravating stroke (35.3%). The backhand and forehand were the second most common injury-aggravating strokes accounting for 17.6% each respectively. Of those players in the participants who were currently injured at the time of the study, 3.4% were forced to retire from a league match due to their injury. It was found that 7.1% of the participants that was currently injured were unable to fully participate in tennis for a period of 8 weeks. Overuse was considered to be the cause of 37.1% of current injuries. Of the players who were currently injured, 24.2% chose not to seek treatment from a medical practitioner. Physiotherapists were also the most popular medical practitioners seen by the injured participants with 30.3% of them consulting one for their injury and only 15.2% seeing a chiropractor for treatment. Only 3% of the injured participants saw with a biokineticist for their current injuries.

Age was considered to be a risk factor for injury in the current study as there was a significant association between age and injury (p=0.049). It was found that the older players (49.32 (17.547) years of age) were less likely to contract injures than the younger players (48.38 (13.210) years of age). Body Mass Index and injury had a significant association with injury (p=0.042). It was found that for every one point increase in BMI score there was an 18% decrease in the likelihood of contracting an injury. The consumption of spirit alcohol and injury were also significantly associated (*p*=0.043). The association between ex-smokers and injury was considered to be significant (*p*=0.013). Those league tennis players in the participants who cycled on a weekly basis were 77% less likely to contract an injury than those who did not cycle. The relationship between injury and cycling was considered to be significant (*p*=0.040).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter includes a summary of the results of the study. Conclusions about the results are explained, the limitations of the study are stated and recommendations for future studies are provided.

6.2 Conclusions

This study determined that injuries to the upper limb were more prevalent than injuries to the lower limb or the trunk and back. The shoulder was the most common anatomical site of injury in league tennis players in the 12-month period prior to the study, whereas the elbow was the most commonly affected site of injury at the time of the study. Factors that increased the likelihood of a player becoming injured were: younger age league tennis players; the consumption of spirit alcohol and ex-smokers. However, the risk of injury decreased by 18% for every one point increase in BMI score. Cycling had a significant association with no injury (p=0.040); it was found that they were 77% less likely to experience an injury compared to players who did not cycle. Factors such as the length of a player's career and the duration a player participates in tennis per week did not have a significant association with injury in this study. Overhead strokes (serving and smashing) were the most common injury-aggravating strokes. Overuse was the cause of the majority of injuries in this sample. Physiotherapists were the most popular, and chiropractors were the second most popular medical practitioners consulted with for the treatment of injuries. Therefore, it is necessary for league tennis players to look at the associations between risk factors and injury in order to have a better understanding of what can be done to minimize risk and ensure as little time loss as possible from tennis.

6.3 Limitations

- The sample was drawn from members of the four tennis clubs that compete in the inter-club league in the northern eThekwini region. Although a satisfactory response rate of 70.16% was achieved (Section 4.5), future studies should aim to investigate a broader scope of league tennis players, for example, league players from the other regions around Kwa-Zulu Natal or even a national study including all league players from around South Africa. This would ensure that the study could represent the entire league tennis population adequately.

- The definition of an acute injury in this study was defined as any traumatic incident that occurred during practice or competition. An overuse injury was defined as one that was not initiated by a specific traumatic incident, but causing symptoms of pain or swelling during or after a game of tennis. Some players may have interpreted this definition of injury differently. Some authors say that an injury should be defined as a “time loss injury” resulting in the recording of more serious injuries that would affect a player’s health and or performance. However, a global definition of injury has not been standardized in tennis literature. Future studies should not use such a broad definition for injury and rather use “time loss” as a definition. This would help reduce recall bias.

- Questionnaires give an overall picture of the league tennis players’ demographics, training and injury statistics, however it is a tool that allows for associations to be determined and not causality. The type of data helps direct future research in the area. Therefore, longitudinal studies are recommended.

6.4 Recommendations

- Using the results of this study, future studies need to implement an injury prevention strategy, such as a strength and conditioning programme, with the goal to prevent injuries in this population.

- Future studies could investigate the prevalence of musculoskeletal injuries in league tennis players from other regions around Kwa-Zulu Natal or from around South Africa.

- The gender profile of competitive league players versus that of recreational players in the northern eThekwini region should be assessed.

- Future studies could look at the relation between body composition and injury.

- Future studies should question participants about their alcohol consumption habits: whether they consume alcohol post-training or post-competition, and whether they consume alcohol with food or on an empty stomach.

- Although a significant association was found between risk of injury and cardiovascular exercise, on further reflection, it was decided that the research tool didn’t adequately explore what type of cardiovascular exercise was undertaken and therefore the statement was retracted. Future studies should explore the association between tennis injuries and the various different cardiovascular exercises.

- The cost of injury was not determined in this study. It could be of importance in future studies.

- The time in the season when the player contracted the injury should be recorded in future studies.

- “Time loss” should be used as a definition for injury in future studies, that way the researcher can determine the prevalence of more serious injuries that can potentially affect the health of the player.

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Appendices

Appendix A: Institutional Research Ethics Committee (IREC) provisional approval

DUT
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Institutional Research Ethics Committee
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www.dut.ac.za

19 August 2014

IREC Reference Number: **REC 51/14**

Mr M C Benporath
16 Somme Road
Durban

Dear Mr Benporath

A musculoskeletal injury profile of league tennis players in the greater Durban area

I am pleased to inform you that Provisional Approval subject to piloting of the data collection tool has been granted to your proposal REC 51/14.

