An epidemiological study of musculoskeletal injuries in league squash players in the eThekwini Municipality

By

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I, Stephen Hawkesworth, 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 DISSERTATION TO MY WIFE.

YOU ARE MY BEST FRIEND, MY REFUGE AND MY STRENGTH.

I WILL STRIVE TO LOVE YOU MORE AND MORE EVERY DAY OF OUR LIVES.

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To God the Father, Son and Holy Spirit- for Your love and countless blessings.

To Our Blessed Mother- for your constant love and intercession.

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ABSTRACT

Background: Internationally squash is a very popular sport with over 15 million players worldwide from 135 nations. With the rapid growth of squash comes a rise in the number of injuries occurring during play. Despite squash being such a popular sport, several reports have stated that there is a paucity of literature and limited research that has been conducted on the injuries occurring from playing the sport. A study of this nature would create an awareness and understanding of the prevalence of injuries in squash which will allow for event organisers, medical personnel, managers and coaches to adapt training approaches that will minimise the development of injuries.

Objectives: This study aimed to investigate the prevalence of musculoskeletal injuries in squash players within the eThekwini Municipality, and to identify selected factors associated with an increased risk of injury in order to improve the management of squash players.

Methods: A quantitative, descriptive questionnaire-based survey was conducted on 126 league squash players in the eThekwini Municipality. Statistical analysis was performed on the results obtained from the questionnaire using IBM SPSS version 24. A p value < 0.05 was used to indicate statistical significance. Associations between 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. The variables that were associated at the p = < 0.01 level of significance were entered into a binary logistical 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. Graphical representation of scores by groups was done using graphs and tables.

Results: One hundred and twenty-nine squash players responded giving a response rate of 69%. The period prevalence and point prevalence of squash related musculoskeletal injury was 62% and 25.6% respectively. A predominance of injuries to the lower limb were recorded (67.65%) compared to the upper limb (21.4%) and the back and trunk (11.3%). The foot and ankle were the most common anatomical site of

injury (22.5%) followed by the knee (15%), the thigh (13.8%) and the elbow (13.8%). Alcohol consumption was considered to be a risk factor for injury (p = 0.03); for every increase in five units of alcohol consumption the odds of incurring an injury increased by 29%. The likelihood of injury decreased in those that did weight training; the odds of an injury for a player not doing weight training was 3.3 (1/0.305) times more compared to a player who did weight training. Thus, it was more likely for a player not doing weight training to sustain an injury.

Conclusion:

The lack of evidence that players train off the court, and the large amount of alcohol consumed on a weekly basis shows that for the majority of players in the eThekwini Municipality squash is more a recreational activity than a professional activity. Despite the study sample being ranked in the top three divisions, this study found that within the eThekwini Municipality squash has not developed on a professional level. Results found that players were more likely to get injured if they did not do weight training and/or consumed alcohol. The population seems to be living a sedentary lifestyle in which squash is their only weight training activity, and after their squash session they consumed alcohol. This lack of training and alcohol consumption predisposes them to lower limb injuries, especially the ankle. Given these results coaches, team captains and medical practitioners should put together cross training programs, which would be a helpful injury prevention.

Future studies could look at the effect that cross training programs have on lowering injury prevalence.

Keywords: Squash players, musculoskeletal injury, prevalence, risk factors

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DEFINITIONS

Acute: A short-term injury that occurs due to a single traumatic event (Dorland 2007), which usually impairs ability to continue play (Hyde and Gengenbach, 2007).

Chronic: a condition that develops over a period of time (Hyde and Gengenbach, 2007) and persists over a long period of time (Dorland, 2007); causing the person to be able to attain activities of daily living but without obtaining optimal function (Hyde and Gengenbach, 2007).

Musculoskeletal (MSK) injury: For the purpose of this study a squash injury was defined as a musculoskeletal problem requiring reduction or interruption of squash activity for any length of time, with or without evaluation or treatment by a health care provider (Pluim *et al.,* 2006). Therefore, an acute MSK injury would be one to interrupt play whereas a chronic MSK injury would be one to reduce the effectiveness of play without stopping play.

Overuse Injury: Overuse injuries occur due to repetitive sub maximal loading of the musculoskeletal system when rest is not adequate to allow for structural adaptation to take place (DiFiori *et al*., 2014). Clinically this would allow for sub-optimal function therefore reduced effectiveness of play, without necessarily stopping play.

ABBREVIATIONS

The following abbreviations appear in this study:

B	Parameter estimates
cm	Centimetre
g	Gram
kg	Kilogram
lbs	Pounds
m	Metre
MSK	Musculoskeletal
N	Number
SE	Standard error
OR	Odds ratio

CHAPTER 1: INTRODUCTION TO THE STUDY

This chapter includes the aims, objectives, hypotheses, rationale and limitations of the study.

1.1 INTRODUCTION

1.1.1 Background of the sport

For many years, all over the world, humans have enjoyed a variety of ball games either with the hand or some form of bat. In the 12th Century in France, “le Paume” (meaning “the palm”) which later became “Jeu de Paume”, developed into what we now know as tennis. This spread quickly throughout Europe where much of the population considered hitting a ball against walls with a racket as a form of exercise. The four main racket sports today are tennis, table tennis, squash, and badminton. Racket sports are characterised by the use of a hand-held racket that is used to hit a ball (or shuttlecock, in badminton) between two or four players. The aim of these sports is to hit the object and place it in such a way that the opponent cannot return it. Racket sports are also characterised by the size of the court, the court surface type, and by a hurdle of a specific height that the object needs to be hit over. Each sport has a different size and shaped court, ball and racket, and court surfaces, and they each have their own set of rules (Lees 2003).

Squash was invented in the early 19th century in England when some school pupils discovered that punctured balls would be “squashed” onto walls in a greater variety of shots and it required more effort from the player. This variation grew in popularity and in 1864 the first squash courts were built, and the sport was officially founded. Despite being a fairly old sport, squash only started becoming competitive in late 20th century with its first world championships in 1967 for men and 1979 for women (Championship Records 2018). Squash is a fast-paced sport that requires agility around the court, while having control over ball placement and needing to be aware of the spatial orientation of the opponent (Finch and Eime 2001). Squash has been classified as a sport with limited contact, high intensity dynamics and demand (Talabi *et al.* 2002).

The players need high levels of fitness since they are active for the majority of game time (Finch and Eime 2001). Internationally squash is growing rapidly, especially on a competitive level. It is played in 185 countries, on almost 50 000 courts by over 15 million players worldwide (Clavisi and Finch 1999b).

1.1.2 Injuries in squash

With the rapid growth of squash comes a rise in the number of injuries occurring during play. Injury prevalence in squash is high (Sankaravel *et al.* 2017; Okhovatian and Ezatolahi 2009; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Clavisi and Finch 1999b), with squash being rated as the twelfth highest sporting activity for hospital emergency-department admittance (Clavisi and Finch 1999b). Chard and Lachmann (1987) noted that injuries are far more common in squash players (59%) compared to other racket sport players. This is due to the higher levels of physical stress, the confined area of play, the close proximity of players in which a racket is swung, and the size, speed and physical properties of the ball (Meyer *et al.* 2007)

Risk factors for injury in squash include:

- Individual or intrinsic factors such as:
  - Age (Benporath 2016; Kondrič *et al.* 2011; Chard and Lachmann 1987),
  - Height
  - Weight
  - Handedness
  - Gender (Okhovatian and Ezatolahi 2009; Meyer *et al*. 2007; Eime *et al.* 2005);
  - Ethnicity
  - Squash experience (Sankaravel *et al.* 2017; Eime *et al.* 2005);
  - Level of play (Abrams, Renstrom and Safran 2012; Okhovatian and Ezatolahi 2009; Meyer et al. 2007; Eime *et al.* 2005; Macfarlane and Shanks 1998);
- External factors or extrinsic factors include
  - Components of training (Meyer *et al.* 2007);
  - Participation in other physical activities
  - Cigarette smoking

    - Alcohol consumption
    - Lack of treatment
    - Playing style
  - Environmental factors such as court flooring conditions (Maquirriain and Baglione 2015; Abrams, Renstrom and Safran 2012; Meyer *et al.* 2007 Talabi *et al.* 2002); and
  - Racket properties (Abrams, Renstrom and Safran 2012; Kondrič *et al.* 2011).

Squash injuries have been grouped into three major categories:

- Musculoskeletal (MSK) injuries, which make up majority of the injuries in squash and are usually repetitive in nature (Clavisi and Finch 1999a; Chard and Lachmann 1987).
- Acute traumatic injuries, including eye and head injuries, possibly due to the small number of players that utilise eye protection (Eime *et al.* 2005).
- And finally, those injuries related to cardiovascular fitness and general health, which include cardiac injury, death, and heat illness, with mortality rates of approximately five deaths a year (Montpetit 1990).

Most of the research has focused on more severe injuries, such as the eye, head and cardiac region. This is a natural consequence of the fact that these injuries have a direct impact on the health, fitness, quality of life and presence / absence of disabilities in the player's life (Finch and Eime 2001). As a result, the less severe, more repetitive strain injuries (which are more common injuries but have a lesser impact on the players quality of life, presence / absence of disability); have been underreported (Finch and Eime 2001).

Of those studies that have been completed in the domain of repetitive injury; the majority of the studies that have looked specifically as MSK injuries have confirmed that muscular strains and ligamentous sprains were the most common types of injuries (Sankaravel *et al.* 2017; Maquirriain and Baglione 2015; Kondrič *et al.* 2011; Fong *et al.* 2007; Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002). It is also interesting to note that a significant number of injuries occurred within a few minutes of starting to

play squash (Meyer *et al.* 2007; Chard and Lachmann 1987), which is most likely due to a lack of appropriate warm up and stretching exercises.

Sankaravel *et al.* (2017) found that the most common sites of injury on Malaysian squash players were the hand/wrist (31.7%), followed by the ankle/feet (26.7%), hip/thigh and knee (20% each), and the upper back and neck (16.7% each). Unfortunately, the literature on injuries occurring during squash is scarce (Finch and Eime 2001; Talabi *et al.* 2002; Meyer *et al.* 2007). As a result of the paucity of the literature in this domain, it brings about a need for a study to focus on the common injuries that are incurred during squash. The focus of this research was the MSK incurred by players in the top three league divisions in the eThekwini Municipality.

1.1.3 Injuries in other racket sports

Benporath (2016) conducted a study on tennis injuries in the eThekwini Municipality (n = 80). The study found that the majority of injuries (50.0% and 49.0% for current and previous injuries respectively) were found in the upper limb. Furthermore, younger age was noted as a significant risk factor for injury due to improper technique, lack of MSK maturity and under-reporting of injuries. The majority of injuries were caused by overuse (37.1% and 36.9% for current and previous injuries respectively). By contrast, factors such as the length of player career and the amount of time spent playing tennis per week had no significance relationship with injury. The only injury prevention mechanism found in these tennis players was through cross training with cycling, where those that cycled were 77% less likely to incur an injury compared to those that did not cycle.

Other tennis studies that reported either a higher incidence of lower limb injuries than upper limb (Lynall *et al.* 2015; Chard and Lachmann 1987) or an equal amount of both but with differences in chronicity. As reported by Maquirriain and Baglione (2015), there is a trend of acute injuries occurring in the lower limb and chronic injuries occurring in the upper limb and the trunk of tennis players. Chard and Lachmann (1987) reviewed hospital records over an eight-year period for players presenting to an injury clinic, 59% of their population sample were 26 years or older. Maquirriain and Baglione (2015) reviewed official online information for professional tennis players over an eight-year period. Neither study looked into cross training, or any other injury

prevention This could be a reason for the difference in the studies. Abrams, Renstrom and Safran (2012) and Pluim *et al.* (2006) concur with these tennis study results. All of these studies collected their data from hospital, sport injury clinics and official website reports. No information was gained directly from the injured individuals.

A study by Kondrič *et al.* (2011) on injuries in Slovenian racket sport athletes (table tennis, tennis and badminton) (n = 83) determined that the areas of the body that were most susceptible to injury were the shoulder girdle (17.27%), spine (16.55%), and ankle (15.83%). However, this study was conducted on international or national ranking athletes that were on average 19.5 years old. The extensive amount of training required by the highly ranked athletes, as well as their younger age may have played a role in the results obtained.

The differences in terms of the recorded data for each of the above studies (viz incidence versus prevalence; various age groupings, elite versus recreational racket sports as well as the combination of the various sporting codes in some of the studies and the inclusion or exclusion of various intrinsic / extrinsic factors unique to squash players), makes it difficult to compare the data sets between these studies as the natural population group in each study shows so much variance. Therefore, the results of the above studies, cannot be extrapolated to a general squash playing population in general; even though the sporting disciplines mentioned above have similarities with regards to equipment and general rules (World Squash Federation 2018; Association of Tennis Professionals 2018; Badminton World Federation 2018; International Table Tennis Federation 2018). Therefore, further research is needed to determine injury rates and identify risk factors (Okhovatian and Ezatolahi 2009; Meyer *et al.* 2007; Eime, Zazzryn and Finch 2003; Finch and Eime 2001; Clavisi and Finch 1999a; Macfarlane and Shanks 1998).

1.2 RATIONALE

Evidence on the prevalence of injuries of South African squash players is limited, although several international studies are available (Okhovatian and Ezatolahi 2009; Eime, Zazzryn and Finch 2003; Finch and Eime 2001; Clavisi and Finch 1999a; Macfarlane and Shanks 1998; Talabi *et al.* 2002; Mace and Carroll 1986; Sankaravel *et al.* 2017). Meyer *et al.* (2007) conducted a study on amateur adolescent squash

players in the Western Cape (n = 106). Of the reported injuries 68% of them were incurred while playing other school sports besides squash (i.e.; rugby and hockey). The results of their study noted a high prevalence of injury; however, based on the specific population reported on in the study, these results cannot be extrapolated to a greater squash community; when the specific demographics of the group are lacking and/or not consistently reported.

Chard and Lachmann (1987) performed an eight-year study which reviewed hospital records on squash injuries (thus predominantly acute, traumatic injuries). It was reported that a third of the participants studied had only recently taken up the sport (less than three months), 25% of the injuries occurred in those that played infrequently (less than once a week) and 20% of those reviewed had a past history of an injury that was reinjured by playing squash. It therefore suggests that acute injuries are more likely to present in underprepared players; with no reporting on the development of repetitive strain injuries in these same players. Similarly, Macfarlane and Shanks (1998) noted a high frequency and severity of back injuries in squash players. However, like Chard and Lachmann (1987), the study only provided data on acute and traumatic injuries and limited information on repetitive strain injuries, therefore providing only a portion of the information required for adequate medical management of squash players.

International studies on squash injuries from 1986 to 2010 reviewed hospital records and reported on online scientific literature (Chard and Lachmann 1987; Eime, Zazzryn and Finch 2003; Finch and Eime 2001; Clavisi and Finch 1999a; Macfarlane and Shanks 1998; Mace and Carroll 1986; Finch and Clavisi 2010). The fact that the players presented to hospital shows that the injury was most likely significant enough that it was affecting their activities of daily life. These studies therefore provided information on severe acute injuries which affect players' activities of daily life i.e.: loss of eye, laceration to head, concussion due to collision, cardiac injury or death, heat illness, broken lower or upper limb (Chard and Lachmann 1987; Eime, Zazzryn and Finch 2003; Finch and Eime 2001; Clavisi and Finch 1999a; Macfarlane and Shanks 1998; Finch and Clavisi 2010). However, there is very little information on the less severe more common chronic injuries that players experience but live with and do not find the need to be admitted to hospital. In addition to the above limitations, the results

from the few studies that have been conducted on squash injuries, the data has been obtained mainly from amateur players who lack expertise in the sport (Meyer *et al.* 2007). For a methodological vantage point, the majority of the studies are limited as they do not provide any significant insight into risk factors for the reported injuries (Sankaravel *et al.* 2017; Meyer *et al.* 2007; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Finch and Eime 2001; Chard and Lachmann 1987), nor do they consider literature-derived potential risk factors, such as different racket or ball sizes and/or compositions (constituent materials). In addition, many of the studies did not report any statistical conclusions, with only the frequencies being evaluated. Since this may skew the data currently available on the sport, there is a need for a study to be performed on players who play the sport frequently on a more professional level, in order to determine the common repetitive strain injuries that develop from the sport.

This study investigated the prevalence, characteristics of injury, impact and risk factors for injury among squash players within the eThekwini Municipality. This data collection aimed at creating an awareness and understanding of the injuries in squash, which will allow for event organisers, medical personnel, managers and coaches to adopt training approaches that will minimise the development of injuries. This could lead to safer training and successful management of squash players (Meyer *et al.* 2007; Eime, Zazzryn and Finch 2003; Clavisi and Finch 1999b; Talabi *et al.* 2002).

1.3 RESEARCH QUESTION

What are the risk factors (intrinsic and extrinsic) that cause MSK injuries (both repetitive / overuse injuries as well as acute injuries) in squash players?

1.4 AIM OF THE STUDY

To determine the prevalence of musculoskeletal injuries in league squash players in the eThekwini Municipality.

1.5 OBJECTIVES

- Objective One was to determine the prevalence (12 months and point) of musculoskeletal injuries in league squash players in the eThekwini Municipality.

- Objective Two was to describe the injury profile (location, severity, duration, nature of onset, disability).
- Objective Three was to identify demographic, physical activity and equipment risk factors.
- Objective Four was to evaluate the impact of injury on training and performance.
- Objective Five was to describe the relationship between prevalence and selected risk factors.

1.6 DELIMITATIONS

1.6.1 Internal validity

Although the scope of this study was to determine risk factors for injuries within squash, external factors (unrelated to squash) may be predisposing factors to injury. The identification of these factors was beyond the scope of this study; however, the questionnaire was designed to account for external variables (e.g. Question 10: 'Have you suffered from any non-squash related injuries?'), thereby increasing the internal validity of the questionnaire. The potential scenario of a squash player unable to differentiate whether the injury occurred during squash-related activities or in an unrelated activity is a limiting factor. The use of a questionnaire might present as a limitation as well, since data relies on the participants' honesty and open-mindedness (Mouton, 2001; Mouton, 2006). It is also assumed that the participants understand the questionnaire and the information that is required from them. Human error may also contribute to limitations as a participant may have failed to understand a question or forgotten an injury which would have an effect on the study results. (Mouton 2001; Morgan 1998)

1.6.2 External validity

Meyer *et al.* (2007) performed their study on South African amateur adolescent squash players, who were involved in other sporting activities. This study wanted to expand the squash population group in South Africa by focusing on more professional squash players for whom squash was their main sport.

Epidemiological studies can potentially introduce bias as there are specific inclusion and exclusion criteria. The results of these studies may note an effect that would not

have been identified if selection were random when including participants. For adequate population validity, the population sample must be highly representative of the whole population. In this study, the entire population of league squash players in the eThekwini Municipality were invited to participate, however, the number of participants eligible to participate was limited to those who fulfilled the required criteria (see Chapter 3 for the inclusion and exclusion criteria), which may affect the ability to identify certain trends. Given the small sample size there is a decreased generalizability of the results. The inclusion and exclusion criteria were necessary for logistical purposes as well as maintaining the reliability of the data. (Lapane, Quilliam and Hughes 2007).

1.7 CONCLUSION

Squash falls under the umbrella of racket sports, with its origins in England in the 19th century. It is considered a highly dynamic and demanding sport with limited contact. Despite its popularity, limited research has been conducted and conclusions have principally been drawn in the domain of acute and traumatic injuries (Finch and Eime 2010; Finch and Clavisi 2000; Finch and Clavisi 2010; Finch and Eime 2001; Meyer *et al* 2007; Finch and Eime 2005; Macfarlane and Shanks 1998; Okhovatian and Ezatolahi 2009; Sankaravel et al. 2017; Talabi et al. 2002), therefore meaningful conclusions cannot be specifically drawn for the repetitive strain injuries suffered by these players. Further research is needed to determine injury rates and identify risk factors in order to put accurate and appropriate preventative measures in place (Meyer *et al.* 2007; Eime, Zazzryn and Finch 2003; Clavisi and Finch 1999b; Talabi *et al.* 2002).

The rationale, then, of this research project was to determine and provide information regarding the demographics of risk factors that caused musculoskeletal complaints experienced by squash players in the top three divisions of squash in the eThekwini Municipality. It was through the analysis of the data that health care practitioners, especially those manual therapists (viz. chiropractors, biokineticist and physiotherapists), can better diagnose, treat and manage injuries and associated complications experienced by many squash players (Ramasamy, Hill and Clasper, 2009). Additionally, the information obtained from this study may prove to be beneficial

for future event organisers and regulating bodies of squash players, by allowing them to fully understand the injuries and illnesses with which squash players are afflicted, so as to better prepare adequate medical care for these athletes (Finch and Cook, 2013; Junge *et al.,* 2008).

CHAPTER 2: LITERATURE REVIEW

This chapter covers the following; a description of squash as a sport, the equipment utilized as well as the required normal biomechanics. This is followed by the risk factors that have been identified in squash and related racket sports and the injuries that result from these risk factors. This culminates in a summary of the injuries found, outlining their nature, location, severity and impact on return to play and the activities of daily living.

2.1 SQUASH INTRODUCTION

2.1.1 Overview

Squash is a fast-paced racket sport requiring agility, control over ball placement and spatial awareness. Players need to display cardiovascular fitness, agility and speed of accuracy as they are active for the majority of game time (Finch and Eime 2001). Despite it being classified as a limited contact sport, it is highly intensive, dynamic and demanding (Talabi *et al.* 2002). Given the context of the high demand placed on squash players, the increasing popularity of the sport (Finch et al. 2003); there has been a concomitant increase in the number of injuries incurred during play. However, despite its popularity, several reports have stated that there is a paucity of literature and limited research on the repetitive strain MSK injuries obtained from playing the sport (Finch and Eime 2001; Talabi 2002 Meyer *et al.* 2007).

2.1.2 Plan of the court

The game is played on a rectangular area bounded by four walls (front wall, two side walls and a back wall). It has a level floor and has a minimum height of 5 640 mm. The length of the court is 9 750 mm; the breadth of the court is 6 400 mm. It is important to note that the court size does not increase in the case of more players (i.e. doubles compared to singles). The court surface may be constructed from various materials provided they have suitable ball rebound characteristics and are safe for play; different surfaces change the general “speed” of the game due to the amount of friction between the ball and the court surface. Running across the bottom of the front wall is the tin, a

metre-wide metal band that covers the full length of the front wall. The ball must always be hit above the tin when in play. The top boundaries of the court (on all four walls) are clearly marked; the ball must remain within these boundaries (World Squash Federation 2018).

Inside the court area are two service-boxes. These are demarcated square-areas on opposite sides of the court from which a player can choose to serve from. However, the usage of the boxes must be alternated (i.e. a game cannot start with a serve in the right box in the first rally and have the second rally serve in the right box as well) (Brunette and Durbach 2011).

2.1.3 Object of the game

Squash can either be played individually against a single opponent (known as singles), or it can be played in teams of two against a team of two opponents (known as doubles). The game is divided into various segments of play known as rallies; each rally starts with a serve and ends when the ball cannot be returned. A rally ends when: the ball bounces twice on the floor; the ball hits the front wall (either directly or after hitting any other wall/s) below the tin or above the out-line; and/or rebounds from the front wall after touching the tin (World Squash Federation 2018).