In addition, the IREC recommends the following:

- The submission of a letter to the IREC stating that the expert group can be done before application for ethics clearance.
- The questionnaire will produce a statistical problem since figures overlap e.g. 0-2, 2-4 and 4-6. The researcher should consider reviewing the options provided.

The Proposal has been allocated the following Ethical Clearance number **IREC 055/14**. Please use this number in all communication with this office.

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

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

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

Please note that you may continue with validity testing and piloting of the data collection tool. Research on the proposed project may not proceed until IREC reviews and approves the final document. If there are no changes to the data collection tool, [illegible] writing.

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC

Appendix B: IREC Approval of final questionnaire

DUT
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22 September 2014

IREC Reference Number: **REC 51/14**

Mr M C Benporath
16 Somme Road
Durban

Dear Mr Benporath

A musculoskeletal injury profile of league tennis players in the greater Durban area

The Institutional Research Ethics Committee acknowledges receipt of the letter confirming that the expert group was allowed to be done before application for ethics clearance

In addition, the IREC acknowledges receipt of your final data collection tool for review.

We are pleased to inform you that the questionnaire has been APPROVED; you may now proceed with data collection on the proposed project.

Kindly ensure that participants used for the pilot study are not part of the main study.

Yours Sincerely

[redacted]

Prof J. K. Adam
Chairperson: IREC

Appendix C: IREC approval of amendment

Institutional Research Ethics Committee
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17 November 2014

Mr M C Benporath
16 Somme Road
Durban

Dear Mr Benporath

Application for Amendment of Approved Research Proposal

A musculoskeletal injury profile of league tennis players in the northern eThekwini region

I am pleased to inform you that your application for amendments to the title and methodology of your research proposal have been Approved.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

Appendix D: Expert group letter of information

Dear Participant,

I would like to welcome you into the focus group of my study, the title of my research project is:

A musculoskeletal injury profile of league tennis players in the greater Durban area

Name of Supervisor: Dr G. Haswell
Name of Student: Michael Benporath
Institution: Durban University of Technology

The purpose of this expert group is to identify and determine the risk factors and management protocols that are used on tennis players in this area, that may have an effect on the rate of injury in the sport. The discussions will focus on any changes that are necessary to alter the questionnaire into a more accurate tool.

Your participation in this expert group will remain totally confidential. You are also permitted at any point to disagree with reason at any point in the discussion. Your participation in the expert group is both appreciated and respected.

Thank you for your participation,
Yours sincerely

Michael Benporath (Chiropractic student)

Dr G. Haswell (Supervisor)

Appendix E: Expert Group Informed Consent Form

Date: _______________

TITLE OF RESEARCH PROJECT

A musculoskeletal injury profile of league tennis players in the northern eThekwini region

Name of supervisor: Dr G. Haswell
Name of research student: Michael Benporath

Please circle the appropriate answer:

1. Have you read the research information sheet? Yes No

2. Have you had an opportunity to ask questions regarding this study? Yes No

3. Have you received satisfactory answers to your questions? Yes No

4. Have you had an opportunity to discuss this study? Yes No

5. Have you received enough information about this study? Yes No

6. Do you understand the implications of your involvement in this study? Yes No

7. Do you understand that you are free to:

a. Withdraw from this study at any time Yes No

b. Withdraw from this study at any time, without reasons given Yes No

c. Withdraw from this study at any time, without affecting your future health care or relationship with the chiropractic day clinic at the Durban University of Technology Yes No

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

9. Who have you spoken to regarding this study? _________________

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

Please Print in Block Letters

Expert group member: ________________ Signature: _________________

Witness name: ______________________ Signature: ___________________

Researcher's name: __________________ Signature: ___________________

Supervisors name: ___________________ Signature: ___________________

Appendix F: Expert group code of conduct

Code of Conduct

This form needs to be completed by every member of the Expert Group prior to the commencement of the expert group meeting.

As a member of this committee I agree to abide by the following conditions:

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

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

3. The information from this expert group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

Member Represents	**Members Name**	**Signature**	**Contact Details**

Appendix G: Expert group confidentiality statement

<u>IMPORTANT NOTICE:</u> THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE EXPERT GROUP, BEFORE THE EXPERT GROUP MEETING CONVENES.

<u>CONFIDENTIALITY STATEMENT – EXPERT GROUP DECLARATION</u>

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

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

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

4. The information from this expert group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

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

Please Print in block letters:

Expert Group Member: _________________Signature: _______________

Witness Name: ______________________Signature: ________________

Researcher's Name: __________________Signature: ________________

Supervisor's Name: ___________________Signature: ________________

Appendix H: Pre-expert group questionnaire

<u>Section A: Patient information</u>

1. What is your age in years?

Years

2. What is your sex?

Male	Female

3. Which ethnic group do you belong to?

Black	White	Coloured	Asian	Indian

4. Do you **compete** in any other sport besides tennis?

Yes	No

a) If yes, please specify which sports:

____

____

b) Please state your two most serious injuries from the sport mentioned:

____

____

5. Do you eat a balanced diet?

Yes	No

6. Do you take any nutritional supplements?
(i.e. vitamins, protein shakes, energy drinks)

Yes	No

If yes, please specify which products:

____

____

<u>Section B: Tennis History</u>

7. In total, how many years have you played tennis for?

Years

8. How many years have you played competitively?
(i.e. League, club championships, tournaments etc.)

Years

9. What is the highest team you have represented?
(i.e. National, Provincial, Club etc)

International	Provincial	Club	Other

10. At present how many hours per week do you play tennis?

Hours

11. Do you do any extra training off the court?

Yes	No

If yes, please specify what training you do, and how many hours per week you train for:

___

___

Section C: Previous Tennis Injuries

12. In the past, have you ever sustained an injury from playing tennis?

Yes	No

a) If **yes**, please indicate whether it was an Acute, Traumatic or Overuse injury

Acute – Sudden muscle strain
Overuse/repetitive injury – i.e Tendonitis/Tendonosis
Traumatic – eg ankle sprain/Torn ligament

Acute	Traumatic	Overuse

b) Which region of the body did that injury effect ?

Foot/ankle		Neck	
Lower Leg		Shoulder	
Knee		Arm	
Thigh		Elbow	
Groin		Forearm	
Hip		Wrist	
Low back		Hand	
Mid back			

c) Have you ever received treatment for that injury?

Yes	No

d) If **yes**, what type of treatment did you receive?

Bracing/Strapping		Orthopedic	
Medication/Injections		Physiotherapy	
Home remedy e.g. Ice		Chiropractic	
Nutritional therapy		Homeopathy	
Rehabilitation		Other	

13. Do you **currently** have any injuries from tennis?

Yes	No

a) If **yes**, please indicate whether it is an Acute, Traumatic or Overuse injury

Acute	Traumatic	Overuse

b) Which region of the body is this injury?

Foot/ankle		Neck	
Lower Leg		Shoulder	
Knee		Arm	
Thigh		Elbow	
Groin		Forearm	
Hip		Wrist	
Low back		Hand	
Mid back			

c) Have you ever received treatment for that injury?

Yes	No

d) If **yes**, what type of treatment did you receive?

Bracing/Strapping		Orthopedic	
Medication/Injections		Physiotherapy	
Home remedy eg. Ice		Chiropractic	
Nutritional therapy		Homeopathy	
Rehabilitation		Other	

14. How often have the following areas of your body been injured while playing tennis? (This includes all your tennis sustained at **any time during your playing career** that may have caused you to forfeit a match or render you unable to practice)

Seldom: Once
Often: 2 - 5 times
Very often: More than 5 times

a) Foot/toes	Very often	Often	Seldom
b) Ankle	Very often	Often	Seldom
c) Achillies Tendon	Very often	Often	Seldom
d) Leg (calf/shin)	Very often	Often	Seldom
e) Knee	Very often	Often	Seldom
f) Hamstring (back of thigh)	Very often	Often	Seldom
g) Quadriceps (front of thigh)	Very often	Often	Seldom
h) Hip / Groin	Very often	Often	Seldom
i) Lower back	Very often	Often	Seldom
j) Upper back	Very often	Often	Seldom
k) Neck	Very often	Often	Seldom
l) Head	Very often	Often	Seldom
m) Shoulder	Very often	Often	Seldom
n) Biceps (front of upper arm)	Very often	Often	Seldom
o) Triceps (back of upper arm)	Very often	Often	Seldom
p) Elbow	Very often	Often	Seldom
q) Forearm	Very often	Often	Seldom
r) Wrist	Very often	Often	Seldom
s) Hand	Very often	Often	Seldom
t) Other	Very often	Often	Seldom

If "Other", Please specify:

____

____

15. Consider the **worst** injury you ever sustained in your tennis career:
a) how long were you unable to play/practice for?

No time lost	
1 day	
1 week	
2 – 4 weeks	
4 – 8 weeks	
8 – 12 weeks	
12 weeks – 6 months	
6 months – 1 year	
Over 1 Year	

b) Was it Acute, Traumatic or Chronic/Overuse injury?

Acute	Traumatic	Overuse

16. From the list above (Q. 14 (a) – (t)) please state the area that was most severely injured

____

____

17. When you were injured did it prevent you from playing, decrease your performance while playing or have no effect on your game?

a) Foot/toes	Prevented playing	Decreased performance	No effect
b) Ankle	Prevented playing	Decreased performance	No effect

c) Achillies Tendon	Prevented playing	Decreased performance	No effect
d) Leg (calf/shin)	Prevented playing	Decreased performance	No effect
e) Knee	Prevented playing	Decreased performance	No effect
f) Hamstring (back of thigh)	Prevented playing	Decreased performance	No effect
g) Quadriceps (front of thigh)	Prevented playing	Decreased performance	No effect
h) Hip / Groin	Prevented playing	Decreased performance	No effect
i) Lower back	Prevented playing	Decreased performance	No effect
j) Upper back	Prevented playing	Decreased performance	No effect
k) Neck	Prevented playing	Decreased performance	No effect
l) Head	Prevented playing	Decreased performance	No effect
m) Shoulder	Prevented playing	Decreased performance	No effect
n) Biceps (front of upper arm)	Prevented playing	Decreased performance	No effect
o) Triceps (back of upper arm)	Prevented playing	Decreased performance	No effect
p) Elbow	Prevented playing	Decreased performance	No effect
q) Forearm	Prevented playing	Decreased performance	No effect
r) Wrist	Prevented playing	Decreased performance	No effect
s) Hand	Prevented playing	Decreased performance	No effect
t) Other	Prevented playing	Decreased performance	No effect

If "Other", Please specify:

____

____

18. Have your injuries **ever** caused you to stop training?

Yes	No

No time lost	
1 day	
1 week	
2 – 4 weeks	
4 – 8 weeks	
8 – 12 weeks	
12 weeks – 6 months	
6 months – 1 year	