The winner of a rally scores one point and serves to start the next rally. Each game is played to 11 points, except in the event of a 10-all game, when there is a continuation until there is a two-point lead by the winner. A match is usually the best of three games. It is important that a player does not obstruct his/her opponent (with his/her body and/or racket) in any way from hitting the ball (i.e. a player must immediately move clear after striking the ball) (Brunette and Durbach 2011).

Prior to the game starting, players go on the court together to warm up the ball for a maximum of five minutes. This is necessary since when rubber is heated it is much more pliable and therefore the ball is easier to hit and rebounds well (World Squash Federation 2018).

2.1.4 Equipment

2.1.4.1 Balls

Squash balls are black in colour so that they can be easily seen against the white walls of the court. The extent to which the ball bounces can vary; therefore, there are a range of balls made with different bounce characteristics (Brunette and Durbach 2011; World Squash Federation 2018).

There are two main types of balls: standard double yellow dot and standard single yellow dot. Both are small, hollow, made of rubber, are roughly 40 mm in diameter, and weigh 23/24 grams. The double yellow dot ball is used for competitions; the single yellow dot ball is used for more recreational matches, club matches and/or training (World Squash Federation 2018). The difference between the two lies in their rebound resilience. A double yellow dot ball has a lower rebound resilience than a single yellow dot ball, meaning that it requires more effort when hitting the ball to get it to rebound appropriately (Brunette and Durbach 2011).

The higher a ball bounces, the longer the rallies last and the more difficult it is to have an overall winner. A ball that bounces less provides greater control and allows tighter shots to be played; therefore, rallies are much shorter with a slower ball. Beginners may choose a faster ball that gives them a bigger bounce to work with as opposed to a slower ball with less bounce (Brunette and Durbach 2011).

2.1.4.2 Rackets

The World Squash Federation (2018) states that the racket is made up of:

- The frame (the part of the racket that contains or surrounds the strung area);
- The strings and string ends (the strings must be alternatively interlaced with only two layers to make a uniform plane over the racket head; it may be composed of gut, nylon or a substitute material);
- The bumper strip (a cushioning to protect the racket during contact with the floor or wall, made of a flexible material); and
- Grommets/string spacers may be used to limit the vibration and must be reasonable in size and placement.

The racket is allowed a maximum length of 686 mm and a maximum width of 215 mm; the size of the racket is dependent on the player's age and size. Racket frame composition is a very important decision (Brunette and Durbach 2011). Traditionally wooden rackets were used; in modern times, these have been swapped for a lighter graphite or carbon fibre racket (Miller 2006; Tagliafico *et al.* 2009). An aluminium frame is slightly heavier and tougher than a graphite frame; therefore, it is suited to a beginner or junior player. A graphite frame is stiffer, lighter and better balanced which allows the racket to be swung at a higher speed (Brunette and Durbach 2011). The lighter material also allows for better control and greater power (Miller 2006; Tagliafico *et al.* 2009).

String composition and tension are also significant considerations as they influence the racket's performance. Synthetic fibre strings are more robust but gut strings provide the most amount of control. Multifilament strings offer a practical compromise between the two. The strings stretch over time and need to be replaced, depending on how often a person plays (Brunette and Durbach 2011).

2.1.4.3 Footwear

In modern times, the shoe worn during training or a match has become an increasingly significant part of the equipment. Most recreational players simply use their most comfortable 'running shoes'; whereas the competitive players use squash shoes that have a specific design to provide stability and reduce the amount of shock impact on the foot and ankle (Clavisi and Finch 1999b; Sinclair, Bottoms, Taylor and Greenhalgh 2010). The choice of shoe is important because movements in squash are sharp with a large number of sideways lunges and dynamic changes in direction; therefore, a non-slip rubber sole is necessary. The shoe must also provide some degree of traction and must leave no marks on the wooden floor (Brunette and Durbach 2011).

Shoes with rigid soles allow for an even distribution of pressure over the sole of the foot, thereby preventing overuse injuries from occurring (Chapman 2008). The shoe is important in preventing any slippage and possible contact injuries. Shoes with high friction can prevent slippage and falling as opposed to shoes with low friction that remove foot contact with the ground, thus resulting in slipping. However, friction needs

to be well considered as shoes with extremely high friction can lead to shearing forces at the ankle, resulting in ligamentous injury (Chapman 2008).

2.1.4.4 Safety glasses

A large concern in squash is eye safety; being hit in the face or eye by a ball or racket. Protective eyewear can prevent injuries from a strike from a ball or an opponent's racket, which is the usual mechanism of injury. Although safety glasses are not a requirement, it is highly recommended to use them during all squash training and matches (Brunette and Durbach 2011).

Eye injuries tend to be rather serious, with Eime, Zazzryn and Finch (2003) reporting that eye injuries were the most common reason for a hospital emergency department presentation. Despite the high severity of these injuries, only a small percentage of the population (9% to 10%) uses protective eyewear (Eime *et al.* 2005; Clavisi and Finch 1999a). This risk can be effectively managed by changing players' attitudes and enforcing the use of protective eyewear.

2.2 NORMAL SQUASH BIOMECHANICS

Biomechanics is a branch of sports science that tries to identify the mechanical characteristics that affect performance and resultant injury. It is concerned with the technique used to perform various skills. The advance of technology in recent years has enabled detailed three-dimensional kinematic analyses of racket skills to be undertaken. It has also allowed selected kinetic characteristics of racket skills to be established. These methods of investigation have enabled the investigation of underlying mechanisms used in performing racket skills (Lees 2003).

Squash biomechanics are utilised in all movements especially during the two major movements in squash: the forehand swing and the backhand swing. The descriptions below apply to all types of forehand and backhand shots, regardless of the player's court position or whether they are attacking or defending. Each swing has various phases in it that must be executed in order to perform a perfect swing (Yarrow and Harrison 2010).

2.2.1 Forehand swing

Yarrow and Harrison (2010) state that the forehand swing is considered the easier of the two to execute. When striking the ball on the forehand, it is important to remember that the power comes from the preload phase and not the follow-through. There are five phases to the forehand swing:

Phase one: Preload Phase

- The front shoulder must be dropped and pointed in the direction of the sidewall.
- The players' body weight must be on the front foot, which is positioned closer to the sidewall than his/her back foot.
- The racket must be positioned high, with the elbow away from the body bent at an angle (no more than 90 degrees). The wrist must be cocked so that the racket face is almost directly above the players' head.
- The player's focus must be on the ball.

Phase two: Forward swing

- The player must continue to transfer weight onto the front foot, while bending the leading leg. The hips must be rotated towards the sidewall.
- The ball can begin to drop before contact is made. The drop is done at a comfortable distance away from the body.

Phase three: Contact

- Begins when contacting the ball with the racket face to generate power in the shot.
- The player must keep the racket face open while maintaining the wrist position (firm and cocked).
- The front shoulder must still be dropped in order to allow for a "crouched" body position.

Phase four: Follow-through

- The hips are kept still, with the weight still on the front foot. It is important to prevent the back foot from sliding or lifting off the ground.

Phase five: Finish

- The player can now turn their head to watch the path of the ball.
- The elbow is bent to allow for the racket to move face up over the front shoulder.

However, if it is not learnt properly with all the basic elements, the accuracy of the shot can be problematic, for the outcome of the game, as optimal shots are missed or inappropriately executed; as well incorrectly loading joints leading to repetitive injuries and / or acute injuries.

2.2.2 Backhand swing

Yarrow and Harrison (2010) state that the backhand swing is very difficult for the beginner to execute, unlike the forehand swing. Players must learn the basic elements of the swing otherwise it becomes a weak part of their game. As mentioned earlier, the power comes from the preload phase backswing and not the follow-through. There are five phases:

Phase one: Preload Phase

- The racket face must be close to the back of the neck. The wrist must be cocked and firm so that the racket face is steady prior to the swing; the knuckles must be facing upwards.
- The elbow must be close to the body and pointed downwards.
- The front foot must be closer to the sidewall than the back foot.
- The player's body must face the back corner.

Phase two: Forward swing

- The front shoulder must be dropped and pointed to the sidewall.
- The elbow is pulled back around the body so that a good wind-up is achieved for the shot.
- The racket face will follow a U-shape during the swing (downwards on the back swing, though the ball and then upwards on the follow-through).
- The player must continue to transfer weight onto the front foot, while at the same time bending the leading leg.
- The ball can begin to drop before contact is made. The drop is done at a comfortable distance away from the body.

Phase three: Contact

- The ball must be contacted slightly in front of the front foot on the side of the body.
- The arm is kept straight, and the wrist position is maintained so that the racket face does not drop below the level of the hand. The racket face must be kept opened.
- The wrist must be firm in order to prevent the ball being pushed with the wrist in a snapping motion.

Phase four: Follow-thorough

- The hips must be kept still with all the body weight placed onto the front foot.
- It is important that the back foot does not slide or lift off the ground.

Phase five: Finish

- The player can now turn his/her head to watch the path of the ball.
- The elbow is bent to allow the racket face to move above the players' head.

In a similar manner to the forehand swing, if the backhand swing is not learnt properly with all the basic elements, the accuracy of the shot can be problematic.

Based on the above discussions around the demands of the sport, the equipment and the player, it is evident that these specific entities may predispose the player to injuries, therefore the next section will present a discussion on the intrinsic and extrinsic risk factors.

2.3 RISK FACTORS

2.3.1 Intrinsic risk factors

2.3.1.1 Age

Squash professes to be a sport for all ages with a wide appeal to a large age range, however, there may be associations between age and squash-related injury risk.

It has been identified that the extremes of age are at risk of injury for different reasons. There is a possibility that younger players (preadolescent and adolescent) participate at a higher intensity and more often (i.e., higher exposure) than their senior (55 and

older) counterparts, placing them at a higher risk of injury on an exposure basis alone (Eime, Zazzryn and Finch 2003). Younger players are vulnerable to repetitive micro trauma with a resultant loss in flexibility and strength, leading to areas of instability and susceptibility to injury (Bylak and Hutchinson 1998; Gerrard 1993). Preadolescent and adolescent players have open growth plates, reduced muscle power, lower level of coordination and smaller stature compared with adult players. The physical characteristics of the young players mean that unique demands are placed on the developing athlete which can, in turn, be associated with different types and patterns of injury. (Cuff, Loud and O'Riordan 2010; Gerrard 1993). By contrast Kondrič *et al.* (2011) attested to the increased risk of injury in younger players but suggested that this was as a result of poor recognition and localization of injuries and a lack of reporting pain. Therefore, adequate treatment is delayed, leading to the development of chronic repetitive strain injuries. In addition, other literature suggests that younger athletes, who incorrectly repeat skills at high repetitions in order to achieve perfection, may be predisposed to chronic, overuse injuries (Gerrard 1993).

Other researchers report that there is a high prevalence of chronic pain and severity of pain that increases progressively with age (Parsons *et al.* 2007; Eime, Zazzryn and Finch 2003; Silva *et al.* 2003; Chard and Lachmann, 1987). Benporath (2016) confirmed this in his study, reporting that older age players (48 years old and older) were more likely to sustain a repetitive strain injury. This was further substantiated by Eime, Zazzryn and Finch (2003) who reported that the majority (84.0%) of hospital admissions for acute and severe squash-related injuries (loss of an eye, heat illness, concussion, cardiac failure, death) were by players who were ≥ 30 years. It is believed that squash players tend to be older, with a study noting that majority of the participants were at least 36 years of age (58.9%) (Chard and Lachmann, 1987). A high level of physical stress is less tolerated by the body tissues as they age; ageing has been associated with a decline in muscle and tendon functions. There is an overall decrease in muscle mass and tendon flexibility which leads to a restriction in joint mobility and an increased susceptibility of injury risk (Parsons *et al.* 2007; Chard and Lachman 1987). Older athletes have also been exposed to a greater load of training and games.

A reason the studies (that reviewed hospital records and online literature) reporting that the older population are more at risk for injury than the younger population is that

younger people don't tend to report their injuries as frequently as their elder counterparts. They ignore injuries and are more likely to have repetitive strain injuries without accurately reporting them (Huguenin 2016). By contrast the older players tend to report injuries more readily; this may be as a result of increased understanding that a lack of adequate treatment leads to further complications. It may also be as a result of the accumulated injuries in youth that have not been addressed that now result in direct impact to participation in play and / or activities of daily living. It is also possible that a decrease in healing time with increasing age may incur longer time out of play than when they were younger and therefore results in earlier reporting. The above can be seen in that the older patients tend to be reported to a greater extent in those studies where data was collected through medical records (Chard and Lachmann 1987; Eime, Zazzryn and Finch 2003; Finch and Eime 2001; Clavisi and Finch 1999a; Macfarlane and Shanks 1998; Finch and Clavisi 2010).

2.3.1.2 Gender

Many squash studies stress that the male population is reportedly injured to a greater extent than the female population (Okhovatian and Ezatolahi 2009; Meyer *et al.* 2007; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002; Macfarlane and Shanks 1998; Chard and Lachmann, 1987). A study that looked at hospital and emergency department admissions for squash injuries in Australia noted that the vast majority (90.0%) of hospital admissions were male (Eime, Zazzryn and Finch 2003). This was substantiated by Meyer *et al.* (2007) in their study as 25% of reported squash injuries were sustained by females and 75% of injuries were sustained by males.

By contrast, Sankaravel *et al.* (2017) had a majority of females in their population (51.7% female versus 48.3% male).

It has been suggested that males generally produce higher forces and torques at the shoulder and elbow joints than females (Chad and Lachmann, 1987). This may result in an increased risk of injury due to overload at the shoulder and elbow joints (Elliott *et al.* 2003). Another explanation for an increased risk of injury in the male gender is that females play gently and smoothly, whereas males have an energetic character while playing with a weak technique and playing in wrong directions in the court

(Okhovatian and Ezatolahi 2009). These outcomes may explain the greater intensity of competitive squash injuries in male players.

By contrast, a study performed on Iranian squash players suggested that neither gender has a greater injury risk but rather that each gender suffers from different types of injuries. Female players have more injuries from ball “kicking” due to their weakness in racket control; whereas, male players suffer more from racket “kicking” due to their energetic character of playing in addition to weak technical ability (Okhovatian and Ezatolahi 2009). Chan *et al.* (2007) confirmed this in their study when the odds ratios indicated that males were unlikely to sustain more injuries than females.

2.3.1.3 Ethnicity

In general, with regards to a MSK pain comparison among different races a study conducted by Allison *et al*. (2002) posited similar pain prevalence between ethnic minorities and the white population. Previous research in other sporting disciplines (Benporath 2016; Coetzee 2013; Adamson 2006) has shown a trend of increased risk of injury in the white population, however, this could be due to the varied frequencies between the different ethnic groups that could have skewed the data. Therefore, the above-mentioned study is of great interest as it shows that there is the possibility that ethnicity has no effect on injury. However, this had yet to be determined within the squash playing community.

2.3.1.4 Height and weight

It is thought that increased upper body mass may increase the risk of back pain due to the greater compressive forces on the spine (Macfarlane and Shanks 1998). Ranchordas *et al.* (2013) explained that a low body fat percentage aids in speed and agility and improves heat tolerance. However, no scientific evidence has concluded that low body fat levels are required to be a successful player. Both ends of the scale need to be considered; there is no benefit in low body fat levels (ectomorph) nor is there in excess body fat levels (endomorph). It is better to have lean muscle mass (mesomorph) that allows for maximal contraction without placing unnecessary stress on the bone and joints.

Wong *et al.* (2014) found that a greater BMI (body mass index) was associated with greater power and torque production with an overall increase in serve speed. A study by Benporath (2016) confirmed that the risk of injury decreased by 18% for every one-point increase in the BMI score. However, Prentice and Jebb (2001) have stated that the BMI score gives a poor representation of body fat in those individuals with developed musculature, as the BMI scaling system gives no differentiation between body fat percentage and muscle fat percentage.

2.3.1.5 Handedness

The majority of the global population is right-handed; this trend carries through to squash, as there is an obvious majority of right-handed dominance in players. Since the dominant hand is engaged in more work making it more prone to injury than the non-dominant hand (Incel *et al.* 2002; Raymond *et al.* 1996). Due to repetitive demands on the dominant shoulder, there is constant micro trauma, scar formation, capsular contractures and subsequent reduction in internal rotation. This decrease can cause a deficiency in the production of force and therefore increasing the risk of injury (Vad *et al.* 2003). The non-dominant hand generally suffers from injuries that result from supporting oneself during falls and collisions with a player/wall; dominant hand injuries are usually blisters resulting from friction with the grip.

Despite left-handedness being a minority (10% to 13%), it seems to be associated with a fitness advantage and increased stability (Raymond *et al.* 1996). Therefore, there may be benefits to being left hand dominant in squash. A noteworthy study is that by Incel *et al.* (2002) that looked at the effect of grip strength on hand dominance. The authors stressed that the dominant hand is significantly stronger in right-handed subjects. However, there are no significant differences between sides in left-handed subjects. This implies that the left-handed subjects have a greater balance of strength in both hands as they are often forced to use their non-dominant hands for daily activities.

2.3.1.6 Squash experience

Squash experience can be assessed in two ways: the frequency and intensity of training sessions and/or matches, or the total amount of years of squash participation.

The frequency and intensity can be varied with regards to the level of play. A player at a higher level of play (i.e. a professional squash player) will train more frequently and at a higher intensity than a player at a lower level of play (i.e. an amateur squash player) (Okhovatian and Ezatolahi 2009). On average, amateurs train approximately 5.7 hours a week and have a squash experience of 6.5 years; professionals train approximately 13.2 hours a week and have a squash experience of 13.4 years (Okhovatian and Ezatolahi 2009). Therefore, professionals spend over double the number of hours per week and have dedicated over double the number of years to squash. These results are confirmed by Eime *et al.* (2005) who reported that the majority (80.9%) of squash players in their study played between one and five hours per week, and most of them (72.4%) had been playing squash for 10 years or more.

2.3.1.7 Level of play

Professional players are at risk of chronic injuries due to their vast amount of training experience, as well as their intensive and hard training programmes (Abrams, Renstrom and Safran 2012; Kondrič *et al.* 2011; Finch 2006). Whereas injury in the beginner or amateur player is often a result of poor technique and low fitness levels which results in increased stress on the musculoskeletal system (Kondrič *et al.* 2011; Okhovatian and Ezatolahi 2009; Clavisi and Finch 1999a). In addition, in the novice level of play, there is a need to constantly repeat the same skills in order to perfect them, which can lead to overuse injuries.

2.3.2 Extrinsic factors

2.3.2.1 Squash components

Components of squash include: warm-up drills, cardio, matches and warm-down. Various studies stress the significance of a warm-up as a component of squash training and/or competing (Meyer *et al.* 2007; Macfarlane and Shanks 1998; Chard and Lachmann 1987). Meyer *et al.* (2007) found that 43.0% of the players who did not warm up were injured compared with 27.0% of players who performed a warm-up prior to playing squash. This implies that either the starting period of each match (insufficient warm-up and/or stretching) or the period between matches (lack of recovery) may increase the risk of injury (Macfarlane and Shanks 1998)

The above assertions have however not been investigated conclusively as an increase in frequency of play is significantly associated with an increased prevalence of back pain; and a longer duration of play is not. Both of these may therefore modify the effects of a warm up and its protective benefits.

2.3.2.2 Participation in other physical activities

The evidence on effect of participation in other physical activities on squash injuries is minimal and inconclusive. Meyer *et al.* (2007) reported a high amount of participation in other sports in his population. Eighty-eight percent of the players reported participation in other sports and more than half of the players (64.0%) reported sustaining injuries in sports other than squash. It is unknown whether an injury from one sport will have an effect on injury risk in another sport. Also worth mentioning is confusion on the part of a participant because it is sometimes difficult for a participant to discern whether an injury was caused by one sport or another. As asserted by Cuff, Loud and O'Riordan (2010), high school athletes who participate in more than one sport are at an increased risk of sustaining an overuse injury, therefore single sport specialisation does not seem to be a risk for injury formation.

Some sports may allow for the development of skills that can have a protective effect and allow for different areas to be strengthened etc. Benporath (2016) demonstrated this idea in his study on tennis players, which established that participants who also cycled were 77.0% less likely to experience an injury than participants who did not cycle.

2.3.2.3 Cigarette smoking

Many studies have noted a relationship between smoking and sarcopenia (age-related loss of muscle mass and strength). There are also known health risks associated with smoking (e.g. cardiovascular disease, cancers etc.) in addition to the impact of smoking on the musculoskeletal system. Smoking causes catabolism of the skeletal muscle and can also result in systemic processes that can lead to an increase in inflammatory activity and insulin resistance (Kaisari *et al.* 2012).

Smoking has been shown to be significantly associated with musculoskeletal pain and may be a contributory cause of musculoskeletal pain (Brage and Bjerkedal 1996).

Benporath (2016) confirmed this in a study that reported an increased risk of injury in ex-smokers. This was further substantiated by Altarac *et al.* (2000) who noted that the detrimental effects of smoking on injuries persist for a period of time even after smoking had stopped. In addition, a history of smoking has been associated with a higher risk of injury during physical training due to impaired tissue healing. Smokers had more previous injuries, less physical activity, more prior illness and lower physical fitness than non-smokers. Albrecht *et al. (*1998) stressed this in his study, which showed that those who quit show a further increase in their exercise capabilities compared to those that remained active smokers.

2.3.2.4 Alcohol consumption

In their study on college athletes Cameron *et al.* (2013) noted that excessive alcohol consumption has a number of detrimental effects on athletic performance such as decreased psychomotor coordination, decreased maximal oxygen consumption, and impaired temperature regulation. The dehydrating effects of alcohol can negatively impact athletic performance and drinking alcohol after athletic activity can worsen dehydration associated with physical activity, impede muscle recovery, and enhance injury risk.

Benporath (2016) substantiated this in his study which proved that there is an increased risk of injury in those that consume spirit alcohol. The reasoning behind this is that alcoholic beverages that fall under the category of ‘spirits’ are more likely to produce higher peak blood alcohol concentration (BAC) levels than ‘beer’ or ‘wine’. Although the type, amount and rate of alcohol consumption is significant, it is also important to note that BAC levels are more likely to peak when the person is in a fasting state. Therefore, it is recommended that a person does not drink on an empty stomach (Mitchell, Teigen and Ramchandani 2014).

2.3.2.5 Lack of Treatment

Some studies have noted that players do not often seek treatment after an injury. A study by Macfarlane and Shanks (1998) reported that out of all the players who suffered from an injury (n = 257), 113 (44.0%) did not seek any professional treatment. The remaining 144 (56.0%) utilised the following professional care: general

practitioner (91.0%), physiotherapist (59.0%), and chiropractor (16.7%). Home treatment is generally more popular. Home treatment includes the use of cold packs and rest (Meyer *et al.* 2007). A lack of reported surgical interventions in those studies and high use of home remedies indicate that injuries were either not severe and/or they were not adequately managed and therefore have a high chance of re-occurring. Time spent recovering from injury can be minimised with adequate and appropriate rehabilitation, which should include balance, joint flexibility, muscular strength and endurance and motor ability (Finch 2006).

2.3.2.6 Playing style

Bartlett, Gratton and Rolf (2010) and Wang (2009) note that there are four basic single-handed grips used to hit the forehand: continental, Eastern, semi-Western, and full Western. For each grip, the player places the base knuckle of the index finger and the heel pad of the palm on the grip of the racket. Nirschl speculated that grip size would have a direct effect on the muscle activity of the wrist and arm (Speer 2005). If a grip was too small, greater muscle activity was needed in order to grip harder; a bigger grip required less muscle activity as less grip force was needed. Poor grip, poor racket swing technique and over-extension of the wrist have been identified as factors that increase the likelihood of a wrist injury (Talabi *et al.* 2002). Nirschl developed a measurement technique for determining a player's recommended grip. Grip size is determined from the tip of the player's ring finger to his/her proximal palmar crease (Hatch *et al.* 2006; Speer 2005).

2.4 SQUASH-RELATED INJURY

2.4.1 Definitions

The prevalence of musculoskeletal pain and/or injury among squash players are is noted to vary from 29% (Meyer *et al.* 2007) to 83.33% (Sankaravel *et al.* 2017). Unfortunately, the comparability of these studies is restricted by a number of methodological limitations such as poor injury definition, inadequate classification of the population at risk and non-systematic data collection. (Clavisi and Finch 1999a, Sankaravel *et al.* 2017). There is often a lack of commonality in terminology used for different body regions injured. Macfarlane and Shanks (1998) reported on "back"

injuries in squash players, while Chard & Lachman (1987) used the term “trunk” in their study. Sankaravel *et al.* (2017), Meyer *et al.* (2007) and Finch and Eime (2001) grouped the hand and wrist injuries together in their studies, while Talabi *et al.* (2002) separated them. Sankaravel *et al.* (2017) also reported the foot and ankle as a unit, while Meyer *et al.* (2007), Talabi *et al.* (2002), Finch and Eime (2001), Chard and Lachman (1987) and Okhovatian and Ezatolahi (2009) separated the two. Chard and Lachman (1987) also grouped all their upper limb injuries together while the other studies divided them into shoulder, elbow, wrist and hand. The lack of consensus between studies makes comparisons and determining injury profiles in the squash population difficult.

Additionally, reliance on the nature of injuries has been self-reported by squash players (Sankaravel *et al.* 2017, Meyer *et al.* 2007, Okhovatian and Ezatolahi 2009, Macfarlane and Shanks 1998, Talabi *et al.* 2002) with the exception of (Finch and Eime 2001, Chard and Lachman 1987, Eime, Zazzryn and Finch 2003, Clavisi and Finch 1999a, Clavisi and Finch 1999b, Eime *et al.* 2005) who utilized hospital records to find the diagnosis of injury (increasing reliability of the diagnosis). According to Mouton (1996), such self-reporting impacts on the reliability and validity of the data captured, as a result of recall bias, self-diagnosis and association with the mechanism of injury. Therefore, it would seem that those studies that had participants self-record any injuries tended to have increased ranges in injury types recorded; as compared to those studies that focused on the acute injury reporting in a hospital setting. These data comparisons are then further compounded by player identification of their own injuries – as most studies involving chronic injuries cannot utilise official diagnoses when players have not sought care for the injury. This then complicates the comparison between studies as patient perception of injury severity, need for care, injury type and time out of play differs according to level of play as well as the cultural background of the player. (Henschke *et al.* 2016).

There are two mechanisms that can result in a sports injury, namely, a single episode of major contact (referred to as an acute injury) or the accumulation of multiple minor traumas (referred to as a chronic injury / repetitive strain) (Gerrard 1993). Repeated microtrauma results in an overuse injury. In the case of an overuse injury, the tissue injury process develops over a period of time during which the athlete may not

experience any symptoms of the injury (Bahr and Maehlum 2004). However, if the overuse injury continues to undergo further insults, the tissue repair process will become overloaded and no longer be capable of repairing itself. It is at this point that the athlete will begin to experience various symptoms.

For the purposes of this study, a squash injury was defined as a musculoskeletal problem requiring reduction or interruption of squash activity for any length of time, with or without evaluation or treatment by a health care provider. (Pluim et al 2006). Therefore, an acute MSK injury would be one to interrupt play whereas a chronic MSK injury would be one to reduce the effectiveness of play without stopping play.

2.4.2 Characteristics of squash injuries

2.4.2.1 Prevalence and incidence

A literature review on squash has noted disparate results with regards to prevalence rates. Multiple authors have reported that squash has a high injury prevalence (Sankaravel *et al.* 2017; Okhovatian and Ezatolahi 2009; Meyer *et al.* 2007; Eime, *et al.* 2005; Eime, Zazzryn and Finch 2003; Clavisi and Finch 1999a). As seen in Table 2.1.

Table 2.1: Comparisons of studies presenting original data relating to musculoskeletal injuries in squash players

Author	Year	Sample size / population response rate	Incidence	Prevalence – point	Prevalence – period	Context of data collection
Okhovatian and Ezatolahi	(2009)	52			(79.0%) – 2 years	Questionnaire
Chard and Lachmann	(1987)	372		(59.0%)		8-year retrospective study reviewing records from racquet sports (squash, tennis and badminton) in an injury clinic
Sankaravel *et al.*	(2017)	60			(83.33%) – 12 months	Questionnaire
Macfarlane and Shanks	(1998)	495			51.9%) – lifetime prevalence	Questionnaire on back pain
Meyer *et al.*	(2007)	106			29%- 4 weeks	Questionnaire

Table 2.1 adapted from Finch and Eime (2001)

According to the authors above the high prevalence is due to the higher levels of physical stress, the confined area of play, the close proximity of players in which a racket is swung, contact with other players and the size, speed and physical properties of the ball in squash.

In contrast, Meyer *et al.* (2007) and Macfarlane and Shanks (1998) suggested that squash is a relatively low-risk sport for injury. The reason for this difference could be that Meyer *et al.* (2007) only looked at injuries over a 4-week period, and Macfarlane and Shanks (1998) only reported on back pain.

2.4.2.2 Area of injury

The three major areas for injury were: the upper limb, the lower limb and the spine (spinal injuries are often a result of a combination of rotational and sagittal plane activity [Okhovatian and Ezatolahi 2009]). This can be seen in Table 2.2.

Table 2.2: Studies investigating the percentage of squash injuries according to different body regions

Area of Injury	Sankaravel 2017	Talabi et al 2002	Okhovatian 2009	Meyer et al 2007	Finch and Eime 2001	Chard & Lachman 1987	Macfarlane and Shanks (1998)
Head		15%					
Neck	16.7%						
Trunk / Back						20%	51.9%
Shoulder	25%			13%	13%		
Upper arm				8%			
Forearm				10%			
Elbow	8.3%	6.2%	21%		7%		
Wrist/Hand	31.7%	5.1%		4%	7%		
Finger		4.2%					
Upper limb					17% to 35%	22%	
Upper back	16.7%			4%			
Lower back	**11.7%**		**36.5%**	**13%**	**10% to 16%**		
Hip/Thigh	**20%**			**19%**			
Groin				**2%**			
Knee	**20%**	**20.5%**	**10%**	**8%**	**7% to 9%**	**23%**	
Shin				**2%**			
Ankle	**26.7%**	**30.2%**	**2%**	**6%**	**13% to 36.6%**	**13%**	
Foot		**13.2%**		**10%**			
Lower limb					**32% to 81%**	**58%**	

The majority of the literature states that the lower limb is more at risk of injury than the upper limb (Table 2.2). Many studies have substantiated the above statement (Okhovatian and Ezatolahi 2009; Meyer *et al.* 2007; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002). Two studies conducted on squash players specifically noted that approximately two-thirds of all injuries were found in the lower limb (Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002). A study by Talabi *et al.* (2002) broke down squash injuries further ranking the following areas according to frequency: ankle (30.2%), knee (20.5%), head (15.0%), foot (13.2%), elbow (6.2%), other (5.6%), wrist (5.1%), and finger (4.2%). The lower limb is at increased risk of injury due to a lack of lower leg fitness, poor agility, improper positional play, poor footwear and floor conditions, sudden changes in direction, and twisting of the knees due to the small court and speed of the ball (Okhovatian and Ezatolahi 2009; Talabi *et al.* 2002).

In contrast to the above studies, some studies report that the upper limb suffers from more injuries than the lower limb or the spine (Sankaravel *et al.*2017; Okhovatian and Ezatolahi 2009). Sankaravel *et al.* (2017) broke down squash injuries ranked according to frequency: wrist and hand (31.7%), ankle and feet (26.7%), shoulder (25.0%), hip and thigh (20.0% each), neck and upper back (16.7%). Okhovatian and Ezatolahi (2009) confirmed that most squash injuries occur in the trunk and upper limb, as the shoulder and arm are extensively used throughout the game. The control and drive of the racket and ball comes from the wrist. The high amount of injuries found in the upper limb can be attributed to the force and torque at the shoulder and elbow joints during a serve which significantly overloads those areas and increases the risk of injury formation. This movement (i.e. the serve) is repeated many times and has the potential to cause an overuse injury (Meyer *et al.* 2007; Elliott *et al.* 2003).

2.4.2.3 Type and onset of injury

These two characteristics have been grouped together as they often relate to and have an effect on each other. Generally, injuries either have an intrinsic or extrinsic cause (see Section 2.2.3), resulting in either an acute or chronic injury. For this study the data collection procedure was not in line with only acute injury reporting as would be found in a hospital setting. Therefore, players were more likely to report any / all injuries irrespective of whether it was reported to a medical practitioner. This, as stated

in Section 2.3.1, would have decreased the specificity of reported diagnoses but increased the reporting of all injuries (whether they prevented play or not).

Given the above discussion, it is therefore more likely for the players to have reported general chronic injuries, which were then classified according to the type of tissue that had been affected (musculoskeletal system). The musculoskeletal system is made up of muscles, ligaments, tendons, nerves, bones (the skeleton), discs, cartilage and joints (Lynall *et al.* 2015). In many sport injury-related studies, musculoskeletal injuries are frequently seen. Strain on the musculoskeletal system can result in microscopic injury when the threshold of the body's capabilities are exceeded (Meyer *et al.* 2007). Increased stresses on the musculoskeletal system which result in musculoskeletal injury, include: poor technique (see Section 2.2.3), improper equipment (extrinsic causes), and congenital anomalies / demands of life stages (intrinsic causes) (Kondick *et al.* 2011).

Injuries frequently occur to the ligaments and tendons due to their avascularity and slow-healing properties, as well as their location (Benjamin *et al.* 2006; Fenwick, Hazleman and Riley 2002). They are the sites of high stress as they join bone to bone/muscles, respectively. A study on hospital and emergency department admissions of squash players confirmed that the most common type of injury was a sprain or strain, which accounted for half of the admitted cases (Eime, Zazzryn and Finch 2003). Ankle sprains are very common in court sports (Fong *et al.* 2007). Talabi *et al.* (2002) affirmed this in his study with the majority (85.7%) of the participants reporting soft tissue injuries.). However, there is insufficient research on squash-related musculoskeletal injuries outside of the hospital data collection setting (Finch and Eime 2001).

Many studies note a high number of musculoskeletal injuries irrespective of data collection point (Maquirriain and Baglione 2015; Kondrič *et al.* 2011; Fong *et al.* 2007; Meyer *et al.* 2007; Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002; Finch and Eime 2001). Of particular note is the study by Sankaravel *et al* (2017), which reported a high of 83.3% of reported musculoskeletal complaints in squash players; indicating that more studies are necessary in non-hospital settings to determine the full extent of squash related injuries.

Onset of an injury is generally classified into one of two categories: acute or chronic. Acute injuries are injuries that occur suddenly and are the result of a traumatic event and necessitating immediate care (Hyde and Gengenbach, 2007). Chronic injuries occur as result of repetitive trauma and overuse; they develop slowly, persist for a long period and are difficult to heal due to their limited impact on play and quality of life resulting in delayed care seeking behaviours (Hyde and Gengenbach, 2007).

According to Schneider *et al.* (2006), younger players are more likely to suffer from acute and traumatic injuries (such as fractures), whereas older players were more likely to suffer from cartilage and tendon injuries. This is usually consistent with the level of play and the intensity of play which are higher in younger players than older players (Hyde and Gengenbach, 2007). Additionally, this may be complicated by the young athlete that has an immature body with muscles, ligaments and bones that are not yet fully developed (Gerrard 1993), thus not enabling them to deal with the high stress load (Jayanthi *et al.* 2015). By contrast literature suggests that those of an older age are more at risk of sustaining an overuse injury (Cuff, Loud and O'Riordan 2010; Junge *et al.* 2015) as their bodies are more mature and undergo a prolonged duration of the 'wear and tear' process which later results in chronic injury formation (Platts-Mills and Dayaa 2017; Galloway and Jokl 2000; Berson *et al.* 1981). These assertions in the literature do however not prevent younger players from experiencing chronic injuries or alternatively older players from experiencing acute injuries (Hyde and Gengenbach, 2007). It has been suggested that, younger players have poor injury recognition, localisation and reporting of pain and therefore, these players delay appropriate treatment and result in chronic injuries (e.g. the development of chronic ankle instability syndrome from untreated grade I or II ankle inversion sprain) (Reid, 1992; Pellow and Brantingham, 2001; Kohne, 2006). This trend of under-reporting was confirmed by Macfarlane and Shanks (1998) who reported that 44% of their injured population did not seek medical attention when they were injured. This leads us to question if there is a significant population of squash player who have "sub-clinical" squash-related injuries that are not reported. Not only does this skew the data but it also leads to a large amount of future chronic injuries, which could have been prevented if early treatment was implemented.

A retrospective study of squash players by Chard and Lachmann (1987) stressed the high number of acute injuries. Approximately 80.0% of all injuries to the squash player were acute. Talabi *et al.* (2002) investigated squash-related injuries in a large population (n = 187). The majority of the injuries were acute (55.2%) with only a quarter of injuries (26.6%) being chronic. However, the results of this study may be considered hard to interpret as the categories used were ambiguous (e.g. overuse injuries were classified separately to chronic injuries).

On the other hand, a second body of studies report a larger frequency of more chronic/overuse injuries (Lynall *et al.* 2015; Meyer *et al.* 2007; Bylak and Hutchinson 1998). Kondrič *et al.* (2011) offered an explanation for the above statement; racket sports (squash, tennis, table tennis and badminton) require a high repetition of activities and various skills to develop perfection which can produce chronic, overuse injuries (Sankaravel *et al* 2017).

A study by Eime, Zazzryn and Finch (2003), stressed an equal split of acute and chronic injuries. Half of the players (50.0%) who presented to the hospital with squash-related injuries were as result of overuse. An explanation for this inconclusive result could be that the records from the hospital setting only covered severe injuries; therefore, acute and traumatic injuries were over-represented. However, all the above-mentioned studies cannot draw accurate conclusions are there is an unequal split of the participant demographics and training characteristics.

With the nonuniformity in the literature regarding the type and onset of injuries seen in squash players, it would seem pertinent that the mechanism of injury is reported in studies so as to further assist in forming a clinical picture of the injured squash player. This however has only been reported in one study which looked at hospital records (Eime, Zazzryn and Finch 2003). Therefore, it is important that future studies include the mechanism of injury to better contextualize those mechanisms of injury that can be avoided (by for example modifying extrinsic risk factors) or ameliorated (by modifying intrinsic risk factors), thereby managing injuries more effectively (McBean 2015)

2.4.2.4 Severity

Sports injuries are generally classified into one of three groups (Walker 2007):

- Mild: this injury will result in minimal pain and swelling. There is generally no adverse effect on the sporting performance and the affected area is neither deformed nor tender to touch.
- Moderate: this injury will result in some pain and swelling. Generally, there is a limiting effect on the sporting performance and the affected area is slightly discoloured and will be mildly tender to touch.
- Severe: this injury will result in increased pain and swelling. Generally, it will affect the athletes sporting performance in addition to their normal daily activities. The affected area is commonly deformed and discoloured and is very tender to touch.

It has been noted that squash is a sport that has an increased risk of severe injury occurrence (Finch and Eime 2001). Clavisi and Finch (1999a) attested to this high severity when they rated it as the twelfth highest sport activity for emergency-department admittance.

Another method of measuring injury severity is the consideration of time taken off by a player to allow the injured area to rest. Macfarlane and Shanks (1998) stressed the high number of days taken off work by players. Of the players who reported an injury, 44.0% stated that their worst back injury caused them to temporarily stop playing squash and 21.4% reported that they needed to take time off work (average of 16 days off work). This was confirmed by Schneider *et al.* (2006) who reported that 62% of all sports injuries result in time off work. Even more serious are injuries that result in hospital admission. A study that looked at hospital and emergency department admissions as result of squash injuries confirmed a high severity of squash injuries (Eime, Zazzryn and Finch 2003). Seventy-two percent of players were admitted for less than two days, and all others were admitted for two to seven days in hospital.

Based on the fact that all the studies reporting time out of work, were only those studies conducted at a hospital setting (i.e. requiring the need for treatment), it is therefore possible to understand that studies outside of this (non-hospital based) either assumed that the players did not have an injury significant enough to affect work ,

quality of life or play (thus not necessitating the question in the questionnaire) or the question has never been raised prior to this in any study where the player was self-reporting the diagnosis (again the implication being that the player has not sought care because the injury does not impact activity). This limitation in the literature was addressed in the current study.

2.5 CONCLUSION

Squash is a highly competitive sport which requires a player to combine fitness, coordination, and concentration. Due to the substantial skills required to play, along with the confined space in which players are required to play, squash players are often exposed to factors that can result in an injury. Injuries in squash have been outlined and discussed in terms of incidence and prevalence, type, mechanism, and physical site. The above have been expressed to the degree that these aspects are noted in the relevant literature. The rate of injury differs among various studies; however, no study has shown a lack of injuries in squash players. Risk factors for injury have been discussed in terms of the threat they present to the squash player, as well as whether these risk factors can be generalised to all squash players. An awareness and understanding of the prevalence and risk factors in squash will enable event organisers, medical personnel, managers, and coaches to adopt training approaches that will minimise the development of injuries. This information will also aid in developing monitoring systems to prevent adaptation injuries, which will lead to safer training and better management of players.

CHAPTER 3: METHODOLOGY

This chapter describes the research methodology as well as the procedures used to collect the data.

3.1 STUDY DESIGN

This research was a quantitative, cross-sectional, descriptive study which documented squash related musculoskeletal injuries in league squash players in the eThekwini Municipality. The questionnaire (Appendix A) contained sections for player information; squash history, training, equipment and injuries.

3.2 QUESTIONNAIRE DEVELOPMENT

The final questionnaire (Appendix A) was developed for the assessment of prevalence and risk factors for injury in squash players. The questionnaire consisted of five sections:

- Section A: Player information: participant demographics (gender, ethnicity, age); medical conditions; alcohol consumption; smoking information and non-squash related injuries.
- Section B: Squash history and training: what age did the participant start squash training; years of squash experience; number and duration of squash training session and components of the squash training sessions.
- Section C: Equipment: racket head diameter; racket weight, composition; string tension, composition; racket grip; and ball type.
- Section D: Squash injuries over the past 12 months: physical site of injury/ies; cause and duration of most severe injury; aggravating factors; medical treatment for injury and time taken off as result of injury.
- Section E: Current squash injuries: physical site of injury/ies; cause and duration of most severe injury; aggravating factors; medical treatment for injury and time taken off as result of injury.

A similar questionnaire was utilised by Benporath (2016) in his study of musculoskeletal injuries in tennis players. Permission was given by Benporath

(Appendix E) to modify his questionnaire to suit squash players. The appropriate adaptations were made (Appendix F); thereafter, the questionnaire was validated by means of a focus group and a pilot study.

3.3 FOCUS GROUP

Participation in the focus group required that the participants met the following criteria:

3.3.1 Inclusion criteria

- At least one league squash player
- At least two people with experience in utilising questionnaires for research purposes.
- At least one qualified chiropractor.
- The above participants were required to read the Letter of Information (Appendix I) and sign an Informed Consent form (Appendix J) as well as a Code of Conduct and a Confidentiality Statement (Appendix K)**.**

3.3.2 Exclusion criteria

- Any person that declined the invitation to participate.
- Any person who did not voluntarily read the Letter of Information (Appendix I) or sign the Informed Consent form (Appendix J), code of conduct form (Appendix K) or Confidentiality Statement (Appendix K).

3.3.3 Focus group procedure

After provisional approval and clearance was given, the pre-focus group questionnaire (Appendix H) was scrutinised and refined through the focus group discussion. A focus group is set up to address issues such as the face validity and content validity of criteria in the questionnaire. A focus group enables a group of individuals to discuss the questionnaire (Salant and Dillman 1994). The members of the group critically assess the relevance of questions presented in a questionnaire. They have the authority to suggest additional questions, as well as the deletion of questions. They can also request clarification of any questions with the goal of strengthening the validity of the questionnaire (Salant and Dillman 1994).

The following procedures were used to recruit participants for the focus group:

- The focus group consisted of one Durban league squash player, two research students who were doing, or had done questionnaire-based studies and a qualified chiropractor.
- The individuals were approached personally or contacted telephonically by the researcher and asked if they would be interested in participating in the focus group.
- Once the focus group had been set up, arrangements were made to host the focus group meeting. These arrangements included; determining a date and time that suited all members, making a booking for the chiropractic boardroom, arranging snacks, refreshments and stationery and setting up equipment to record the meeting.

Once the participants had arrived, the focus group began. The researcher opened the meeting by welcoming all participants, thanking them for attending, and explaining the procedure for the focus meeting. All participants were required to read the Letter of Information (Appendix I) and sign the Informed Consent form (Appendix J), Code of Conduct (Appendix K) as well as the Confidentiality Statement (Appendix K) before the questionnaires were handed out. The focus group went through the questionnaire discussing each question individually. Everyone was given an opportunity to voice their advice/concerns about each question; if any changes were required the researcher noted the changes. Changes to the focus group questionnaire are noted in Appendix O. The resulting questionnaire became the Final Questionnaire (Appendix A).

3.4 PILOT STUDY

Participation in the pilot study required that the league squash players met the criteria listed below.

3.4.1 Inclusion criteria

- Male or female league squash players who are ranked in the top three divisions.
- Participants who read the Letter of Information and signed the Informed Consent form (Appendices L and M).

3.4.2 Exclusion criteria

- Players under 18 years of age whose parents or guardians did not sign the Informed Consent page (Appendix M).
- Players who represent a club outside of the eThekwini Municipality.
- Players who refused to sign the Informed Consent page (Appendix M).
- Any person who took part in the Focus group.

3.4.3 Pilot study procedure

After the focus group, a pilot study was conducted. A pilot study was compiled by taking a small sample of the research population (four participants). The purpose of the pilot study was to determine the average time taken to complete the questionnaire, as well as any problematic areas that may be present (Fink and Kosecoff 1985). The questionnaire was administered to the group exactly as it would be to the main research sample. Participants of the pilot study were required to read a Letter of Information (Appendix L) and sign the Informed Consent form (Appendix M). The pilot study questionnaire (Appendix H) was administered to the group. These were hand-delivered in person by the researcher to the league squash players who volunteered to participate in the pilot study. No changes to the questionnaire were deemed necessary by the pilot study.