19. What was the longest period of time you were unable to practice or play due to injury?

Over 1 Year	

Section D: Present Tennis Injuries

20. Are you **currently** suffering with any injuries due to tennis?

Yes	No

*If you answered **No** then the questionnaire is complete. Thank you for your participation.*

21. Is it an Acute, Traumatic or Chronic/Overuse injury?

Acute	Traumatic	Overuse

22. Which region of the body is this injury located?

Foot/ankle		Neck	
Lower Leg		Shoulder	
Knee		Arm	
Thigh		Elbow	
Groin		Forearm	
Hip		Wrist	
Low back		Hand	
Mid back			

23. How would you rate the pain this injury causes you on a scale from 0 to 10 (0 represents no pain and 10 represents severe pain)

0	1	2	3	4	5	6	7	8	9	10

24. How does this present injury affect your tennis?

Prevents play	Severe limitation & pain	Some limitation	Some Pain	No effect

25. What is the longest period of time this **present injury** has prevented you from practicing or playing?

No time lost	
1 day	
1 week	
2 – 4 weeks	
4 – 8 weeks	
8 – 12 weeks	
12 weeks – 6 months	
6 months – 1 year	
Over 1 Year	

26. How long have you been suffering with this injury?

No time lost	
1 day	
1 week	
2 – 4 weeks	
4 – 8 weeks	
8 – 12 weeks	
12 weeks – 6 months	
6 months – 1 year	
Over 1 Year	

27. What would you say might have caused this injury?

Serving		Ground strokes	
Acceleration/Deceleration		Collision	
Incorrect Equipment		Twisting	
Over training/playing		Poor nutrition	
Insufficient warm up		Insufficient Rest	
Incorrect technique		Muscle imbalance	
Court Surface		Other	

If "Other", Please specify:

___

___

Thank you for your participation.

Appendix I: Changes to the post-expert group questionnaire

The expert group questionnaire (Appendix H) was changed to produce the pilot study questionnaire (Appendix K).

General formatting changes for the pilot study questionnaire:

- Questionnaire changed from vertical orientation to horizontal.
- Entire questionnaire style is now in tables.

Questions removed from the expert group questionnaire (Appendix H)

- Q4 removed
- Q5 removed
- Q12 (a) to Q12 (d) removed
- Q13 (a) to Q13 (d) removed
- Q15 (b) removed
- Q16 removed
- Q21 removed
- Q23 removed

Questions that were re-worded or formatted differently in the pilot study questionnaire (Appendix K):

- Q1 reworded to “Age? At last birthday”
- Q2 reworded to “Gender”
- Q5 added option “Other:”
- Q7 changed answer format from Yes/No to bands
- Q10 reworded to “On average, how many hours per week do you: Practice skills, Play social or practice matches, Play league matches”. Bands added with time options in each band.

- Q11 reworded to “Besides tennis training, do you participate in any of the following (training type): Cardiovascular, Flexibility training, Interval training (sprints), Weight training (gym), Other:” Bands added with time options in each band
- Section C: “Previous Tennis injuries” becomes Section D: “Past Tennis Injuries”
- Section D: “Present Tennis Injuries” changed to Section E: “Most Current Tennis Injury”
- Q26 reworded to “Do you currently have an injury?”

Questions numbers changed on the pilot study questionnaire (Appendix K)

- Q3 changed to Q5
- Q6 changed to Q7
- Q7 and Q8 combined into Q7
- Q20 changed to Q26
- Q14, Q15 (a), Q17, Q18, Q19 combined into Q25
- Q22, Q24, Q25, Q26 combined into Q27
- Q27 changed to Q29

Questions added to the pilot study questionnaire (Appendix K)

- Q3 added
- Q4 added
- Q12 added
- Q13 to Q19 added
- Q21 to Q24 added
- Q28 added

Questions that were left unchanged

- Q9 unchanged

Appendix J: Letter of information and informed consent (pilot study)

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

LETTER OF INFORMATION

Title of the Research Study: A musculoskeletal injury profile of league tennis players in the greater Durban area.

Principal researcher: Michael Benporath
Supervisor: Dr G. Haswell (M Tech: Chiropractic)

Brief Introduction and Purpose of the Study:
I am conducting research on tennis injuries among league tennis players in the greater Durban area. The purpose of this study is to investigate the nature of these injuries among players and to identify the risk factors involved in these injuries and the management thereof.

The study will include league tennis players from various clubs in the greater Durban area. If you agree to participate, you will be required to complete a questionnaire. All information supplied by you will be treated confidentially and used for research purposes only.

Procedure: You will be required to complete a questionnaire about tennis injuries, where and how they occurred, and how those injuries were managed. The average time for a player to complete the questionnaire is 10 minutes.

Benefits: An abstract of the results of this research will be forwarded to you as well as the tennis captains and coaches to allow for improved recommendations with regards to training. It will also benefit health care providers to better understand which injuries are most prevalent in the local tennis community and allow them to formulate more effective management strategies for these players.

Cost: There is no cost to you from your participation in the study.

Confidentiality: All patient information is confidential and the results will be used for research purposes only. You have the right to be informed of any new findings that are made and you may ask questions of an independent source if you so wish.

Research-related Injury: The research is questionnaire based, so there is no possibility for injury**.**

Persons to contact in the Event of Any Problems or Queries:
Please contact the researcher (0825570755), my Supervisor (0837821007) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

CONSENT

Statement of Agreement to Participate in the Pilot Study:

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

Full Name of Participant: _______________ Date:______ Time: ______

Signature/Right Thumbprint: ______________

I, ______________ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher______________ Date: _____Signature:_________

Full Name of Witness ______________ Date:_______ Signature:__________

Full Name of Legal Guardian(If applicable)_______Date:____ Signature:___

Appendix K: Pilot study questionnaire

Please fill out the required information in the spaces provided.
Mark your selection with "X" where required.

Questionnaire							
Section A: Player information							
1	Age? At last birthday	years	2	Gender	Female	Male	
3	Height	m	4	Weight	kg		
5	Which ethnic group do you belong to?	Black	Coloured	Indian	White	Other (specify)	
6	Do you participate in any other sport(s) besides tennis	No	Yes	If **yes**, please specify which sport(s):			
7	Do you take any nutritional supplements	No	Yes				
	If **yes**, please specify which product(s):	Creatine	Meal Replacement Shake	Multivitamin	Protein Shake		
		If you chose **other**, please specify which products you use:					
Section B: Tennis History							
8	How many years have you played tennis:	Socially:	yrs	Competitively:	yrs		
9	What is the highest level you have competed at?	National	Provincial	Club	Other (please specify)		
10	On **average**, how many hours per week do you:						
	Practice skills:	0	1-2	3-4	5-6	7+	
	Play social/practice matches:	0-2	3-4	5-6	7-8	9+	
	Play league matches:	0-2	3-4	4-6	7-8	9+	
11	Besides tennis training, do you participate in any of the following:						
	Training type	**Average time spent per week on each activity (hours)**					
	Cardiovascular	0	0-2	3-4	5-6	7+	
	Flexibility training	0	0-2	3-4	5-6	7+	
	Interval training (sprints)	0	0-2	3-4	5-6	7+	
	Weight training (gym)	0	0-2	3-4	5-6	7+	
	Other:	0	0-2	3-4	5-6	7+	
12	If you have more than one option for **other**, please specify **what** training it is that you do, and how many **hours per week** you train for:						

Section C: Equipment and Court Surface

13	What court surface/type of court do you often play on?	Hard court	Grass court	Clay court	Carpet court
14	How do you grip your racket when playing a forehand stroke?	Eastern grip	Continental grip	Semi-Western grip	Western grip
15	What is the head size/diameter of your racket? (Square inches)	Small 85-95 sq. in.	Traditional 95-105 sq. in.	Oversize 105-130 sq. in.	
16	What is the weight of your racket? (grams)	Light: 225-280g	Medium: 280-300g	Heavy: 300-340g	
17	What tension are the strings on your racket? (pounds/lbs)	Soft: Less than 55 lbs	Medium: 55-60 lbs	Tight: Over 60 lbs	
18	Is your racket grip size the correct size for your hand?	No	Yes		
19	Do you have a vibration dampener on your strings/built into your racket?	No	Yes		

Section D: Past Tennis Injuries

20	In your career, have you **ever** sustained an injury from playing tennis?	No		Yes	(If **no**, please move to question 4)		
21	Which region(s) of your body have you injured during your career? (You may select more than one answer)	Head	Neck	Mid back	Low back	Hip	Groin
		Thigh	Knee	Lower Leg	Foot/ankle	Shoulder	Arm
		Elbow	Forearm	Wrist	Hand	Other:	
22	Did you received treatment for those injury(s) (note which regions you received care for)	Head	Neck	Mid back	Low back	Hip	Groin
		Thigh	Knee	Lower Leg	Foot/ankle	Shoulder	Arm
		Elbow	Forearm	Wrist	Hand	Other:	
23	Which medical practitioner(s) do you see for treatment of tennis injuries (you may select more than one)	Biokineticist		Chiropractor		GP (Medical Doctor)	
		Homeopath		Massage Therapist		Neurologist	
		Orthopaedic Surgeon		Physiotherapist		Traditional Healer	
		Other:					
24	When you get an injury, please rank from first to last (1-10) which medical practitioner you **would go and see**?	Biokineticist		Chiropractor		GP (Medical Doctor)	
		Homeopath		Massage Therapist		Neurologist	
		Orthopaedic Surgeon		Physiotherapist		Traditional Healer	
		Other :					

25. In the past **12 months,** have you ever injured the following body part(s)/Region(s)? [**No/Yes]**
If **Yes:** how frequently? [**Frequency?]**
Did injury(s) to those region(s) ever prevent you from playing? **[Prevent play]**
If **yes**: On average, how long (in weeks) did those injury(s) prevent you from playing? [**If yes, how long for? Avg. Weeks**]
Do those injury(s) have an effect on your performance today? [**Effect on performance?]**

	Region	**No/Yes**		**Frequency?**			**Prevent Play?**		**If yes, how long for? (Avg. Weeks)**					**Effect on performance?**	
				(5+ times)	**(2-5 times)**	**(Once)**									
A	Foot/toes	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
B	Ankle	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
C	Achilles Tendon	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
D	Leg (calf/shin)	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
E	Knee	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
F	Hamstring (back of thigh)	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
G	Quadriceps (front of thigh)	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
H	Hip / Groin	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
I	Lower back	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
J	Upper back	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
K	Neck	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
L	Head	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
M	Shoulder	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
N	Biceps (front of upper arm)	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
O	Triceps (back of upper arm)	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
P	Elbow	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
Q	Forearm	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
R	Wrist	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
S	Hand	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased
T	Other:	N	Y	Very often	Often	Seldom	No	Yes	0-1	1-2	2-4	4-6	6+	None	Decreased