3.5 MAIN STUDY

Participation in the study required that the league squash players met the following criteria:

3.5.1 Inclusion criteria

- Male and female league squash players ranked in the top three divisions.
- Players who train for at least three hours a week.

- Participants who read the Letter of Information and signed the Informed Consent page (Appendix C and D).

3.5.2 Exclusion criteria

- Players under 18 years of age whose parents or guardians did not sign the Informed Consent page (Appendix D).
- Players who represent a club which is outside of the eThekwini Municipality.
- Players who refused to sign the Informed Consent page (Appendix D).
- Any person who partook in the Focus group or Pilot study.

3.5.3 Identification of the population

The 12 squash clubs in the eThekwini Municipality are Amanzimtoti, Berea Rovers, Durban Country Club, Chiltern, Crusaders, Gillitts, Glenwood High School, Kearsney, Kloof, Mount Edgecombe, University of KwaZulu-Natal and Westville County Club. All these clubs were involved in the study and no preference was shown to any club in particular.

3.5.4 Sample size

Twelve clubs in the eThekwini Municipality are recognised by the KwaZulu-Natal Squash Union (KwaZulu Natal Squash Union 2011). At the time of proposal approval, there were 186 registered league squash players in the top three divisions in the eThekwini Municipality. Therefore, to obtain a 95% confidence level, a minimum sample size of 126 participants was recommended by the statistician Singh via email on 16 March 2017. The calculation for the sample size is found on Appendix P. At the conclusion of data collection, a sample size of 129 was achieved.

3.5.5 Study population

The study population consisted of squash players who were ranked in the top three divisions and trained at least three hours per week at an accredited squash club in the eThekwini Municipality. The population age ranged from 14 to 65 making the mean age 41.65. The age rates were only determined once the questionnaires were completed. However, given the level of play, it was thought that the majority of the players would be between the ages of 20 and 45.

3.5.6 Permissions

Full ethical approval was subject to a focus group and piloting the data collection tool (Appendix G). After reviewing the results of the focus group and the pilot study the Durban University of Technology's Institutional Research and Ethics Committee (DUT IREC) gave full approval to commence data collection (Appendix B). Full ethical approval indicated that the study complied with the principals of the Declarations of Helsinki of 1964, and Nuremburg and Belmont of 1947 (Johnson, 2005). Permission to perform the study on the league players in the eThekwini Municipality was obtained from the KwaZulu Natal Squash Union (Appendix N) prior to ethical approval (but subject to the proposal receiving ethics approval), and permission to do the study at the specific squash clubs was obtained from the team captains.

3.5.7 Recruitment

After permission was granted by the chairperson of the KwaZulu Natal Squash Union, the team captains of the various squash clubs were approached. The researcher contacted each captain telephonically, explaining the purpose of the research as well as how it would be conducted and confirming a time and date for data collection. Following these conversations, the captains confirmed with their players that they were interested in participating and arrangements for data collection were confirmed. As a result, formal advertising was not required since participants were informed through the team captains. This allowed the researcher to address and recruit potential participants personally. Participation in the study was voluntary, and players signed a letter of informed consent if they chose to participate in the study (Appendix D). Participants under the age of 18 years of age were required to have a parent/guardian present on the day of data collection in order to attain child assent and parental consent respectively.

On the day of data collection, the potential participants were addressed and had the research procedure explained to them. Convenience sampling was then used to accept participants who willingly volunteered and who fitted the inclusion criteria (Denscombe 2003). The letters of information and consent (Appendices C and D) were then given to the potential participants to complete and then collected by the researcher, prior to the participants completing the questionnaires

3.5.8 Main study data collection

Data collection took place at each of the clubs' training locations in the eThekwini Municipality. The researcher visited the squash clubs on the day that the participants had a practice/tournament in order to reach the largest number of participants at one time. The researcher explained the aims and objectives of the study to the participants, as well as the content of the Final Questionnaire (Appendix A). They were then required to read the Letter of Information (Appendix C) and sign the Informed Consent form (Appendix D) and place it in a sealed ballot box. Thereafter, participants were given a questionnaire (Appendix A). The questionnaire was anonymous and completed by the participants in a self-reported manner in the presence of the researcher. The length of time it took for an individual to complete the questionnaire varied according to the number of injuries that needed to be reported; the average time was ten minutes. On completion the questionnaires were placed in another separate sealed ballot box. The questionnaires will be stored in the Department of Chiropractic and Somatology for five years, after which time they will be destroyed. Only the researcher and the researcher's supervisor will have access to the completed questionnaires.

3.6 ETHICAL CONSIDERATION

Ethical clearance was given by the Durban University of Technology's Institutional Research and Ethics Committee (Appendix B). This clearance indicated that the study was approved and complied with the principles outlined in Declarations of Helsinki of 1964, and Nuremburg and Belmont of 1947. Consent was obtained from the KwaZulu Natal Squash Union, as well as each squash club team captain, granting permission for the recruitment of research participants at the various clubs. All participants were required to sign a consent form (Appendix D), including parental consent for participants under the age of eighteen. The participants had the right to withdraw at any point in the study. Access to the questionnaires was kept strictly limited to the researcher and the statistician. The questionnaires were numbered and coded to ensure participant anonymity and confidentiality (Brink 2007).

On the completion of this study, participants will have access to the results of the study in the form of a dissertation (available online and in the DUT library) and possibly as

an article published in an appropriate journal. The recording of the focus group meeting will be stored with any other research documentation in the Chiropractic Department for a period of five years and subsequently destroyed as appropriate at that time.

With regards to non-maleficence, no harm was caused to the participants of this study via the questionnaire. The questions did not expose any sensitive information, or any information that could lead to incrimination.

Regarding beneficence, the questionnaires were anonymous and confidential, so that any open response wouldn't be held against them. The questionnaires were filled out in a non-threatening environment allowing for the participants to respond as freely and openly as possible.

Autonomy was respected in this study. Each participant took part on a voluntary basis and had the freedom to withdraw from the study at any given time.

With regards to justice, this study was fair and equitable, everyone was treated the same and there was no direct benefit from participating in the study.

3.7 STATISTICAL ANALYSIS

IBM SPSS version 24 was used for the analysis.

Descriptive data analysis: The results of each sub-group were expressed as percentages and continuous data were summarised using means, standard deviations, medians and ranges.

Inferential statistics: Associations between 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. Where applicable, reporting was based on 95% confidence intervals. A p value < 0.05 was used to indicate statistical significance, with p standing for the risk of making a Type 1 error (Indrayan and Holt 2016). Those variables that were associated at the $p < 0.01$ level of significance were entered into a binary logistical regression to analyse the risk factors of injury. A backward selection method of likelihood ratios was utilised. Odds ratios and 95% confidence intervals of the variables remaining in the model at the end were reported.

CHAPTER 4: RESULTS

This chapter presents the results obtained from the statistical analysis of the data collected. Bar graphs and charts are used to graphically illustrate the data, with a brief description accompanying each graph or table. The results are organised according to the sequence of the questionnaire used in the study.

4.1 DATA

The data collected in this study was by means of a self-administered questionnaire (Appendix A). This allowed the data to be quantified and analysed (Mouton 1996).

4.2 SAMPLE SIZE AND RESPONSE RATE

The sample consisted of the entire population of league squash players ranked in the top three divisions in the eThekwini Municipality. There were 186 registered players (KwaZulu Natal Squash Association 2017). The highest possible response rate was sought in order to minimise bias and enable the findings to be generalised across other squash populations (Lapane, Quilliam and Hughes 2007). To leave a 5% margin for error and to obtain a 95% confidence level Singh, in an email on 16 March 2017, recommended obtaining 126 responses from the players.

The researcher collected the data over a period of three months. The data was collected in person, rather than other methods of collection such as emailing or mailing the questionnaires, since those methods usually result in a decreased return and response rate (Lapane, Quilliam and Hughes, 2007), which then affects the feasibility of the sample and bias the results (Brink 2007).

One hundred and twenty-nine questionnaires were completed and returned to the researcher; this was more than what the statistician recommended (Singh 2016), and it met the requirements set by the DUT Institutional Research and Ethics Committee (Appendix G).

4.3 RESULTS

It must be noted that not all the questionnaires in this chapter reflect the 129 participants. Since some of the participants were not currently injured or had not been injured during the previous twelve months, not all of the questions were applicable to them. Furthermore, if the results in certain questions added up to more than 129, it meant that the participants were given the option to select more than one answer for that specific question.

4.4 OBJECTIVE ONE

Objective One was to determine the prevalence (point and previous [past 12 months]) of musculoskeletal injuries in league squash players in the eThekwini Municipality.

4.4.1 Prevalence of squash injuries (period [past 12 months] and point)

4.4.1.1 Period prevalence: past twelve months

The prevalence of injuries experienced over a 12-month period was 62.0% (Table 4.1).

Table 4.1: Period prevalence of squash injuries

	Frequency	Percent
No	49	38.0
Yes	80	62.0
Total	129	100.0

4.4.1.2 Point prevalence: current injury

The point prevalence of current injuries experienced by the participants at the time of the study was 25.6% (Table 4.2). However, of the 33 current injuries, 22 of them had unresolved injuries. Only 11 (8.5%) participants experienced a new current injury (Table 4.3).

Table 4.2: Point prevalence of squash injuries

	Frequency	Percent
No	96	74.4
Yes	33	25.6
Total	129	100.0

Table 4.3: Point vs Period prevalence of squash injuries

		No	Yes	Total
Injury	No	63	11	74
	Yes	33	22	55
Total		96	33	129

4.5 OBJECTIVE TWO

The second objective of this study was to describe the injury profile of squash players in the eThekwini Municipality. The factors linked directly to the injury include: the current and past injury/ies, location/s, severity, cause, duration, nature of onset, disability and the treatment received.

4.5.1 Injury location

4.5.1.1 Past 12 months

One hundred and fourteen injuries (n = 80; 62.0%) were reported by the participants who sustained an injury in the past twelve months. The areas most commonly injured were the foot and ankle (22.5%), followed by the knee (15.0%), thigh (13.8%) and the elbow (13.8%), as shown in Table 4.4. The lower limb was the most commonly injured area (67.6%) followed by the upper limb (21.4%) and the back and trunk (11.3%).

Table 4.4: Anatomical sites of injury over past 12 months

Number of injuries		Percent
Foot/Ankle	18	22.5
Knee	12	15.0
Elbow	11	13.8
Thigh	11	13.8
Back	7	8.8
Calf/Shin	7	8.8
Hip/Groin	6	7.5
Shoulder	5	6.3
Glut/ Buttock	2	2.5
Hand	1	1.3
Total	80	100.0

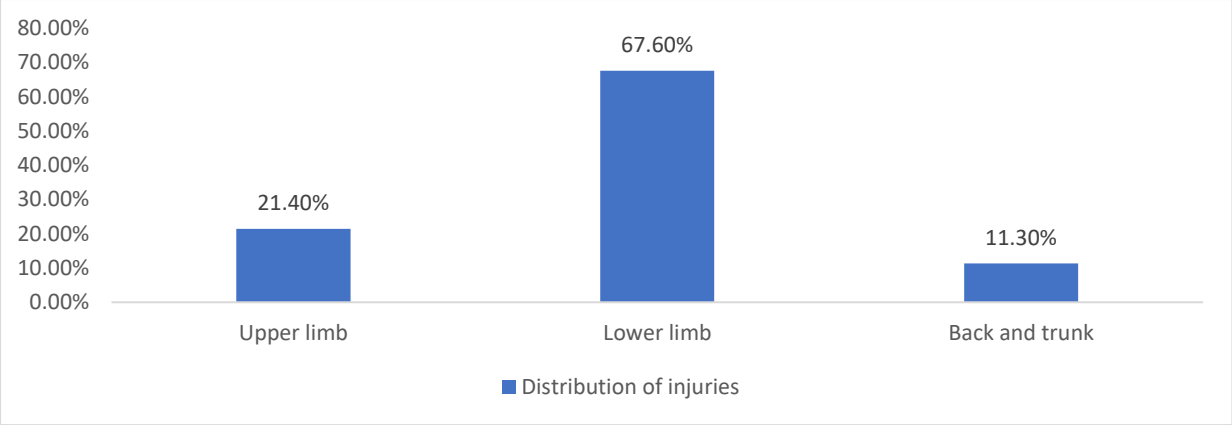

Figure 4.1: Distribution of past injuries

4.5.1.2 Current injuries

At the time of the study, 36 injuries (n = 33; 25.6%) were reported by the participants. With regards to current injuries, the lower limb (60.6%) was most injured region of the body, followed by the upper limb (21.2%) and the back and trunk (18.2%) (Figure 4.2). Injuries to the knee (30.3%) were the most prevalent, followed by the elbow (18.2%) (Figure 4.2 and Table 4.5).

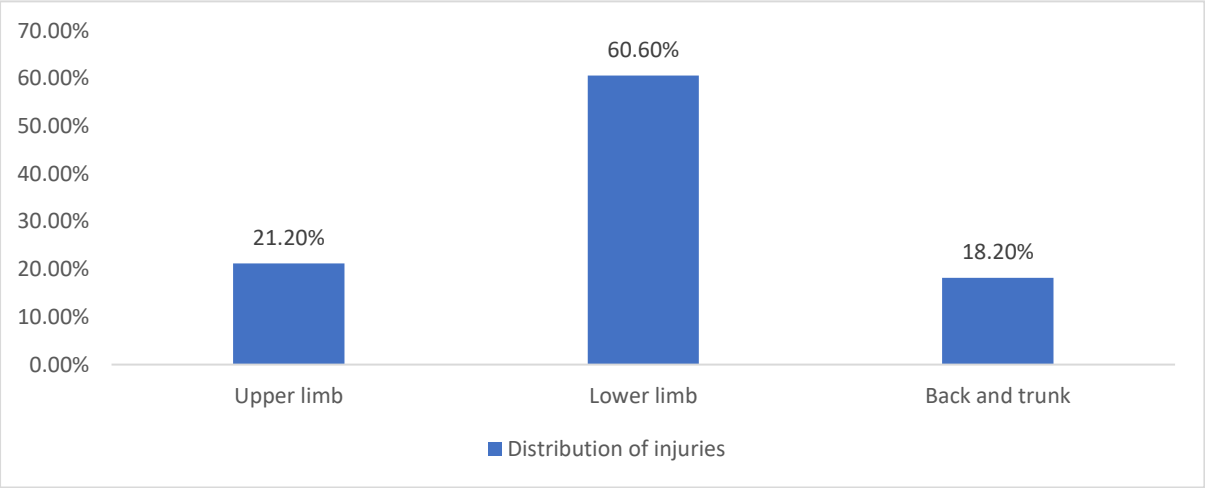

Figure 4.2: Distribution of current injuries

Table 4.5: Anatomical sites of current injuries

	Number of injuries	Percent
Knee	10	30.3
Elbow	6	18.2
Back	4	12.1
Foot/Ankle	4	12.1
Hip/Groin	3	9.1
Glut/Buttock	2	6.1
Shoulder	2	6.1
Calf/Shin	1	3.0
Shoulder	1	3.0
Total	33	100.0

4.5.2 Injury cause

4.5.2.1 Past injuries

The majority of the participants (85.0%) were injured from playing squash. A smaller percentage of participants attributed their injuries to either a lack of warm-up before playing or a non-squash related activity (5.0% and 10.0% respectively) (Table 4.6).

Table 4.6: Cause of injury in past twelve months

		Frequency	Percent
Activity	Squash	68	85.0
	No warm-up	4	5.0
	Gym	2	2.5
	Old age	2	2.5
	Running	2	2.5
	Surfing	1	1.3
	Unsure	1	1.3
	Total	80	100.0

4.5.2.2 Current injuries

Squash was the main cause of current injuries (78.8%). A smaller percentage of participants attributed their injury to either a fall or old age (6.1% each) (Table 4.7).

Table 4.7: Cause of current injuries

		Frequency	Percent
Activity	Squash	26	78.8
	Old age	2	6.1
	Fall	2	6.1
	No warm-up	1	3.0
	Gym	1	3.0
	Unsure	1	3.0
	Total	33	100.0

When considering the cause of past injuries, the majority (85.0%) of participants were injured from playing squash itself. A smaller percentage were injured from either a lack of warm-up before playing squash or a non-squash related activity (5.0% and 10.0% respectively) (Table 4.6). When considering the cause of current injuries, the majority (78.8%), again, were because of squash itself. The smaller percentage differs from past injuries; participants attributed their injury to either a fall or old age (6.1% each) (Table 4.7).

4.5.3 Injury treatment

4.5.3.1 Past injuries

Although a quarter of the injured participants (26.0%) chose not to seek treatment for their injuries, the others went to a variety of medical practitioners. Physiotherapists were the most popular medical practitioners (37.5%), followed by chiropractors and orthopaedic surgeons (17.5% respectively), general practitioners (10.0%) and biokineticists (8.6%) (Figure 4.3).

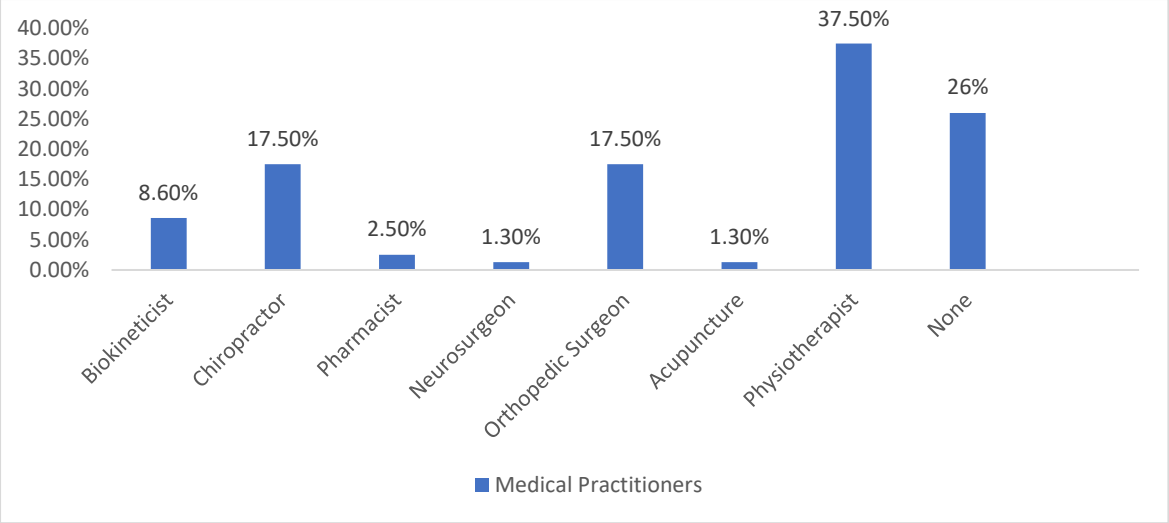

Figure 4.3: Medical practitioners consulted for injuries in the past 12 months

4.5.3.2 Current injuries

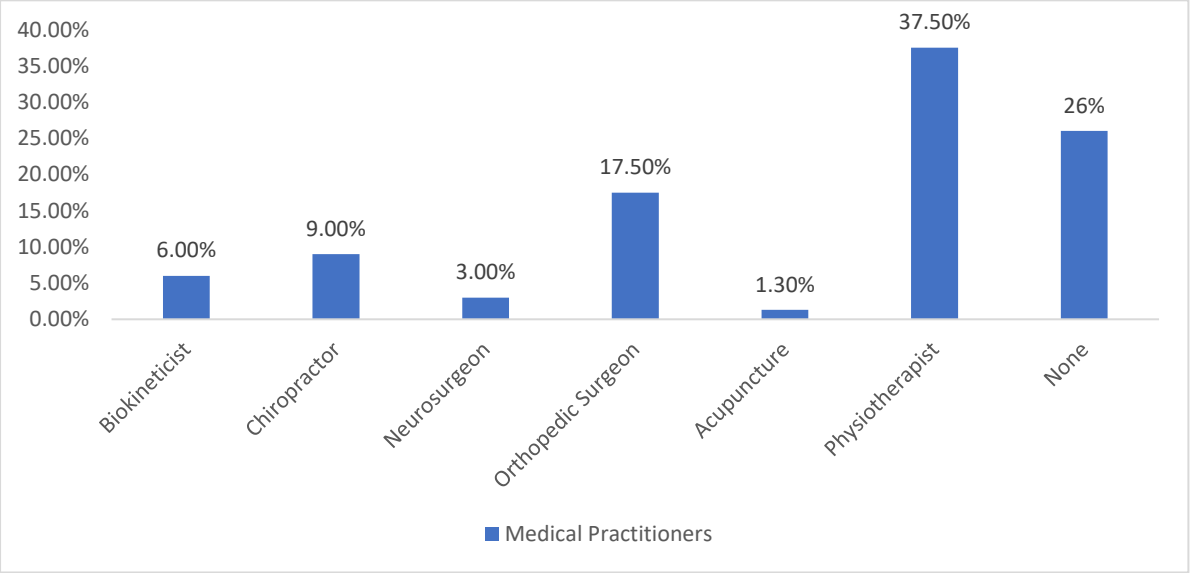

Figure 4.4: Medical practitioners consulted for current injuries

Almost half (48.0%) of the participants who were suffering from current injuries chose not to seek medical attention. The most commonly consulted practitioners were physiotherapists (24.0%), orthopaedic surgeons (21.0%), chiropractors and general practitioners (9.0% respectively) (Figure 4.4).

4.6 OBJECTIVE THREE

The third objective of this study was to identify specific risk factors of squash players in the eThekwini Municipality. Three main characteristics were investigated:

- Participant demographics, which included the participant's age; gender; race; hand dominance; medical conditions; smoking; and alcohol consumption.
- Participant activity factors, which included years of participation; current division; weekly hours of squash training; and weekly exercise/sporting activities.
- Equipment factors, which included equipment information such as; racket and ball descriptions.

4.6.1 Patient demographics

4.6.1.1 Gender and ethnicity

The majority (83.7%) of the participants were male with females making up the other 16.3%. The majority (83.7%) of the participants were white, followed by Indian (14.0%) and lastly African (2.3%) (Table 4.8).

Table 4.8: Gender and ethnicity

		Frequency	Percent
Gender	Male	108	83.7
	Female	21	16.3
Ethnicity	African	3	2.3
	Indian	18	14.0
	White	108	83.7

4.6.1.2 Height, weight, BMI and age

The weight and height of each participant was used to calculate the BMI by taking their weight in kilograms (kg) and dividing it by their height in metres squared (m^2). The tallest participant was 1.94 m; the shortest was 1.41 m (mean 1.75 m). The participants' weight ranged from 46 kg to 120 kg, making the mean weight 83.3 kg. Their BMI scores ranged from 14.68 to 52.81 (mean 27.06). The youngest participant was 14 years old and the oldest was 65 years old. The average age of all the participants was 41.65 years (Table 4.9).