Section E: Most Current Tennis Injury													
26	Do you currently have an injury?	No		Yes		If **no,** this questionnaire is complete. Thank you for your participation.							
27	If **yes:** Which region is injured? **[Region]** Is it a new or recurrent injury? **[New or recurrent injury]** How severe do you rate it? **[How severe is it]** Did it prevent you from playing tennis? **[Did it prevent play]** If **yes:** For how long (in weeks)? **[If yes, how long for / (Weeks)]**												
	Region	**New or Recurrent Injury?**		**How severe is it?**			**Did it prevent play?**		**If yes, how long for? (Weeks)**				
A	Foot/toes	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
B	Ankle	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
C	Achilles Tendon	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
D	Leg (calf/shin)	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
E	Knee	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
F	Hamstring (back of thigh)	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
G	Quadriceps (front of thigh)	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
H	Hip / Groin	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
I	Lower back	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
J	Upper back	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
K	Neck	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
L	Head	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
M	Shoulder	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
N	Biceps (front of upper arm)	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
O	Triceps (back of upper arm)	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
P	Elbow	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
Q	Forearm	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
R	Wrist	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
S	Hand	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+
T	Other:	New	Recurrent	Mild	Moderate	Severe	No	Yes	0-1	2-3	4-5	6-7	8+

28	Considering your **most recent** injury, which body part/region does it affect? (choose from previous table)		
29	What was the cause of that injury?		
	Serving	Changing directions	Insufficient warm-up
	Smash/Overhead shots	Acceleration	Insufficient rest/recovery
	Forehands	Deceleration	Incorrect technique
	Backhands	Slip	Equipment
	Volleying	Fall	Other:

The Questionnaire is now complete. Thank you for your participation.

Appendix L: Changes to the pilot study questionnaire

The pilot study questionnaire (Appendix K) was changed to produce the Final questionnaire (Appendix O).

Formatting Changes made to the questionnaire:

- Questionnaire changed from horizontal orientation to vertical.

Questions removed from the pilot study questionnaire (Appendix K):

- Q6 removed
- Q12 removed
- Q22 removed
- Q24 removed
- Q25 table removed
- Q29 table removed

Questions that were re-worded or formatted differently on the final questionnaire (Appendix O):

- Q1 “At last birthday” removed
- Q5 “For statistical purposes” added
- Q21 table changed to picture in Q25

Questions numbers changed on the Final questionnaire (Appendix O)

- Q7 changed to Q14
- Q8 changed to Q10
- Q9 changed to Q11
- Q11 and Q12 combined into Q13
- Q15 changed to Q16
- Q16 changed to Q17
- Q17 changed to Q18

- Q18 changed to Q19
- Q20 changed to Q24
- Q23 changed to Q30
- Q26 changed to Q32
- Q29 changed to Q37

Questions added to the Final questionnaire (Appendix O)

- Q6 added
- Q7 added
- Q8 added
- Q9 added
- Q21 added
- Q21 added

Questions that were left unchanged from the Pilot study questionnaire

- Q2 unchanged
- Q3 unchanged
- Q4 unchanged
- Q15 unchanged
- Q20 unchanged

Appendix M: Permission letter for chairperson of the chosen tennis club

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

16 Somme
Road
Durban
4001

(Tennis Club Name)
(Address)
(City)
(Postal code)

Dear Sir/Madam

Request for Permission to Conduct a Research Study

I am presently registered for a Masters degree at the Durban University of Technology in the Department of Chiropractic and Somatology.

I am conducting research on tennis injuries among league tennis players in northern eThekwini region. The purpose of this study is to investigate the nature of these injuries among players and to identify the risk factors involved in these injuries and the management thereof.

Should the players be willing to participate, they will be required to complete a questionnaire about their tennis related injuries, which will take between 5 – 10 minutes to fill out.

Title of the Research Study: A musculoskeletal injury profile of league tennis players in the northern eThekwini region

Principal Researcher: Michael Benporath
Supervisor: Dr G Haswell (MTech: Chiropractic)

Based on the above mentioned study, I am requesting permission to conduct my study on your club premises.

Yours in anticipation,

---	----------------------------------
Michael Benporath	Dr G Haswell
(Chiropractic Intern)	(Supervisor)

Appendix N: Letter of information and informed consent (Research procedure)

LETTER OF INFORMATION

Title of the Research Study: A musculoskeletal injury profile of league tennis players in the northern eThekwini Region

Principal researcher: Michael Benporath
Supervisor: Dr G. Haswell (M Tech: Chiropractic)

Brief Introduction and Purpose of the Study:
I am conducting research on tennis injuries among league tennis players in the northern eThekwini region. The purpose of this study is to investigate the nature of these injuries among players and to identify the risk factors involved in these injuries and the management thereof.

The study will include league tennis players from various clubs in the northern eThekwini region. If you agree to participate, you will be required to complete a questionnaire. All information supplied by you will be treated confidentially and used for research purposes only.

Procedure: You will be required to complete a questionnaire about tennis injuries, where and how they occurred, and how those injuries were managed. The average time for a player to complete the questionnaire is 10 minutes.

Benefits: An abstract of the results of this research will be forwarded to you as well as the tennis captains and coaches to allow for improved recommendations with regards to training. It will also benefit health care providers to better understand which injuries are most prevalent in the local tennis community and allow them to formulate more effective management strategies for these players.