Table 4.9: Height, weight, BMI and age

	N	Minimum	Maximum	Mean
Height	129	1.41	1.94	1.75
Weight	129	46	120	83.31
BMI	129	14.68	52.81	27.05
Age	129	14	65	41.65

4.6.1.3 Handedness

The results showed that 89.9% of the participants were right handed and 10.1% were left handed (Figure 4.5).

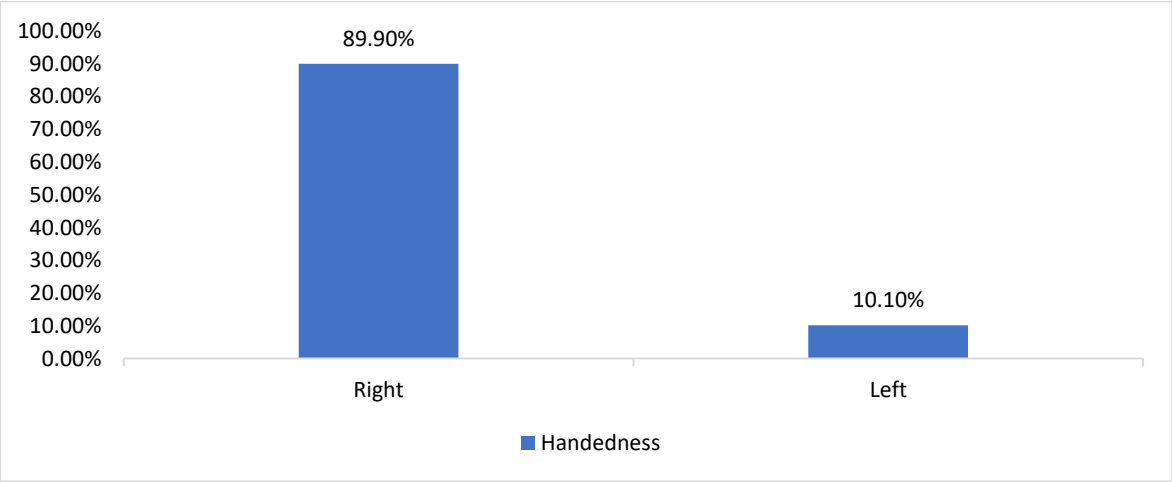

Figure 4.5: Handedness

4.6.1.4 Medical conditions

The participants were asked to report on any diagnosed medical condition(s) that they were currently suffering from. The majority (81.4%) of the participants were not diagnosed with any medical conditions. A small percentage suffered from the following: asthma (7.0%), “other” (4.8%) and high blood pressure (4.7%). Conditions noted under “other” were epilepsy, rheumatoid arthritis, high cholesterol, dust allergy, gout, and diverticulitis (Figure 4.6).

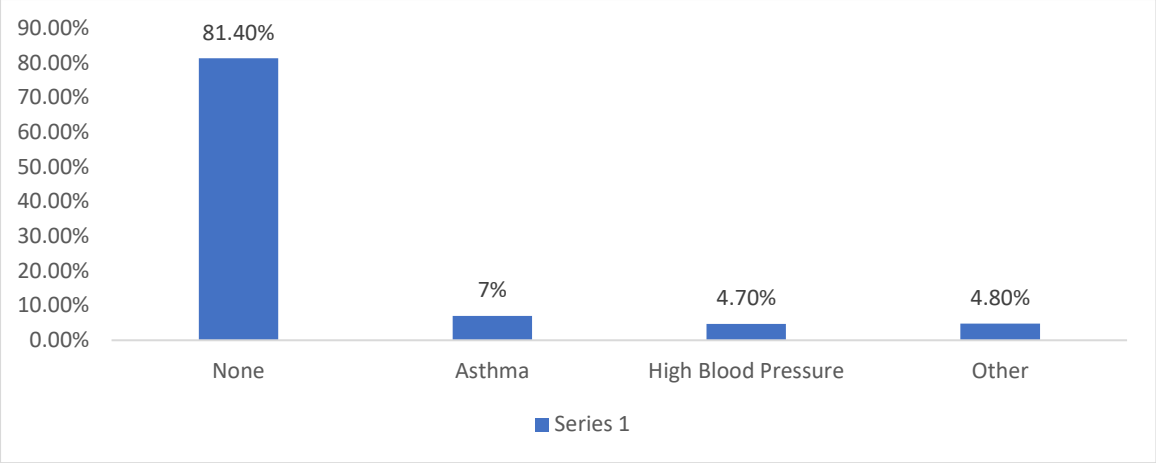

Figure 4.6: Medical conditions

4.6.1.5 Alcohol consumption

Over three-quarters (78.3%) of the participants consumed alcohol. The minimum number of units of alcohol consumed a week was zero and the maximum was 55 (Table 4.10).

Table 4.10: Alcohol consumption

	N	Minimum	Maximum	Mean
Units of alcohol a week	129	0	55	8.81

4.6.1.6 Cigarette smoking

As shown in Figure 4.7, 12.4% of the population were current smokers, 71.3% did not smoke and 16.3% were ex-smokers.

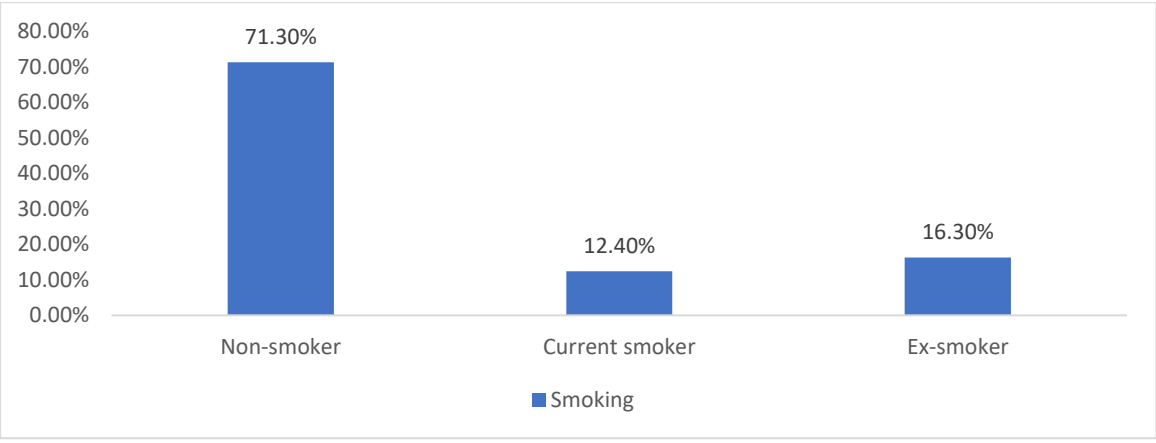

Figure 4.7: Cigarette smoking

4.6.2 Participant activity factors

4.6.2.1 Squash experience and hours of training per week

The mean number of years of squash experience is 24.44 years, with the minimum experience being two years and the maximum being 46 years. The minimum number of hours of squash played a week was two and the maximum number of hours was 26 (mean = 5.43 hours per week) (Table 4.11).

Table 4.11: Duration of squash career and hours played weekly

	N	Minimum	Maximum	Mean
Playing years	129	2	46	24.44
Hours a week	129	2	26	5.43

4.6.2.2 Current division and highest level of competition

Just over a quarter (27.1%) of the participants were from the first division, 32.6% were from the second division and the third division made up the remaining 40.3% (Figure 4.8). Almost a quarter (23.3%) of the participants represented their country or had become professional at some stage of their squash career. Half (50.4%) represented their province in inter-provincial tournaments; 26.4% had competed at a club league level (Figure 4.8 and Figure 4.9).

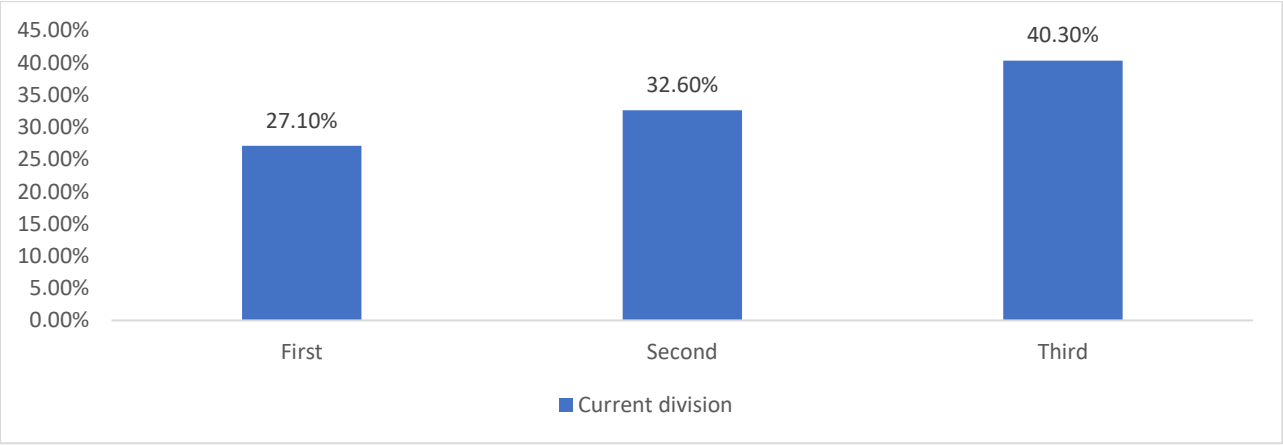

Figure 4.8: Current division

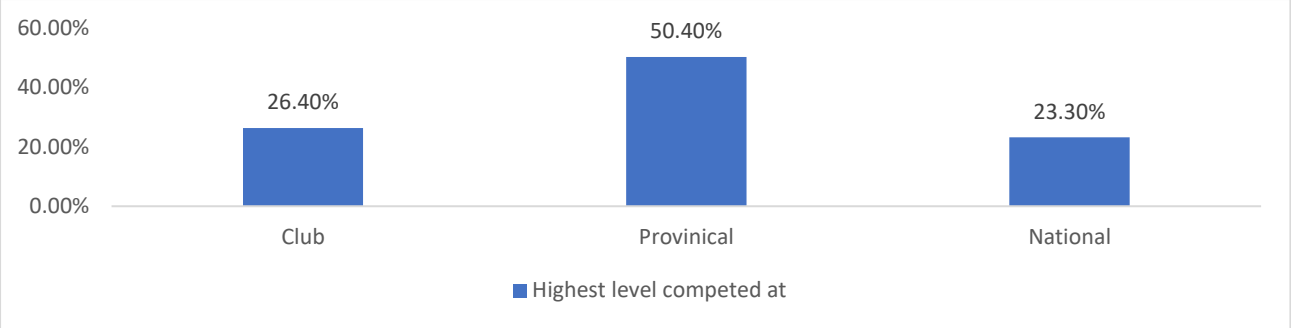

Figure 4.9: Highest level competed at

4.6.2.3 Other sporting activities

Weight training (31.0%) was the most popular activity followed by gym/cardiovascular (27.9%), running (27.1%), cycling (20.2%). “Other” was chosen by 12.5% of the participants. Responses for “other” activities were surfing, soccer, golf, swimming, Pilates and ballroom dancing (Figure 4.10).

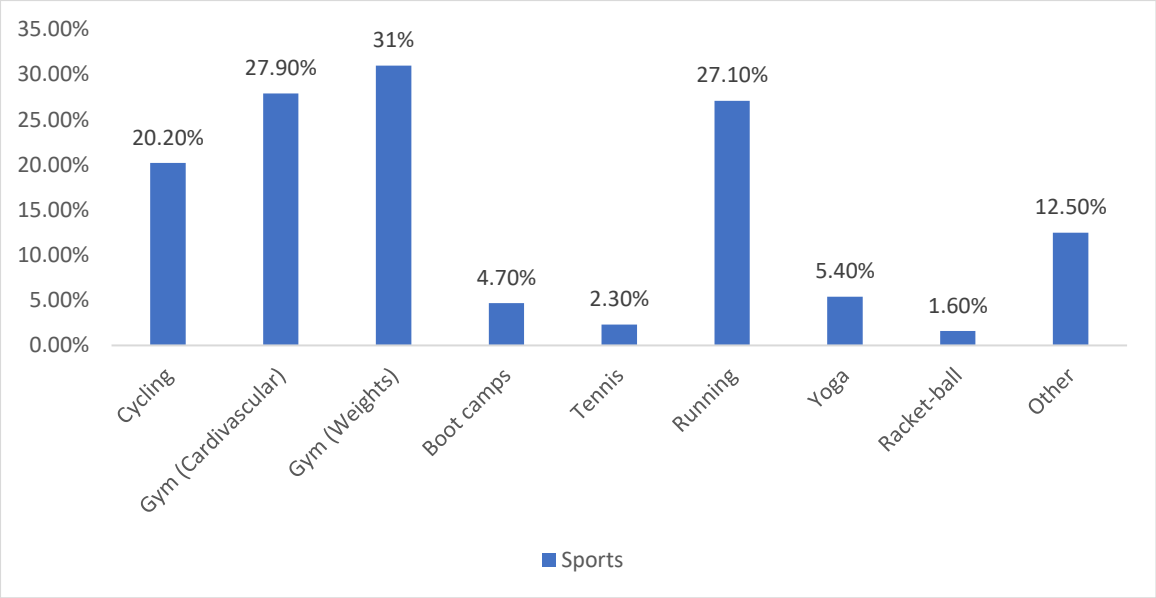

Figure 4.10: Sporting activities

4.6.3 Equipment factors

4.6.3.1 Racket head size

The most popular head size was the smaller 470 cm^2 with 55.0% of the participants using it; 45.0% used the 500 cm^2 head size (Figure 4.11).

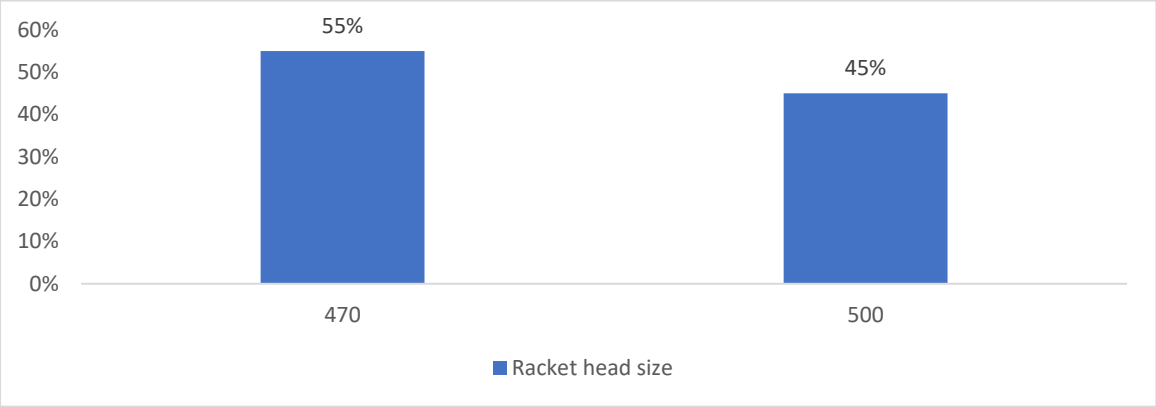

Figure 4.11: Racket head size

4.6.3.2 Racket weight

Half (51.9%) the participants played with the 120 g racket, 37.2% preferred to play with the heavier 140 g racket and the other 10.9% played with the lighter 110 g racket (Figure 4.12).

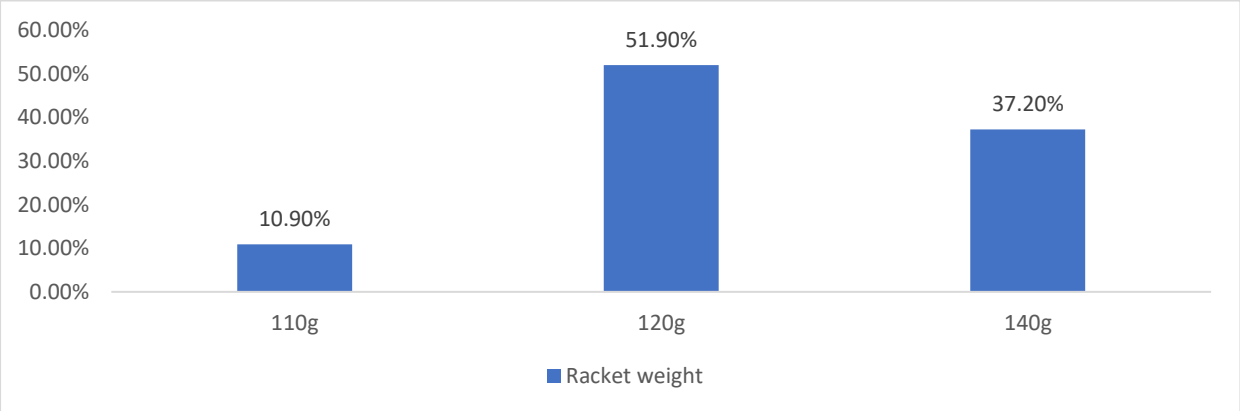

Figure 4.12: Racket weight

4.6.3.3 Racket head weight

Half of the participants (51.9%) used a racket that was equal, 27.9% used a racket that was head-heavy, 18.6% preferred the head-light racket and 1.6% were unsure what their racket was (Figure 4.13).

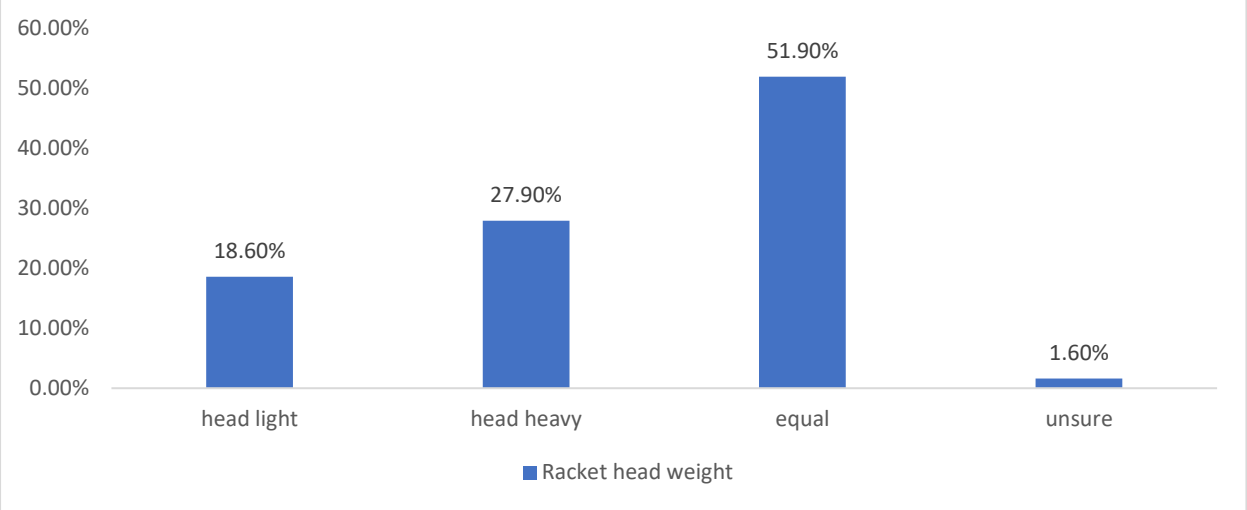

Figure 4.13: Racket head weight

4.6.3.4 Racket string tension

The most popular string tension was 26 lbs to 28 lbs (79.8%), followed by < 26 lbs (13.2%) and the remaining 7.0% of the participants used > 28 lbs (Figure 4.14).

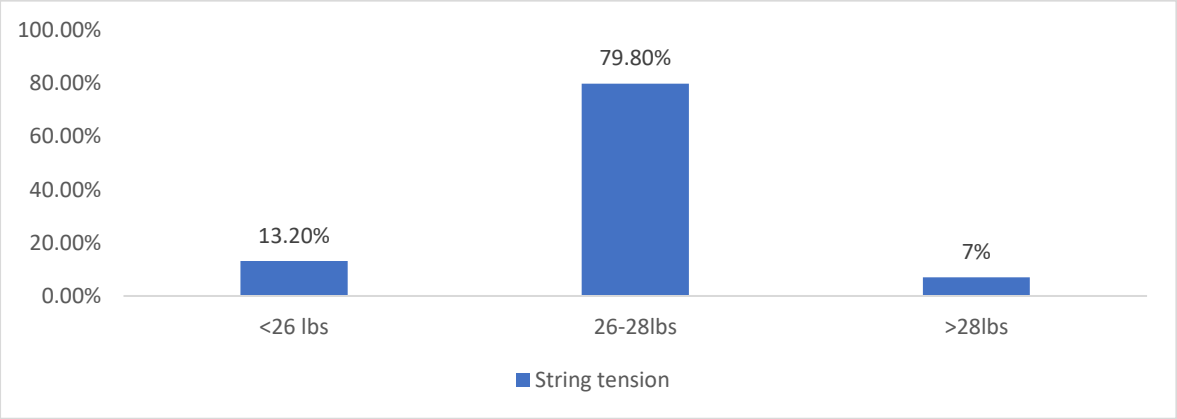

Figure 4.14: Racket string tension

4.6.3.5 Vibration dampener

The majority (86.0%) of the participants did not have a vibration dampener, whilst the reminder of the participants (14.0%) used a vibration dampener that was either built into their rackets or installed on their strings (Figure 4.15).

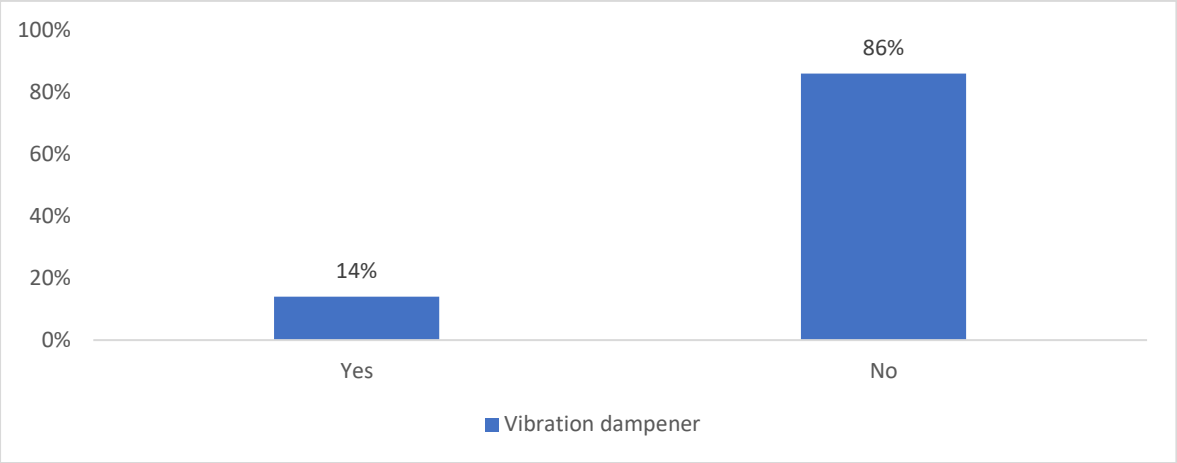

Figure 4.15: Vibration dampener

4.6.3.6 Racket grip/hand

Figure 4.13 highlights that almost the entire population (98.4%) used a grip that was the correct size for their hand. A small portion of participants (1.6%) used a grip that was either oversized or undersized in relation to their hand and grip (Figure 4.16).