Cost: There is no cost to you from your participation in the study.

Confidentiality: All patient information is confidential and the results will be used for research purposes only. You have the right to be informed of any new findings that are made and you may ask questions of an independent source if you so wish.

Research-related Injury: The research is questionnaire based, so there is no possibility for injury**.**

Persons to contact in the Event of Any Problems or Queries:
Please contact the researcher (0825570755), my Supervisor (0837821007) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

CONSENT

Statement of Agreement to Participate in the Research Study:

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

Full Name of Participant: _______________ Date:______ Time: ______

Signature/Right Thumbprint: ______________

I, ______________ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher______________ Date: _____Signature:_________

Full Name of Witness ______________ Date:_______ Signature:__________

Full Name of Legal Guardian(If applicable)_______Date:____ Signature:___

Appendix O: Final questionnaire

A musculoskeletal injury profile of League tennis players in the northern eThekwini region

Please mark an X indicating your choice where applicable. Some questions may require you to answer in more detail.

Section A: Player information

1	Age	years				
2	Gender	Female	Male			
3	Height	m				
4	Weight	kg				
5	Which ethnic group do you belong to? (For statistical purposes)	African	Coloured	Indian	White	Other
6	Are you Left or Right handed?	Left Handed				
		Right Handed				

7	Have you been diagnosed with any of the following medical conditions?	Asthma	Diabetes		
		Epilepsy	Rheumatoid arthritis		
		Hyper/Hypo-Thyroidism	High Blood Pressure		
		Other (Specify):	Osteoporosis		
			None		
8	On **average,** how much alcohol, if any, do you consume per **week**? (You may leave blank for 0)	Beers:	Bottles/cans		
		Glasses of wine:	Glasses		
		Tots of spirits:	Tots		
9	Do you smoke cigarettes? (If you are a **Current** or **ex-smoker,** please indicate how many years you smoked, and on average how many cigarettes per day)	No			
		Ex-Smoker:	yrs	Cigs p/day	
		Current smoker:	yrs	Cigs p/day	

Section B: Tennis History, Training and Nutrition

10	How many years have you been playing tennis?	years		
11	What is the highest level you have competed at?	Club	Provincial	National
12	On **average,** how many hours per week, if any, do you: (You may leave blank for 0)	Practice skills:	hrs	
		Play practice/social games:	hrs	
		Play League matches:	hrs	
13	How many **hours per week**, if any**,** do you participate in the following activities? (You may leave blank for 0)	Cycling:	hrs	
		Gym (Cardiovascular):	hrs	
		Gym (Weights):	hrs	
		Kettle bells/boot camps:	hrs	
		Pilates:	hrs	
		Running:	hrs	
		Yoga:	hrs	
		Other (Specify):	hrs	
		None		

Please turn over

14	Do you use any of the following nutritional supplements?	Carbohydrate drink	Fat burner
		Joint support	Meal replacement shake
		Multivitamin	Protein shake
		None	Other (Specify):

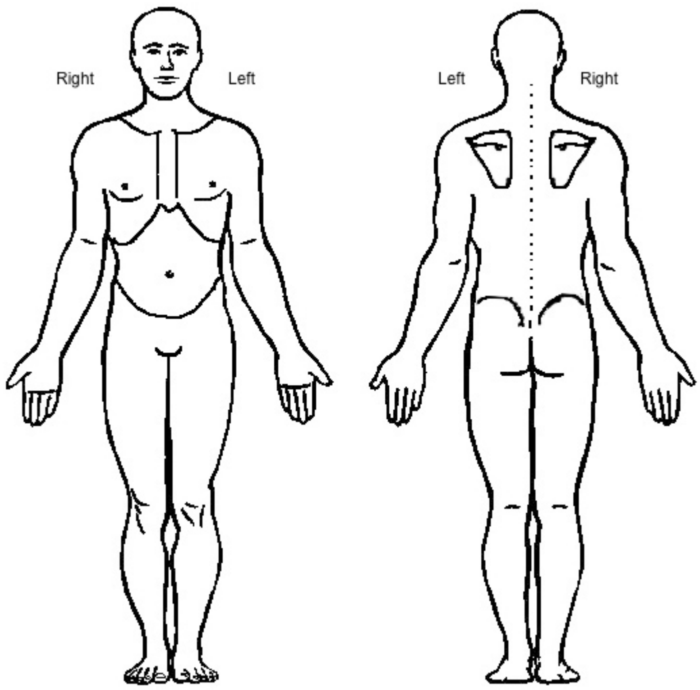
Section C: Court Surface and Equipment

15	What court surface do you play on most often?	Hard court
		Grass Court
		Clay Court
		Carpet (Indoor) Court
16	What is the head size/diameter of your racket? (Square inches)	85-95 sq. in. (Small)
		96-105 sq. in. (Traditional)
		106-130 sq. in. (Oversize)
17	What is the weight of your racket? (grams)	225-280g (Light)
		281-300g (Medium)
		301-340g (Heavy)
18	What tension are the strings on your racket? (pounds/lbs)	<55 lbs (Soft)
		55-60 lbs (Medium)
		60< lbs (Hard)
19	Is your racket grip the correct size for your hand?	No
		Yes
20	Do you have a vibration dampener on your strings/built into your racket?	No
		Yes
21	What shoes do you wear while playing tennis?	Tennis Shoes
		Running shoes/cross trainers
		Other
22	How do you grip your racket while playing a forehand?	Eastern Grip
		Continental Grip
		Semi-Western Grip
		Western Grip
23	Do you play a single-handed or double-handed backhand?	Single-handed
		Double-handed