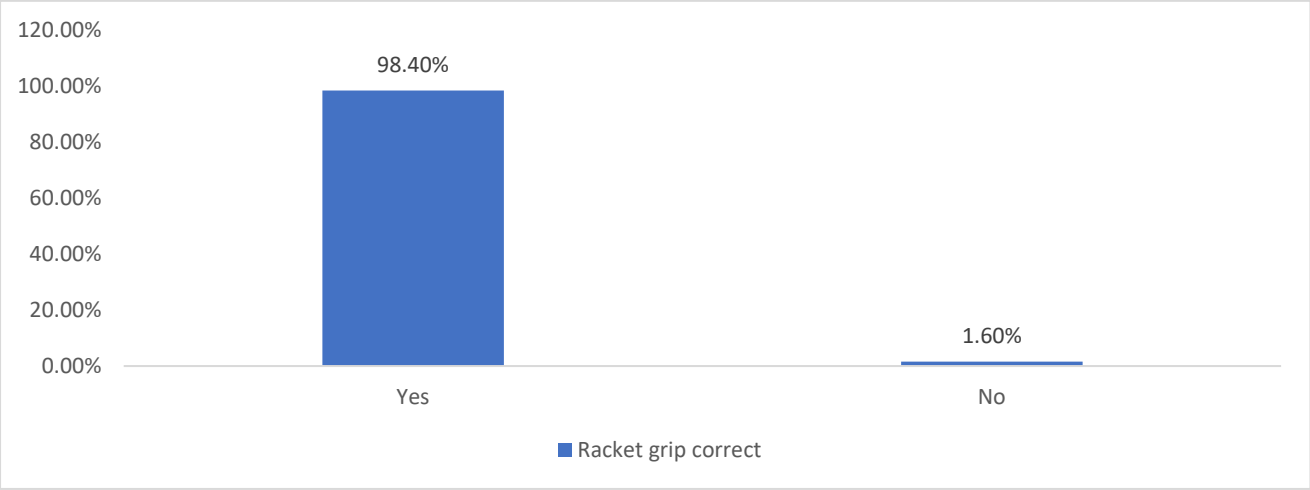

Figure 4.16: Racket grip correct

4.6.3.7 Over-grip

More than half (56.6%) of the participants did not use an over-grip on their rackets (Figure 4.17).

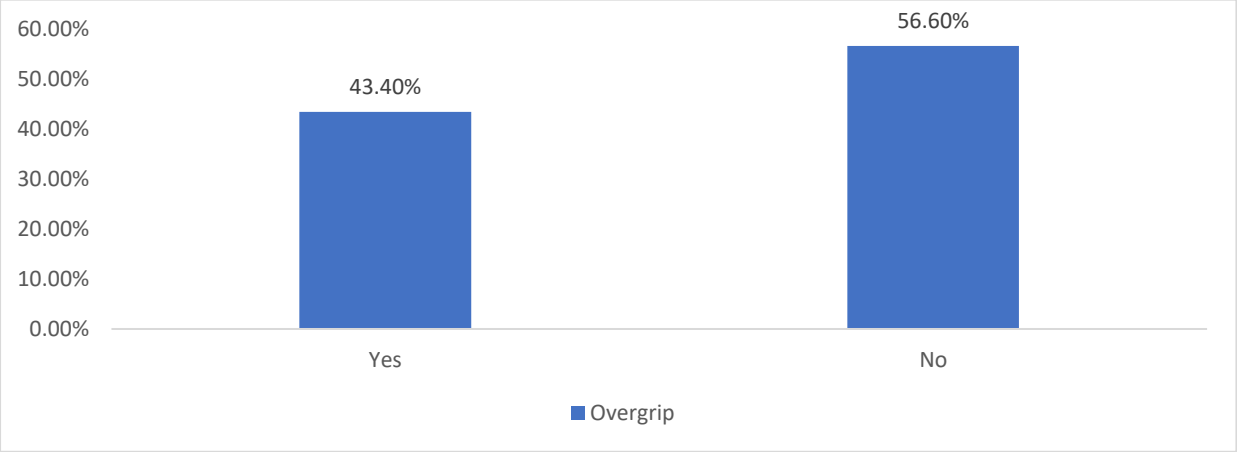

Figure 4.17: Over-grip

4.6.3.8 Racket grip position

Two-thirds of the participants (67.4%) preferred to hold their racket in the middle; the other participants (32.6%) held their racket at the bottom (Table 4.18).

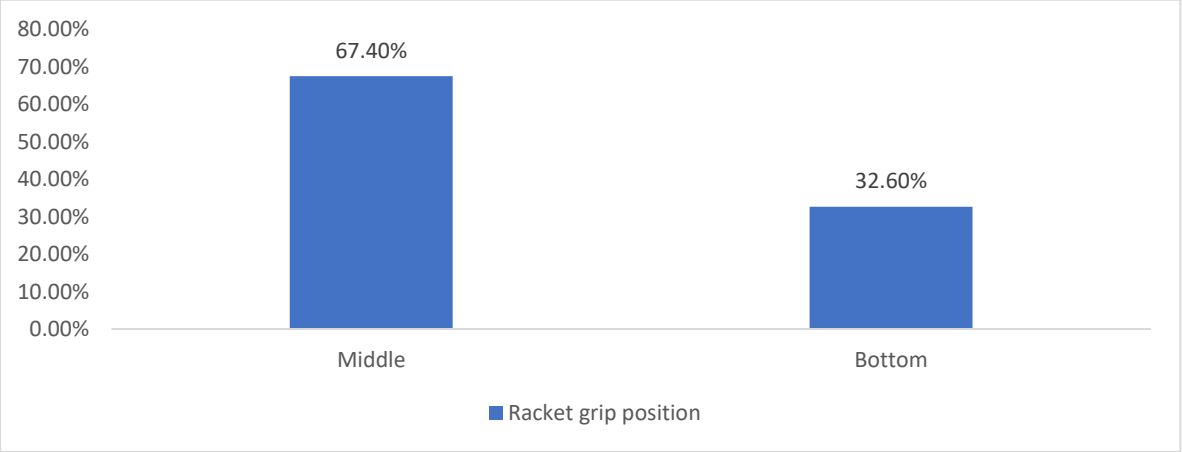

Figure 4.18: Racket grip position

4.6.3.9 Racket composition

Almost a third of the participants (64.3%) were not sure what their rackets were made from. One-fifth of participants (22.5%) stated that they used a graphite composite, a

small percentage used carbon fibre(11.6%) and very few used tungsten composite and titanium (0.8% for each) (Figure 4.19).

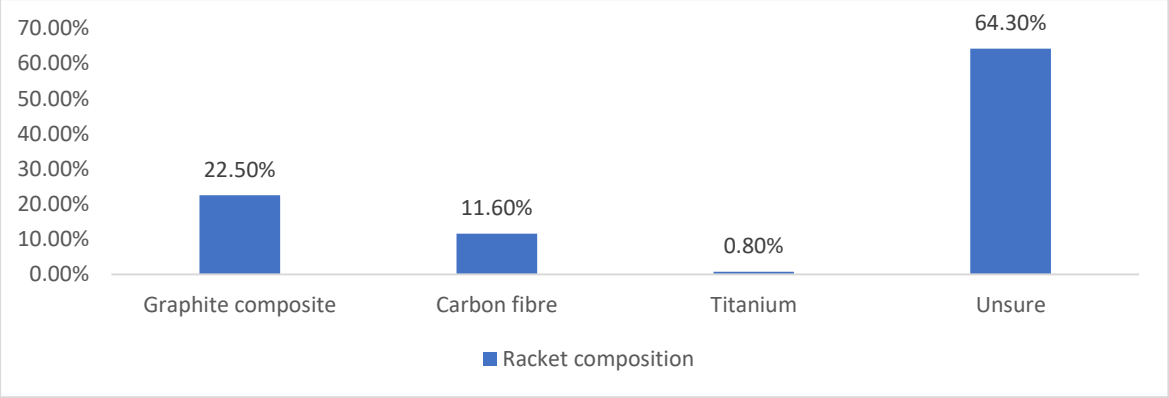

Figure 4.19: Racket composition

4.6.3.10 String composition

Almost the entire population (94.6%) were not sure about the composition of their racket strings. A small percentage reported using fibre and polyamide multifilament (3.9% and 1.6% respectively) (Figure 4.20).

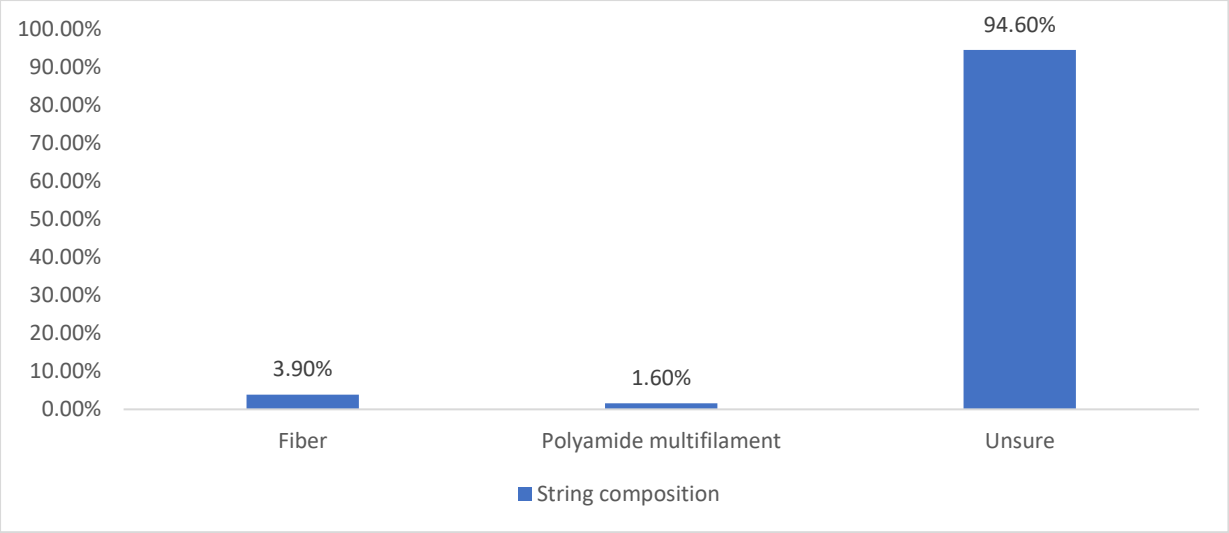

Figure 4.20: String composition

4.6.3.11 Racket repairs

The majority of participants (87.3%) had never had their rackets repaired (Figure 4.21).

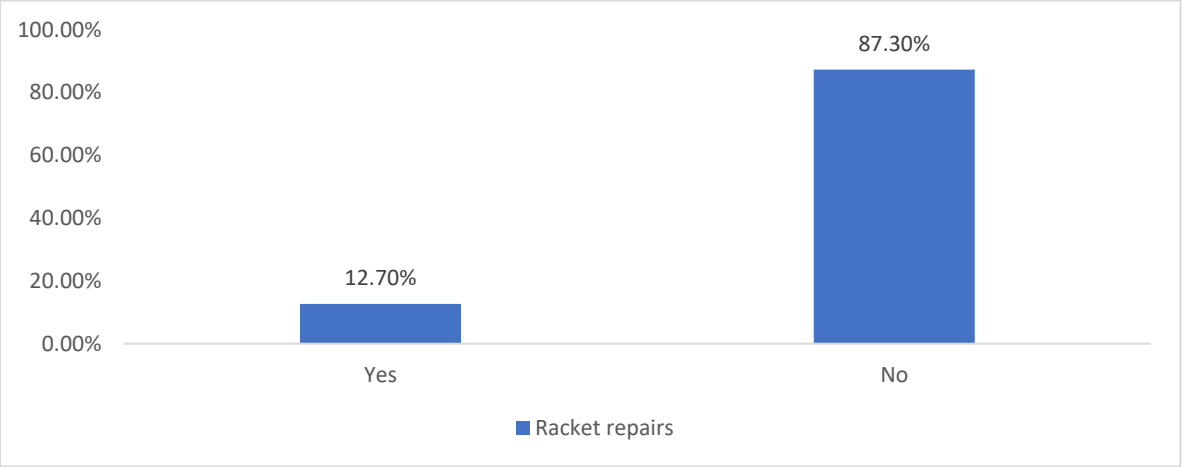

Figure 4.21: Racket repairs

4.6.3.12 Footwear

All of the participants (100.0%) reporting playing squash in squash shoes (Figure 4.22).

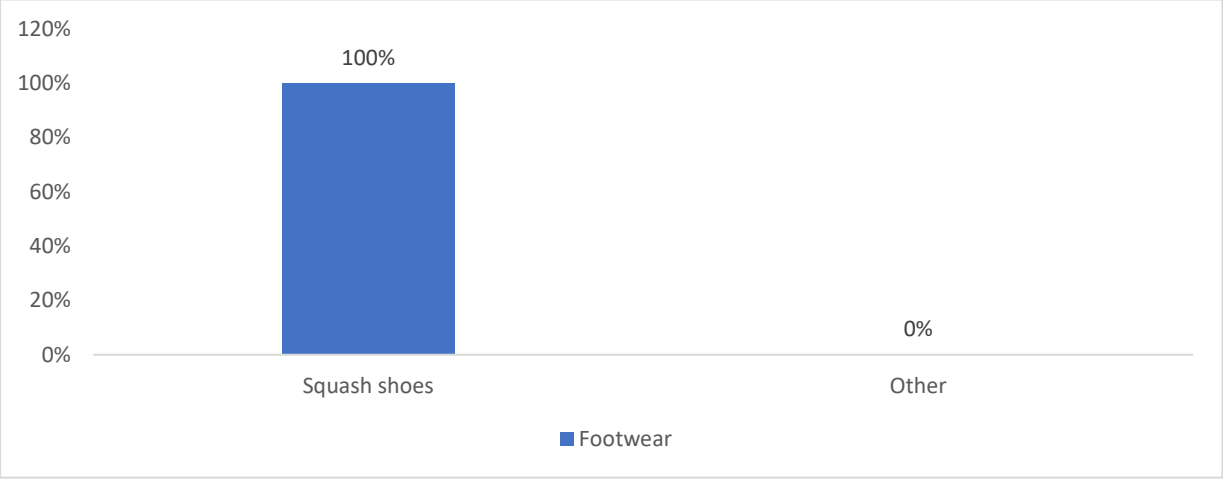

Figure 4.22: Footwear

4.6.3.13 Ball type

The entire population (100.0%) said that they practised and competed with a yellow double dot ball (Figure 4:23).

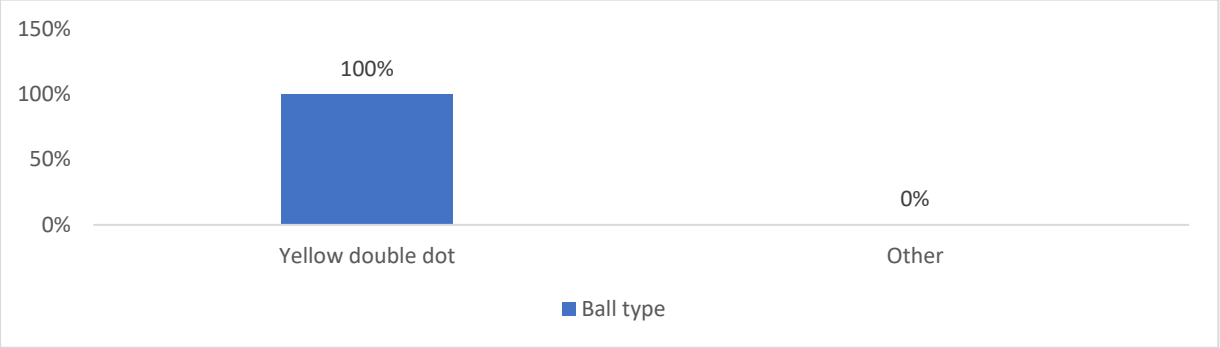

Figure 4.23: Ball type

4.7 OBJECTIVE FOUR

Objective four was to evaluate the impact of injury on training and performance. Impact was evaluated in two ways: time taken off from squash as result of a squash injury and retirement from squash as result of a squash injury.

4.7.1.1 Past injuries – time taken off and retirement

During the last 12 months prior to the study, two-thirds (66.3%) of the injured participants were unable to participate in any squash-related activity due to their injury (Table 4.12). Out of the injured participants that were unable to play squash, the maximum number of weeks that were taken off was 52 and the minimum was a single week (mean number of weeks = 7.98) (Table 4.13). Out of the 80 participants (62.0%) that had sustained injuries, 22 (27.5%) of them were forced to retire from a league match (Table 4.14).

Table 4.12: Number of participants unable to practice due to injury in past 12 months

	Frequency	Percent
No	27	43.7
Yes	53	66.3
Total	80	100.0

Table 4.13: Duration of time off in the past 12 months

	N	Minimum	Maximum	Mean
Time off squash	53	1	52	7.98

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

	Frequency	Percent
No	58	72.5
Yes	22	27.5
Total	80	100.0

4.7.1.2 Current injuries – time taken off and retirement

Just under half of participants with current injuries had to take time off and were unable to play squash for a period of time (42.4%) (Table 4.15). The maximum number of weeks taken off to recover was 52 and the least was a single week (mean number of weeks unable to play squash = 7.57) (Table 4.16). Thirty-three participants (25.6%) were suffering from injuries at the time of the research; of these, 5 (15.6%) stated that they had retired from a league match because their pain was too intense (Table 4.17).

Table 4.15: Number of participants unable to practice due to current injury

	Frequency	Percent
No	19	57.6
Yes	14	42.4
Total	33	100.0

Table 4.16: Duration of time taken off due to current injuries

	N	Minimum	Maximum	Mean
Time off squash	14	1	52	7.57

Table 4.17: Retirement from a match due to current injury

	Frequency	Percent
No	27	84.4
Yes	5	15.6
Total	32	100.0

4.8 OBJECTIVE FIVE

Objective five was to describe the relationship between prevalence and selected risk factors.

4.8.1 Period prevalence (12 months ago)

The following risk factors were statistically analysed against injures that had occurred within the last 12-month period (Appendix A, Question 30).

Table 4.18: Prevalence and selected risk factors

Intrinsic Risk Factors	*p*-value
Age	0.315
Gender	0.320
Race	0.390
Height	0.870
Weight	0.487
BMI	0.913
Handedness	0.970
Medical conditions	0.638
Years of squash participation	0.594
Squash division	0.690
Highest level of competition	0.779
Extrinsic Risk Factors	
Smoking	0.090
Alcohol consumption	0.873
Hours of squash per week	0.459
Racket head size	0.279
Racket weight	0.693
Racket head weight	0.142
String tension	0.030
Vibration dampener	0.137
Racket grip	0.724
Over-grip	0.318
Grip position	0.685
Racket composition	0.371
String composition	0.189
Racket repair	0.991

4.8.2 LOGISTIC REGRESSION MODEL

A logistic regression model was used to identify the odds for sustaining an injury. The binary dependent variable was whether the player had sustained an injury in the past

12 months or not, and this variable is coded 0 and 1. The variables which are significant at a 95.0% level are the units of alcohol (p = 0.03), and whether a player did gym with weights or not (p = 0.003). The output for the logistic regression model is given in Table 4.19.

Table 4.19: Logistical regression table

Variable		B	SE	Wald	df	p-value	OR = Exp(B)
	Alcohol units	.051	.024	4.682	1	.030	1.052
	Gym (Weights)	-1.188	.405	8.592	1	.003	.305
	Constant	.476	.289	2.726	1	.099	1.610

The odds ratios are interpreted as follows: The odds of an injury for a participant not doing gym with weights is 3.3 (1/0.305) times the odds of injury for a participant who does gym with weights. This means that it is more likely for a participant not doing gym with weights to sustain an injury than for a participant who is doing gym with weights. With regards to the alcohol variable, for every increase in five units of alcohol consumption the odds of acquiring an injury increase by 29%. This is because the odds ratio for a five-unit increase results in an odds ratio equal to exp (5 x 0.051) = 1.29). Thus, an increased alcohol consumption results in a higher chance of sustaining an injury.

4.8.3 Point prevalence

Statistically meaningful results could not be obtained since there were not enough current injuries at the time of the study.

CHAPTER 5: DISCUSSION

This chapter discusses the results of the statistical analysis that were presented in Chapter 4.

5.1 OBJECTIVE ONE

Objective One was to determine the prevalence (point and previous [past 12 months]) of musculoskeletal injuries in league squash players in the eThekwini Municipality.

5.1.1 Prevalence of squash injuries (point and period [past 12 months])

Injuries in the past 12 months were defined as injuries that participants reported to have suffered in the 12 months prior to the time of data collection; current injuries were defined as injuries that the participants were suffering from at the time of data collection. Participants were allowed to list more than one injury and were asked specific questions relating to such injuries. The period prevalence of injury experienced by the participants was 62% (Table 4.1); the point prevalence of injuries that they were currently experiencing was 25.6% (Table 4.2). A total of 114 injuries were reported by the 80 participants that reported an injury in the past twelve months. A total of 36 injuries were reported by the 33 participants that reported a current injury, of those 33 only 11 were new current injuries, the other 22 were unresolved injuries.

These results are similar to other studies that have been done overseas (Sankaravel *et al.* 2017; Okhovatian and Ezatolahi 2009; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Clavisi and Finch 1999b) which state that injuries in squash are very high. Squash has been ranked as the 13th highest sport or recreation activity leading to presentation for treatment at a sports-medicine clinic and the 12th highest for emergency-department presentations (Eime, Zazzryn and Finch 2003).

The results of this study are in contrast with other studies (Meyer *et al.* 2007; Finch and Eime 2001; Macfarlane and Shanks 1998) who reported that there was no increased risk of injury in squash players when compared to a normal population. The reason for the contrast in studies could be due to the fact that Meyer *et al.* (2007) only

looked at injuries over a four-week period, Macfarlane and Shanks (1998) only looked at back injuries, and Finch and Eime (2001) reported on hospital records of severe injuries.

More specifically when comparing the results of this study to a South African study (Meyer *et al.* 2007) we see some contradictory conclusions. Despite both studies being of a similar demographic, Meyer *et al.* (2007) noted a smaller period prevalence in comparison to this study (32.0% versus 62.0%), however, the period prevalence time-frame in their study was much shorter (4 weeks). Both studies report a similar point prevalence (29.0% versus 25.6%). It is important to note that Meyer *et al.* (2007) looked only at high-school aged squash players, whereas this study looked at players between the ages of 14 and 65. Therefore, there is a higher period prevalence in this study as the older players have had more squash exposure.

5.2 OBJECTIVE TWO

The second objective of this study was to describe the injury profile of squash players in the eThekwini Municipality. The factors linked directly to the injury include: the current and past injury/ies, location/s, severity, cause, duration, nature of onset, disability and the treatment received.

5.2.1 Injury location

For past injuries experienced in the last 12 months, the area must commonly injured was the foot and ankle (22.5%), followed by the knee (15.0%), thigh (13.8%) and lastly the elbow (13.8%) (Table 4.4). Collectively the lower limb was the most frequently injured part of the body (67.6%), followed by the upper limb (21.4%). The trunk and back were the least injured areas (11.3%) (Figure 4.21).

For current injuries, injuries to the knee (30.3%) were the most prevalent, followed by the elbow (18.2%) and foot and ankle (12.1%) (Table 4.5). The lower limb (60.6%) proved to be the most injured region of the body, followed by the upper limb (21.2%) and the back and trunk (18.2%). Interestingly the results of the most prevalent injuries (lower limb, upper limb, and back and trunk) were found to be the similar in both past and current injuries. Clearly, a trend can be identified that indicates the lower limb as being at most risk of injury.

These findings are in line with those of other studies that show that injuries occurring in the lower limb are the most common (Okhovatian and Ezatolahi 2009; Meyer *et al.* 2007; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002); that reported approximately two-thirds of all injuries occurred in the lower limb alone.

When looking at the specific past injuries in the lower limb, the foot and ankle and knee where the most commonly injured area, as opposed to the majority of injuries occurring in the knee for current injuries. Reasoning behind the lower limb being at increased risk of injury is: a lack of lower leg fitness, poor agility, improper positional play, poor footwear and floor conditions, sudden changes in direction, and twisting of the knees due to the small court and speed of the ball (Okhovatian and Ezatolahi 2009; Talabi *et al.* 2002). In this study these extrinsic factors will be discussed in section 5.3.3.

With regards to the upper limb, the area most commonly injured was the elbow in both past and current injuries. These results are expected since the squash player uses his/her upper limb with every hit of the ball, and there is a significant amount of force and torque load at the elbow joint during the serve motion (Okhovatian and Ezatolahi 2009). The serve is continuously repeated and therefore has the potential to produce an overuse injury (Meyer *et al.* 2007; Elliott *et al.* 2003).

Squash is a sport which requires multidirectional movements (see biomechanics in Section 2.2). These sharp, rapid movements place pressure on the bodies joints, especially the hinge joints (knee and elbow). Since hinge joints move in a uniaxial direction (Standring, 2016), the multiaxial demands of the sport cause repetitive strain injuries in these joints which are less able to accommodate the demands of the sport (Hyde and Gengenbach, 2007). These results suggest that repetitive strain / chronic injuries tend to occur in joints / around joints that have limited ability to adapt or compensate for changes as a result of altered or aberrant biomechanics. Therefore, these study results differ from those studies that reported on acute injuries in a hospital setting, or which only reported injuries in a specific body region (Finch and Eime 2001; Macfarlane and Shanks 1998), as these areas will be different from those in which repetitive strain injuries occur.

5.2.2 Injury cause

When considering the cause of past injuries, the majority (85.0%) of participants were injured from playing squash itself. A smaller percentage were injured from either a lack of warm-up before playing squash or a non-squash related activity (5.0% and 10.0% respectively) (Table 4.6). When considering the cause of current injuries, the majority (78.8%), again, were because of squash itself. The smaller percentage differs from past injuries; participants attributed their injury to either a fall or old age (6.1% each) (Table 4.7).

Although other studies have also made comment on the significance of a warm-up as a component of squash training and/or competing and its relationship to injury (Meyer *et al.* 2007; Macfarlane and Shanks 1998; Chard and Lachmann 1987); the majority of these authors suggest that the lack of a warm up is reported as a significantly higher cause of injury. For example, Meyer *et al.* (2007) declared that 43.0% of the players who did not warm up were injured compared with 27.0% of players who performed a warm-up prior to playing squash. However, with Meyer *et al.* (2007) unlike this study, the majority of their participants also participated or had injuries as a result of other sports.

Meyer *et al.* (2007) administered their questionnaires during the first week of May 2006, which was four weeks into the squash season. This study's questionnaire was administered at the beginning of October, two weeks before the end of the squash season. A reason why a lack of warm up was not a significant cause of injury in this study is that by the end of the season the majority of the players are usually in a good routine which includes warm up (particularly if they have developed discomfort / preinjury muscle tightness). In addition, the mean age of this study was 41.65 years old (Table 4.9), whereas the mean age of the study population for Meyer *et al.* (2007) was 15. The more mature age group are more likely to stretch before play (as a result of need to develop injury prevention strategies or to compensate for prior injuries that they do not want to have recur) (Morris 2006). Future injury profile studies should therefore look at the differences in injuries between questionnaires handed out at the beginning of a season versus the end of a season.

5.2.2.1 Injury treatment

Past injury treatment practitioners are ranked as follows: physiotherapists (37.5%), chiropractors (17.5%), orthopedic surgeons (17.5%), general practitioners (10.0%) and biokineticists (8.6%). A quarter of the injured participants (26.0%) did not seek any medical treatment.

Current injury treatment practitioners are ranked as follows: physiotherapists (24.0%), orthopedic surgeons (21.0%), chiropractors (9.0%) and general practitioners (9.0%). Almost half of the injured participants (48.0%) did not seek any medical treatment.

A large portion of the injured population did not seek any medical treatment. These results are stressed by other studies who report that players often do not seek medical treatment but instead use various home treatment protocols (such as the application of ice packs and rest) (Meyer *et al.* 2007; Macfarlane and Shanks 1998).

A reason why orthopedic surgeons were consulted more in current injuries compared to past injuries in this study; is that of the 33 current injuries 23 of them were unresolved past injuries. These injuries would require more serious attention, as the injury was not resolving. Thus, if the participants were informed and educated on the benefits of early medical intervention by an appropriate medical practitioner, their recovery time would be much faster, allowing them to get back to their sport sooner (Hyde and Gengenbach, 2007).

5.3 OBJECTIVE THREE

The third objective of this study was to identify specific risk factors of squash players in the eThekwini Municipality. Three main characteristics were investigated:

- Participant demographics, which included the participant's age; gender; race; hand dominance; medical conditions; smoking; and alcohol consumption.
- Participant activity factors, which included years of participation; current division; weekly hours of squash training; and weekly exercise/sporting activities.
- Equipment factors, which included equipment information such as; racket and ball descriptions.

5.3.1 Patient demographics

5.3.1.1 Gender, age and ethnicity

The majority of the study population were male (n = 108; 83.7%), while the remaining 16.3% (n = 21) were female (Table 4.8). Pearson's Chi-squared did not find a statistically significant association between gender and injury (p = 0.32) (Table 4.18). However, the spread of the data was highly unequal with the male population over five times the size of the female population (n = 108 versus n = 21). Therefore, meaningful conclusions cannot be deduced. Other studies also noted the challenge of determining which gender is more at risk due the split of the two being highly male dominated (Okhovatian and Ezatolahi 2009; Meyer et al. 2007; Eime *et al.* 2005; Eime, Zazzryn and Finch 2003; Talabi *et al.* 2002; Macfarlane and Shanks 1998; Chard and Lachmann, 1987). One body of thought believes the male gender to be at greater risk due to their competitive nature, aggressive playing technique using higher forces during squash (Okhovatian and Ezatolahi 2009; Meyer et al. 2007; Elliott *et al.* 2003; Macfarlane and Shanks 1998; Chard and Lachmann, 1987). A second body of thought believes that neither is at greater risk but instead each gender has their own types of injuries that they generally suffer from. Females generally have more injuries from weakness in racket control; males generally have more injuries from weakness in technique and over-zealous character (Okhovatian and Ezatolahi 2009; Chard *et al*. 2007).

The mean age of the participants was 41.7 years old, with the youngest player being 14 years of age and the oldest 65 years of age (Table 4.9). Pearson's Chi-squared tests did not find statistical significance between age and injury (p = 0.32) (Table 4.18); however, on examination of the frequency table demonstrates that the majority of injured participants were between the ages of 36 to 57 years of age. The literature review suggested that those at the extremes of age (i.e. very young and very old players) would be at the greatest risk of injury. Younger players have higher squash training intensity and frequency and are vulnerable to microtrauma as they are musculoskeletal system is immature (Kondrič et al. 2011; Cuff, Loud and O'Riordan 2010; Eime, Zazzryn and Finch 2003; Bylak and Hutchinson 1998; Gerrard 1993). Older players have a higher rate of injury based on having a longer exposure to squash

as well as there being a decline in muscle and tendon functions as one ages (Benporath 2016; Eime, Zazzryn and Finch 2003; Silva *et al.* 2003; Parsons *et al.* 2007; Chard and Lachman 1987).

The largest ethnic group in this study was white (n = 108; 83.7%), followed by Indian (n = 18; 14%) and lastly African (n = 3; 2.3%) (Table 4.8). Pearson's Chi-squared did not find a statistically significant association between ethnicity and injury (p = 0.39) (Table 4.18). The frequency tables showed that the white ethnic group suffers from more injuries than the other ethnic groups in this study. However, due to the lack of representation from other groups, this result cannot be conclusive. Not a single squash study to our knowledge has considered ethnicity as a risk factor in their studies, therefore, ours is the first to investigate this.

5.3.1.2 Height, weight, BMI

The averages for height and weight were 1.75 m and 83.3 kgs respectively (Table 4.9). The weight and height of each participant was used to calculate the BMI by taking their weight in kilograms (kg) and dividing it by their height in metres squared (m^2). The average BMI score was 27.06, which is considered overweight (Center for Disease Control and Prevention 2017). No statistically significant associations were found with height (p = 0.87), weight (p = 0.49), nor BMI (p = 0.91) (Table 4.18). The majority of the participants in this study were found to be obese (according to the BMI classification), however, BMI (and height and weight for that matter) were not found to be statistically significant. The literature also noted that although it would seem logical that increased mass would put further strain on the body, no scientific evidence has established that low body fat levels are a requirement of being a successfully squash player (Ranchordas *et al.* 2013; Macfarlane and Shanks 1998).

5.3.1.3 Hand dominance

The majority of the participants were right-handed (89.9%) (Figure 4.5). Pearson's Chi-squared found no statistical significance between hand dominance and injury (p = 0.97) (Table 4.18). The dominant hand is engaged in more work and therefore can be assumed to be at increased risk of injury than the non-dominant hand (Vad *et al.* 2003);

however, it has been posited that the non-dominant hand is at equal injury risk, but as result of falls and collisions with walls/other players (Talabi *et al.* 2002).

5.3.1.4 Medical conditions

Participants were asked to disclose any diagnosed medical conditions that they were currently suffering from; participants were allowed to list more than one condition if applicable. The majority of the participants (81.4%) reported that they were not suffering from any diagnosed conditions. The small percentage of participants that were currently suffering from diagnosed conditions listed the following: asthma (7.0%), "other" (4.8%) and high blood pressure (4.7%) (Figure 4.6). Conditions noted under "other" were epilepsy, rheumatoid arthritis, high cholesterol, dust allergy, gout, and diverticulitis. None of the medical conditions proved to be statistically significant injury risk factors ($p = 0.64$) (Table 4.18). Future studies should consider larger sample sizes than this study to see if medical conditions have any statistical significance.

5.3.1.5 Alcohol consumption

Over three-quarters (78.3%) of the participants consumed alcohol on a regular basis. Participants that did consume alcohol consumed an average of 8.81 units of alcohol per week (Table 4.10). This amount of consumption is within the normal limits set by the U.S Department of Health and Human Sciences which states that; "for women, low-risk drinking is defined as no more than 3 units on any single day and no more than 7 units per week. For men, it is defined as no more than 4 units on any single day and no more than 14 units per week" (National Institute of Alcohol Abuse and Alcoholism 2018).

Pearson's Chi-squared test (Table 4.18) showed that alcohol consumption did not have a significant relationship to injury ($p = 0.87$), even when considering specific alcohol categories (beer $p = 0.17$; wine $p = 0.54$; spirits $p = 0.29$) (Table 4.18). However, logistic regression proved to identify an association between alcohol unit amount and injury. It revealed that for an increase in five units of alcohol consumption the odds of acquiring an injury increased by 29%. Thus, increased alcohol consumption resulted in a higher chance of sustaining an injury (Table 4.18). This was further substantiated by Benporath (2016) who confirmed that there was an increased

risk of injury in those that consumed spirit alcohol as result of the increase in BAC (blood alcohol concentration). Alcohol causes dilation of blood vessels, which can lead to an unwanted increase in swelling around injured body parts and thus delay the healing process (Maughan and Burke 2008).

5.3.1.6 Cigarette smoking

Only a few of the participants were current smokers (12.4%), ex-smokers made up 16.3% of the population, and the majority (71.3%) of the population had never smoked (Figure 4.7). Pearson's Chi-squared test (Table 4.18) showed that there was no statistical significance between smoking and injury (p = 0.09). On examination of the frequency table, there is a highly unequal split between the 'non-smokers' and 'current smokers', therefore meaningful conclusions cannot be drawn. Smoking has been shown to have an association with musculoskeletal pain (Kaisari *et al.* 2012; Brage and Bjerkedal 1996). Studies such as Benporath's (2016) and Albrecht *et al.*'s *(*1998) have proven this association, whereby participants who smoke/have smoked suffered from more injuries than those who did not smoke. Despite the literature noting the risk of smoking on injury, our study reported that smoking had no statistically significant relationship with injury. Future studies should utilise the pack-years calculation, as this would help to compare between studies (Benporath 2016).

5.3.2 Participant activity factors

5.3.2.1 Squash experience and hours of training per week

On average, a participant spent 5.43 hours per week engaged playing squash (min = 3 hours; max = 26 hours) (Table 4.11). No statistically significant associations were found (p = 0.46 (Table 4.18). It is generally accepted that those who train for a longer duration, and more frequently, are at greater risk of injury (Abrams, Renstrom and Safran 2012; Macfarlane and Shanks 1998). This difference in studies could be due to the fact that our population sample may have had a lower frequency with a higher duration of play, compared to those studies that had both a high frequency and duration. This would need to be researched further.

The minimum years of participation recorded was two and the maximum number of years was 46. On average, a participant had 24.44 years of squash experience (Table

4.11). On examination of the Pearson's Chi-squared table, no relationships existed between years of squash participation and injury (p = 0.60) (Table 4.18). Squash experience has not been statistically investigated in any prior studies to our knowledge, however, it is interesting to note that the average squash experience in this study was higher in comparison to other studies (Okhovatian and Ezatolahi 2009; Eime *et al.* 2005).

5.3.2.2 Current division

Just over a quarter (27.1%) of the participants were from the first division, 32.6% were ranked in the second division and the third division players made up the remaining 40.3% (Figure 4.8). Frequency tables as well as the Pearson's Chi-squared table (Table 4.18) demonstrated an insignificant relationship between the division that the participants were in and injury (p = 0.69).

5.3.2.3 Highest competitive level

Just under a quarter (23.3%) of the participants represented their country or had become professional at some stage of their squash career. Half of the participants (50.4%) had partaken in inter-provincial tournaments, and a quarter (26.4%) had partaken in club league tournaments (Figure 4.9). Statistical analysis did not show a significant relationship between level of competition and injury (p = 0.78) (Table 4.18). The literature does stress that professional players are at greatest risk of injury due to their training experience (i.e. on an exposure basis), intensive training regimen, as well as their mentality to play through an injury without allowing for appropriate rest (Sankaravel *et al.* 2017; Benporath 2016; Abrams, Renstrom and Safran 2012; Kondrič *et al.* 2011; Okhovatian and Ezatolahi 2009; Meyer *et al.* 2007; Clavisi and Finch 1999b; Chard and Lachmann 1987). Overall, it was unexpected for this study not to have any statistically significant associations between injury and level of competition, especially since this study had a large amount of professional squash players as participants. A reason for this may be that more professional players are accompanied by medical support, however this needs to be researched further as we do not have the data in this study to confirm this.

5.3.2.4 Other sporting activities

Other sporting activities that participants engaged in were ranked as follows: weight training (31.0%), gym (cardiovascular) (27.9%), running (27.1%) and cycling (20.2%). “Other” was chosen by 12.5% of the participants. Responses for “other” activities were surfing, soccer, golf, swimming, Pilates and ballroom dancing (Figure 4.10). Logistic regression proved to identify an association between ‘Gym (Weights)’ and injury. It revealed that the odds of an injury for a player not doing gym with weights is 3.3 (1/0.305) times the odds of injury for a player who does gym with weights. This means that it is more likely for a player not doing gym with weights to sustain an injury than for a player who is doing gym with weights. Thus, participation in ‘Gym (Weights)’ resulted in a lower chance of sustaining an injury (Table 4.19). Some sports may have a protective effect on an athlete by allowing for a different skill set and musculature to be developed. This was seen in this study as well as in Benporath’s (2016) study, where the participation in a different sporting activity proved to have reduced the odds of injury formation for the participant.

5.3.3 Equipment factors

5.3.3.1 Racket equipment

Under racket equipment the following was investigated: racket head size and weight, racket weight, racket string tension, vibration dampener, racket grip, over-grip, racket grip position, racket and string composition and racket repairs.

- The most popular head size among the participants (55.0%) was the smaller 470 cm^2, while 45.0% used the 500 cm^2 head size (Figure 4.11). No statistically significant associations were identified (p = 0.28) (Table 4.18).

- Half of the participants (51.9%) used a racket that was equal, 27.9% used a racket that was head-heavy, 18.6% preferred the head-light racket and 1.6% were unsure what their racket head weight was (Figure 4.13). No statistically significant associations were identified (p = 0.69) (Table 4.18).

- Half of the participants (51.9%) played with the 120 g racket, 37.2% preferred to play with the heavier 140 g racket and the other 10.9% played with the lighter

110 g racket (Figure 4.12). No statistically significant associations were identified (p = 0.14) (Table 4.18).

- The most popular string tension was 26 lbs to 28lbs (79.8%), followed by < 26 lbs (13.2%) and the remaining 7.0% of the participants used > 28 lbs (Figure 4.14). A statistically significant association was identified between string tension and injury (p = 0.03) (Table 4.18).

- The majority (86.0%) of the participants did not have a vibration dampener, while the reminder of the participants (14.0%) used a vibration dampener that was either built into their rackets or installed on their strings (Figure 4.15). No statistically significant associations were identified (p = 0.14) (Table 4.18).

- Almost the entire population (98.4%) used a grip that was the correct size for their hand (Figure 4.16). More than half (56.6%) of the participants did not use an over-grip on their rackets (Figure 4.17). No statistically significant associations were identified between grip size and injury (p = 0.72) (Table 4.18), nor was there between over-grip and injury (p = 0.32) (Table 4.18).

- Two-thirds of the participants (67.4%) preferred to hold their racket in the middle; the rest of the participants (32.6%) held their racket at the bottom (Figure 4.18). No statistically significant associations were identified (p = 0.69) (Table 4.18).

- Almost a third of the participants (64.3%) were unsure what their rackets were made from. The rest of the participants used the following: graphite composite (22.5%), carbon fibre (11.6%) and tungsten composite and titanium (0.8% each) (Figure 4.19). No statistically significant associations were identified (p = 0.37) (Table 4.18).

- Almost the entire population (94.6%) were unsure about the composition of their racket strings. A small percentage reported using fibre and polyamide multifilament (3.9% and 1.6% respectively) (Figure 4.20). No statistically significant associations were identified (p = 0.19) (Table 4.18).

- The majority of participants (87.3%) have never had their rackets repaired (Figure 4.21). No statistically significant associations were identified (p = 0.99) (Table 4.18).

The literature has noted that inappropriate racket weight and grip may increase the risk of injury formation (Abrams, Renstrom and Safran 2012; Kondrič *et al.* 2011; Talabi *et al.* 2002). However, this was not found on a tennis study by Benporath (2016). By comparison, this study concluded that only string tension proved to have a statistically significant relationship with injury (p-value 0.03). It was found that the players with medium string tension (26-28lbs) were more prone to injury than those who had soft (<26lbs) or hard (>28lbs) string tensions. This significant relationship may reflect as a type two error, and further research with larger groups would be necessary to confirm the result.

5.3.3.2 Footwear

All of the participants (100.0%) reported playing squash in squash shoes (Figure 4.22). Pearson's chi-squared test could not be run as all the participants fell into a single cell and the test would have been considered invalid, therefore shoes in this study were not a source of injury. This is in contrast to Sinclair *et al.* (2010) affirmed that a lack of appropriate shoe wear might have a direct relationship on injury formation; shoe wear must be stable, durable, have sufficient cushioning and a circular profile to allow for agility (Finch 2006). Ankle sprains are a very common court injury and, therefore, shoe wear is of high importance to protect players from injury (Sinclair *et al.* 2010; Fong *et al.* 2007).

5.3.3.3 Ball equipment

All of the participants (100.0%) reported practising and competing with a yellow double dot ball (Figure 4.23). Pearson's chi-squared test could not be run as all the participants fell into a single cell and the test would have been considered invalid, since the same ball is used by everyone. Ball size is an important consideration with regards to injury. A large ball will have more air resistance making it slower and easier to anticipate hitting it; a small ball will have less air resistance making it faster and more dangerous to try and anticipate its path (Andrew *et al.* 2003).

5.4 OBJECTIVE FOUR

Objective four was to evaluate the impact of injury on training and performance. Impact was evaluated in two ways: time taken off from squash as result of a squash injury and retirement from squash as result of a squash injury.

5.4.1 Past injury (twelve months ago)

Two-thirds (n = 53; 66.3%) of the participants with a previous injury were unable to participate in any squash-related activity due to their injury (Table 4.12). On average, a participant had to take 7.98 weeks off as result of a squash injury; the maximum amount of time taken off was 52 weeks (Table 4.12). Over a quarter (27.5%) of the participants with previous injuries were forced to retire as result of a squash injury (Table 4.14).

5.4.2 Current injury

Over two-fifths of the participants (n = 14; 42.4%) reported current injuries that required time off from squash (Table 4.15). On average, a participant had to take 7.57 weeks off as result of a squash injury; the maximum amount of time taken off was 52 weeks (Table 4.16). Over a sixth (15.6%) of the participants with current injuries were forced to retire as result of a squash injury (Table 4.17).

This study stresses the high impact of squash injuries (current and past), with an average of 7-8 weeks of rest that needed to be taken by participants. Macfarlane and Shanks (1998) attested to this high impact in their study, where just under half of their participants had to have a rest from squash-related activities and a fifth of participants needed to take time off work as result of a squash injury. Moreover, Schneider *et al.* (2006) concurred that majority of sporting injuries resulted in time off from work to allow for the injury to heal. In addition to the above, squash injuries have even been proved serious enough to warrant a hospital admission (Eime, Zazzryn and Finch 2003).

On the whole, it can be confirmed that squash injuries result in high impacts on a player's capability of returning to squash, whether temporary or permanent. It is therefore important to educate the players on the importance of seeking medical

treatment early on, to prevent the injury developing further and to prevent extended loss of game time.

5.5 OBJECTIVE FIVE

Objective five was to describe the relationship between prevalence and selected risk factors. 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. Odd ratios and 95% confidence intervals of the variables remaining in the model at the end were reported.