Please turn over

Section D: Tennis Injuries over past 12 months

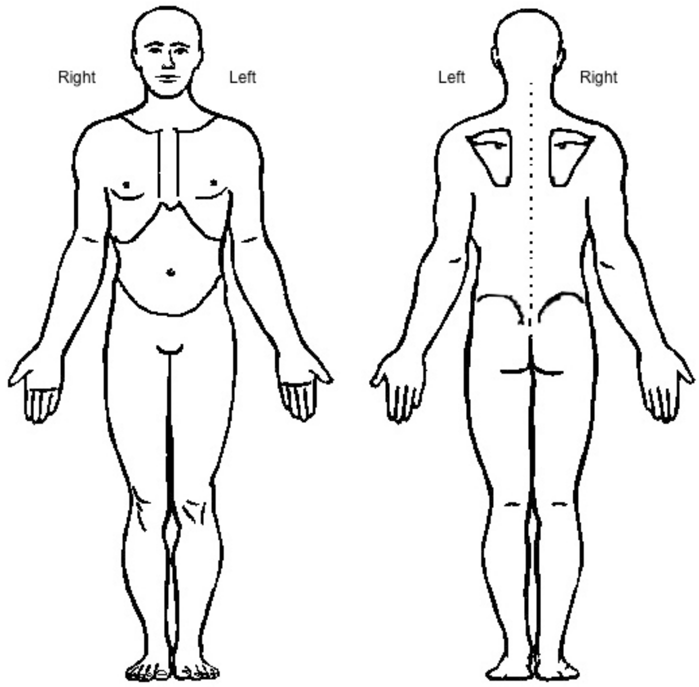
This section requires you to answer questions related to pain that you have experienced while playing tennis over the past 12 months only – Please don't include pain or injuries from over 12 months ago.

24	Did you experience **any pain** over the past **12 months?**	No:	If **no,** please proceed to **Section E** over the page	
		Yes		
25	Where have you experienced pain over the past 12 months? **Please mark all the areas you have felt pain` with an X**			
26	What would aggravate/make the pain worse? (You may select more than 1)	Backhand	Forehand	
		Running	Serving/smashing	
		Other (Specify):		
27	Were you ever forced to retire from a league match due to pain in the past 12 months?	No		
		Yes	If **yes,** how many times?	
28	Were you unable to practice or participate in a league match due to your current pain in the past 12 months?	No		
		Yes	If **yes,** how long were you unable to practice or play?	
29	How did you sustain the injury that caused your pain? (You may select more than 1)	Gym/cross training	Incorrect equipment	
		No warm up/stretching	Old Age	
		Overuse	Unknown	
		Slip/Fall	Other (Specify):	
30	Which medical practitioner, if any, did you seek treatment/advice from for your injuries over the past 12 months? (You may select more than 1)	Biokineticist	Chiropractor	
		GP	Orthopedic Surgeon	
		Pharmacist	Physiotherapist	
		None	Other (Specify):	
31	Were you happy with the treatment/advice you received?	Yes		
		No		

Please turn over

Section E: Current Tennis Injuries

This section requires you to answer questions related to pain that you are **currently** experiencing while playing tennis

32	Do you **currently** experience any pain while playing tennis?	No:	If **no,** the questionnaire is complete – Thank you!!
		Yes	
33	Where do you **currently** feel pain when you play tennis? **Please mark all the areas you feel pain with an X**		
34	What aggravates/makes the pain worse? (You may select more than 1)	Backhand	Forehand
		Running	Serving/smashing
		Other (Specify):	
35	Has your current pain forced you to retire during a league match?	No	
		Yes	If **yes,** how many times?
36	Have you been unable to practice or participate in a league match due to your current pain?	No	
		Yes	If **yes,** how long were you unable to practice or play?
37	How did you sustain the injury that causes your pain? (You may select more than 1)	Gym/cross training	Incorrect equipment
		No warm up/stretching	Old Age
		Overuse	Unknown
		Slip/Fall	Other (Specify):
38	Which medical practitioner, if any, did you seek treatment/advice from? (You may select more than 1)	Biokineticist	Chiropractor
		GP	Orthopedic Surgeon
		Pharmacist	Physiotherapist
		None	Other (Specify):
39	Were you happy with the treatment/advice you received?	Yes	
		No	

THANK YOU FOR YOUR TIME AND EFFORT IN COMPLETING THIS QUESTIONNAIRE!!

Appendix P: Plagiarism declaration

PLAGIARISM DECLARATION

I, ____ (Full name of student) and
________________________________ (full name of supervisor/s), do declare that in respect of the
following dissertation/thesis:
____
____
____
____

As far as we know and can ascertain: (√ appropriate answer)

a. No other similar dissertation/thesis exists

b. The only similar dissertation/s thesis/es that exist/s is/have been referenced in my dissertation as follows:
____
____
____
____

1. I know and understand that plagiarism is using another person's work and pretending it is one's own, which is wrong.
2. This dissertation/thesis/essay/report/project is my own work.
3. All references as detailed in the dissertation are complete in terms of all personal communications engaged in and published works consulted.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

____

Signature

____

Name (in capital letters)

____

Student Number

Appendix Q: Expert group audiovisual DVD (for the use of the examiners only due to the confidentiality agreement)