5.5.1 Period prevalence (12 months ago)

The period prevalence of injuries sustained over a 12-month period was 62.0% (n = 80) (Table 4.1). Over this 12-month period 114 injuries were reported. The lower limb was most commonly injured (67.6%) (Figure 4.1), with the foot and ankle (22.5%), knee (15.0%) and thigh (13.8%) having the highest injury ranking according to area (Table 4.4). Squash-related activities were considered by the majority of the cause of previous injury (85.0%), with a small percentage attributing their injury to a lack of warm-up (5.0%) prior to engaging in squash (Table 4.6). Two-thirds (66.3%) of the participants with previous injuries were unable to participate in any squash-related activity due to their injury (Table 4.12), with a high of a 52-week period of rest from squash as result of injury (Table 4.12). A quarter (27.5%) of participants with previous injuries were forced to retire as a result of injury (Table 4.14). Treatment of previous injuries by various practitioners was sought out by the majority of injured participants (74.0%). The most popular practitioners include physiotherapists (37.5%), chiropractors and orthopedic surgeons (17.5% each), and general practitioners (10.0%). It is worthy to note that over a quarter of participants did not seek out assistance for their injury (Figure 4.3).

In this study, two participant characteristics were found to have a statistical significance concerning injury prevalence (Table 4.18). The first was alcohol unit

consumption; for every increase in five units of alcohol, the odds of acquiring an injury increased by almost a third. The second was participating in an additional sporting activity, namely ‘Gym (Weights)’; the odds of an injury for a participant not doing ‘Gym (Weights)’ was 3.3 times the odds of injury for a participant who did not do ‘Gym (Weights)’. Therefore, a participant was more likely to sustain an injury if he/she did not do ‘Gym (Weights)’ and/or if he/she has increased alcohol consumption. With regards to the other participant characteristics (in particular gender, race, BMI, handedness, medical conditions and smoking) the spread of the data was unequal, with there being an outright majority in one particular group, and therefore the results cannot be conclusive.

Equipment factors were investigated in order to identify any equipment-related risk factors. String tension proved to have a significant association with injury risk (p = 0.3) (Table 4.18). This is quite a useful finding as this risk factor can be easily modified (i.e. change the string tension) and therefore, injury risk can be controlled in this regard. Squash-related activities were the most common cause of previous injury (78.8%), with a small percentage attributing their injury to a fall or old age (6.1% each) (Table 4.7).

5.5.2 Point prevalence

The point prevalence of current injuries sustained by the participants at the time of the study was 25.6 (n = 33) (Table 4.2). At the time of the study the participants with current injuries reported a total of 36 injuries. The lower limb again proved to be the favourite site of injury (60.6%) (Figure 4.2), with the knee (30.3%) having the highest number of reported injuries, followed by the foot and ankle (12.1%) (Table 4.5). Just under half (42.4%) of the participants with current injuries were unable to participate in any squash-related activity due to their injury (Table 4.15), with a high of a 52-week period of rest from squash as result of injury (Table 4.16). Over a sixth (15.6%) of participants with current injuries were forced to retire as a result of injury (Table 4.17). Half of the participants (52.0%) sought various practitioners for treatment of current injuries. The results of the most popular practitioners were mirrored by the results for previous injury: physiotherapist (24.0%), orthopaedic surgeon (21.0%), chiropractor and general practitioner (9.0% each). It is worthy to note that just under half of the

injured participants (48.0%) did not seek assistance for their injury (Figure 4.4). Medical professionals need to educate coaches, players and team managers about the importance of seeking early medical treatment.

CHAPTER 6: CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

This chapter presents conclusion that were drawn from the results of the collected data, as well as recommendations for further studies arising from the data. The data was collected from league squash players by means of a questionnaire.

6.1 CONCLUSIONS

This study found that injuries to the lower limb were more prevalent than injuries to the upper limb, back or trunk. The lower limb proved to sustain the most injuries with the most common sites being the foot and ankle (past injury) and the knee (current injury). Risk factors that increased the likelihood of a player getting injured were alcohol consumption and a lack of weight training. String tension was found to have a significant association with injury; however, it had no impact on increasing the risk of acquiring an injury. Factors such as the length of a player's career, hours of squash played per week, or the division they currently played for had no significant association with injury in this study. The most common cause of injury was some form of squash-related activity. It is significant to note that almost half of the participants did not seek any medical care from a practitioner for current injuries; just over a quarter of participants also did not seek medical care for past injuries. The most common medical practitioners seen for past injuries were physiotherapists. It is necessary for league squash players to understand the associations between risk factors and injury to have a better understanding of what can be done to minimise risk and ensure as little time away from squash as possible.

6.2 LIMITATIONS

The study specifically investigated the 12 clubs in the eThekwini Municipality that had players who competed in the top three divisions of the squash league. Although there was a satisfactory response rate (129 out of 186 registered players), future studies should aim to investigate a broader scope of league squash players, for example, league players from other regions around the Kwa-Zulu Natal province or even a

national study including all league players from around South Africa. Such a study would ensure that the results represent the entire league squash population. A greater sample size could have been more representative of the entire population of squash players in the eThekwini Municipality, resulting in more precise estimates of prevalence and measures of association. Given the smaller number of participants and specific profile of this defined sample, the results can only be generalised to a group with a similar demographic profile.

Although some of the injured squash players at the time of the study were treated and given a medical diagnosis, the injuries from the past 12 months were self-reported in the questionnaire and not all of them were confirmed with a professional medical diagnosis. The reliability of the results could be compromised due to a lack of appropriate recall (Mouton, 2006). Therefore, human error must also be considered as a worthy limitation. A participant may have made an error, failed to understand a question properly, or forgotten a noteworthy incident which would have been significant for inclusion in the study results. Recall bias was accounted for by using carefully selected wording of the questions in the questionnaire, which underwent both a focus group and a pilot study in order to ensure minimal measurement error. The researcher was present on the day of data collection to assist with the clarification of questions when needed.

The questionnaire gave a picture of the squash player's personal, training and injury statistics, however it is a research tool that allows associations to be determined and not causality. The data obtained from the questionnaire is widespread but should help to direct further research in this area. Longitudinal studies are therefore, recommended (see Section 6.3). The use of a questionnaire may also present with limitations, as it requires participants to be honest and understand what information is required from them. In the case of a participant being unable to differentiate whether the injury occurred during squash-related activities or in an unrelated circumstance, the data obtained may not be reliable.

6.3 RECOMMENDATIONS

These recommendations were made on the basis that the information from this study was accurate. They are also made on a general analysis of the participants; recommendations have to be individually tailored to each individual.

6.3.1 Recommendations for future studies

- Based on the results of this study, future studies should aim to implement an injury prevention strategy (such as a strengthening and conditioning programme), with the goal to prevent injuries in the squash population.

- A larger population of squash players, all over KwaZulu-Natal and South Africa should be included in a study in order to assess if there are differing results from the various regions.

- Future studies should investigate the prevalence of musculoskeletal injuries in other racket disciplines from all around South Africa, which would allow for a comparison between all the disciplines and regions.

- Future studies should question participants on their alcohol consumption habits (e.g. whether they consume alcohol pre-training, post-training or post-competition, and if they consume alcohol with food or on an empty stomach) to note if this has an effect on injury formation.

- The association of string tension to injury seems to be present although the Odds ratio did not provide conclusive results. As a lack of weight training was associated with increased injuries, it may stand to reason that there is a protective mechanism provided by weight training that has modified the relationship between string tension and injury. This association requires further investigation with appropriate comparisons between those completing and not completing weight training alongside their squash.

-Biomechanical measurements and various skill testing (strength, flexibility etc.) would note if there are any anatomical or skill factors that can predispose/prevent a player to/from injury.

-Subsequent to this study a new method to determine relative fat mass (RFM) was developed by Woolcott and Bergman (2018) This may be a better method for looking at unfit individuals and their risk for injury in future studies.

6.3.2 Methodological recommendations

- It would be prudent to record at what stage of the season a player was injured, in order to note when a player would be at most risk and what could be done to limit the risk.

- Medical interventions need to be more specifically investigated. Meaningful conclusions cannot be drawn from a few subjective questions.

- The type of injury (i.e. muscle strain, fracture, ligament sprain etc.) was not asked, nor was injury frequency and severity (on a subjective pain rating scale). This would have given better insight into the patient's injury profile.

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APPENDICES

Appendix A: Final Questionnaire

A musculoskeletal injury profile of League squash players in the eThekwini Municipality

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	Male	Female
3	Height	m	
4	Weight	Kg	

5	Which ethnic group do you belong to? (For statistical purposes)	African	Coloured	Indian	White	Other (Specify)
6	Are you left or right handed?	Left Handed				
		Right Handed				

7	Do you suffer with any of the following medical conditions?	Asthma	Diabetes
		Epilepsy	Rheumatoid Arthritis
		Hyper/Hypo-Thyroidism	Osteoporosis
		Other (Specify):	High Blood Pressure
			None

8	On **average,** how much alcohol, if any, do you consume per **week**?	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

10	Have you suffered from any non-squash related injuries? (Car accident, any broken bones?)	No	
		Yes (Please specify)	

Section B: Squash History and Training

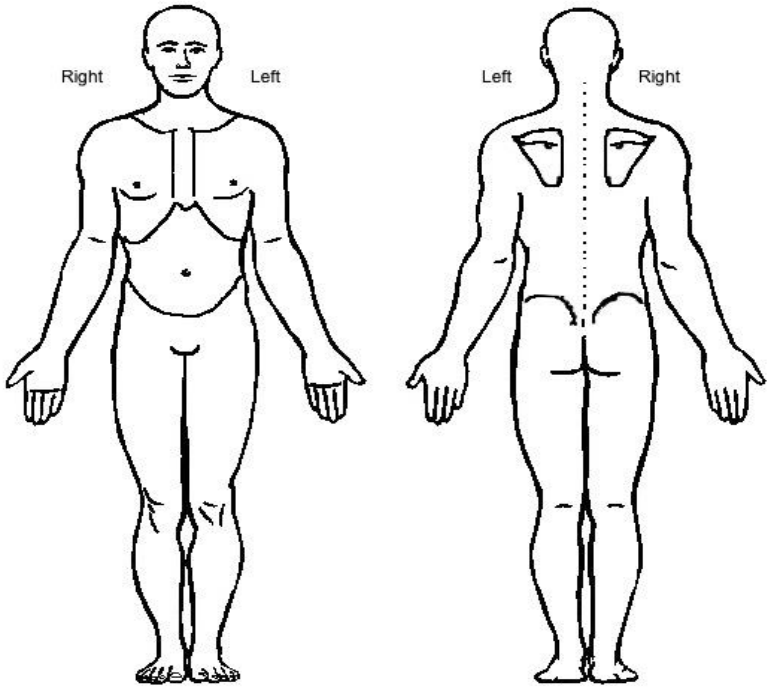
11	How many years have you been playing squash?			years	
12	What division do you currently play in?			First	
				Second	
				Third	
13	What is the highest level you have competed at?		Club	Provincial	National
14	On **average**, how many hours per week do you:	Practice skills:			Hrs
		Play practice/social games:			Hrs
		Play league matches:			Hrs
15	How many **hours per week**, if any, do you participate in the following activities? (You may leave blank for 0 hrs)	Cycling:			Hrs
		Gym (cardiovascular):			Hrs
		Gym (weights):			Hrs
		Kettle bells/boot camps:			Hrs
		Tennis			Hrs
		Running:			Hrs
		Yoga:			Hrs
		Badminton			Hrs
		Table-tennis			Hrs
		Racket-ball			Hrs
		Other (Specify):			Hrs

Section C: Equipment

16	What is the head size/diameter of your racket? (Square inches)	470 cm^2 (small)
		500 cm^2 (large)
17	What is the weight of your racket? (grams)	110g (Light)
		120g (Medium)
		140g (Heavy)
18	Which option best describes your racket?	Head-light
		Head-heavy
		Equal
		Unsure
19	What tension are the strings on your racket? (pounds/lbs)	<26 lbs (Soft)
		26-28 lbs (Medium)
		>28 lbs (Hard)
20	Do you have a vibration dampener on your strings/built into your racket?	Yes
		No
		Unsure
21	Is your racket grip the correct size for your hand?	Yes
		No
		Unsure
22	Do you play with an over-grip?	Yes
		No
		Unsure
23	How do you grip your racket while playing a forehand?	Low Grip
		Middle Grip
		Semi-Western Grip
24	What shoes do you wear while playing squash?	Squash shoes
		Running shoes/cross trainers
		Other (specify)
25	What is the composition of your racket?	
26	What is the composition of your strings?	
27	Has your racket ever been repaired?	Yes
		No
		Unsure
28	What ball type do you train with?	
29	What ball type do you compete with?	

Section D: Squash injuries over the past 12 months

This section requires you to answer questions related to pain that you have experienced while playing squash **over the past 12 months only**- Please do not include pain or injuries from over 12 months ago.

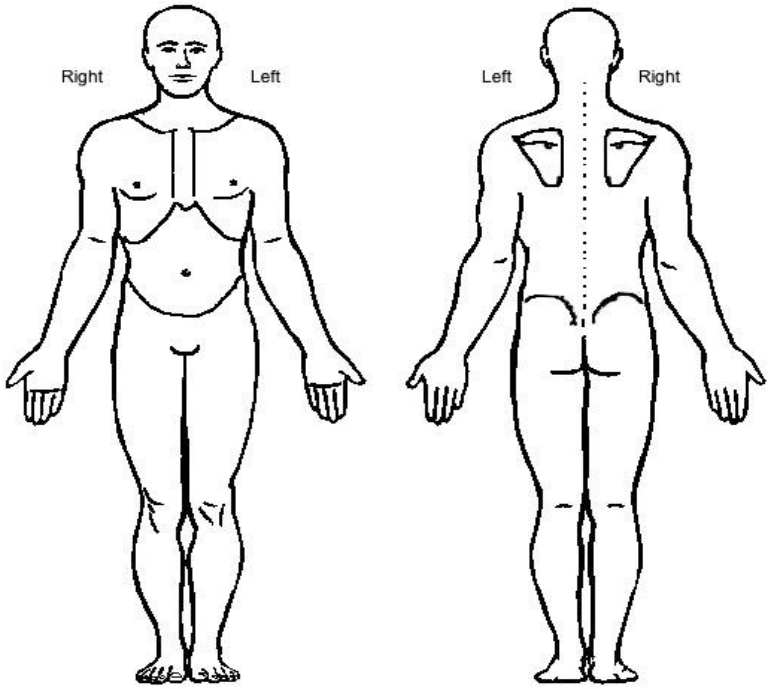
30	Did you experience any **pain** over the last **12 months**?	No:	If **no,** please proceed to **Section E** over the page
		Yes	
31	Where have you experience pain over the last 12 months? **Please mark all the areas you have felt pain with an X**		
32	Which was your most severe injury of the above?	Please specify:	
The following questions apply to your most severe injury.			
33	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	Unsure
		Slip/Fall	Other (Specify):
34	What would aggravate/make the pain worse?	Backhand	Forehand
		Running	Serving/smashing

	(You may select more than 1)	Other (Specify):		
35	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?	
36	In the past 12 months were you unable to practice or participate in a league match due to the pain?	No		
		Yes	If **yes,** how long were you unable to practice or play?	
37	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):	
38	How long did you have the injury for?			

Section E: Current Squash Injuries

This section requires you to answer questions related to pain that you are **currently at this point of time** experiencing while playing squash.

<table>
<tr><td>39</td><td>Do you currently experience any pain while playing squash?</td><td colspan="2">No: If no, the questionnaire is complete-- thank-you!
Yes</td></tr>
<tr><td>40</td><td>Where do you currently feel pain when you play squash?

Please mark all the areas you have felt pain with an X</td><td colspan="2"> 
</td></tr>
<tr><td>41</td><td>Which is your most severe injury of the above?</td><td colspan="2">Please specify:</td></tr>
<tr><td colspan="4">The following questions apply to your <u>most severe current injury.</u></td></tr>
<tr><td rowspan="4">42</td><td rowspan="4">How did you sustain the injury that causes your pain?
(You may select more than 1)</td><td>Gym/cross training</td><td>Incorrect equipment</td></tr>
<tr><td>No warm-up/stretching</td><td>Old Age</td></tr>
<tr><td>Overuse</td><td>Unsure</td></tr>
<tr><td>Slip/Fall</td><td>Other (Specify):</td></tr>
<tr><td rowspan="3">43</td><td rowspan="3">What aggravates/makes the pain worse?
(You may select more than 1)</td><td>Backhand</td><td>Forehand</td></tr>
<tr><td>Running</td><td>Serving/smashing</td></tr>
<tr><td colspan="2">Other (Specify):</td></tr>
</table>

44	Has your current pain forced you to retire during a league match?	No		
		Yes	If **yes**, how many times?	
45	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?	

46	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):
47	How long have you had this injury for?		

Appendix B: Full IREC ethical clearance

UNIVERSITY OF TECHNOLOGY

Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

12 September 2017

IREC Reference Number: **REC 52/17**

Mr S Hawkesworth
PO BOX 1515
Kloof
3640
KwaZulu-Natal

Dear Mr Hawkesworth

An epidemiological study of musculoskeletal injuries in league squash players in the eThekwini municipality.

The Institutional Research Ethics Committee acknowledges receipt of your final data collection tool for review.

We are pleased to inform you that the questionnaire has been approved. Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the IREC acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Yours Sincerely,

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY

2017 -09- 12

INSITUTUTIONAL RESEARCH ETHICS COMMITTEE

Appendix C: Letter of Information for participants

LETTER OF INFORMATION

Dear Participant,

Welcome to my study, I appreciate you participating in it!

The title of my study is:

An epidemiological study of musculoskeletal injuries in league squash players in the eThekwini municipality.

Brief Introduction and Purpose of the Study:

I am conducting research on squash injuries among league squash players in the eThekwini municipality. The purpose of this study is to achieve a greater awareness of the injuries acquired in squash, as this understanding will help with the management of such injuries thereafter.

The study will include league squash players from various clubs in the eThekwini municipality. 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 squash 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:

The results of the study will be forwarded to the club coaches to allow for improvements in training to be made.

Risks/ Discomforts/Costs:

There are no risk/discomforts or costs involved from your participation in this 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:

Researcher: Stephen Hawkesworth (B.tech Chiropractic) 0780218591

Supervisor: Dr Garrick Haswell (M Tech: Chiropractic) 0837821007

Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the

Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

Thank-you for your participation!

Yours sincerely,

Stephen Hawkesworth Dr G. Haswell (M Tech: Chiropractic)

Researcher Supervisor

Appendix D: Letter of consent for participants

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Stephen Hawkesworth, about the nature, conduct, benefits and risks of this study- Research Ethics Clearance Number: REC 52/17
- I have also received, read and understood the above written information (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 researches, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____ _____ _____

Full Name of Participant Date Signature

I, Stephen Hawkesworth, 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

(Below must be filled in for squash players younger than 18 years of age)

Full Name of Parent Date Signature

Appendix E: Permission from Benporath

Questionnaire Doc Inbox x

Michael Benporath <michael@benporath.com> Nov 2 (7 days ago)

to me

Hi Stephen

I grant you full permission to use and or adapt my questionnaire as you feel necessary, for use on squash players.

Kind Regards,

Dr. Michael Benporath
(M Tech: Chiropractic)
237 High Ridge Road
Durban North
Tel: (031) 563 4451
Email: michael@benporath.com

Appendix H1 - Po...

Appendix F: Adaptations from Benporath's questionnaire

With regards to the Questionnaire seen in Appendix H:

Question 1: same question used in Benporath's Questionnaire (Section A, Question 1).

Question 2: same question used in Benporath's Questionnaire (Section A, Question 2).

Question 3: same question used in Benporath's Questionnaire (Section A, Question 3).

Question 4: same question used in Benporath's Questionnaire (Section A, Question 4).

Question 5: same question used in Benporath's Questionnaire (Section A, Question 5).

Question 6: similar question used in Benporath's Questionnaire; simply replace the word tennis with squash (Section B, Question 10).

Question 7: same question used in Benporath's Questionnaire (Section B, Question 11).

Question 8: same question used in Benporath's Questionnaire (Section B, Question 12).

Question 9: same question used in Benporath's Questionnaire (Section B, Question 13).

Question 10: similar question used in Benporath's Questionnaire; the head sizes for squash and tennis rackets are different (Section C, Question 16).

Question 11: similar question used in Benporath's Questionnaire; the weight of squash and tennis rackets are different (Section C, Question 17).

Question 12: similar question used in Benporath's Questionnaire; the string tensions of squash and tennis rackets are different (Section C, Question 18).

Question 13: same question used in Benporath's Questionnaire (Section C, Question 19).

Question 14: same question used in Benporath's Questionnaire (Section C, Question 19).

Question 15: similar question used in Benporath's Questionnaire; replaced the word tennis with squash (Section C, Question 21).

Question 16: similar question used in Benporath's Questionnaire. However, there are different ways to grip the racket in squash compared to tennis (Section C, Question 21).

Question 17: same question used in Benporath's Questionnaire (Section D, Question 24).

Question 18: same question used in Benporath's Questionnaire (Section D, Question 25).

Question 19: same question used in Benporath's Questionnaire (Section D, Question 26).

Question 20: same question used in Benporath's Questionnaire (Section D, Question 27).

Question 21: same question used in Benporath's Questionnaire (Section D, Question 28).

Question 22: same question used in Benporath's Questionnaire (Section D, Question 29).

Question 23: same question used in Benporath's Questionnaire (Section D, Question 30).

Question 24: same question used in Benporath's Questionnaire (Section D, Question 31).

Question 25: similar question used in Benporath's Questionnaire; replaced the word tennis with squash (Section E, Question 32).

Question 26: same question used in Benporath's Questionnaire (Section E, Question 33).

Question 27: same question used in Benporath’s Questionnaire (Section E, Question 34).

Question 28: same question used in Benporath’s Questionnaire (Section E, Question 35).

Question 29: same question used in Benporath’s Questionnaire (Section E, Question 36).

Question 30: same question used in Benporath’s Questionnaire (Section E, Question 37).

Question 31: same question used in Benporath’s Questionnaire (Section E, Question 38).

Question 32: same question used in Benporath’s Questionnaire (Section E, Question 39).

Appendix G: Partial IREC ethical clearance

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

15 August 2017

IREC Reference Number: **REC 52/17**

Mr S Hawkesworth
PO BOX 1515
Kloof 3640
KwaZulu-Natal

Dear Mr Hawkesworth

An epidemiological study of musculoskeletal injuries in league squash players in the eThekwini municipality.

I am pleased to inform you that Provisional Approval has been granted to your proposal REC 52/17 subject to:

- Piloting of the data collection tool and
- Obtaining and submitting the necessary gatekeeper permission/s to the IREC.

Full approval is subject to meeting the above conditions.

The Proposal has been allocated the following Ethical Clearance number **IREC 059/17**. Please use this number in all communication with this office.

Approval has been granted for a period of two years, 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.

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, kindly notify the IREC in writing.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

Appendix H: Pre-focus group and pre-pilot study questionnaire

A musculoskeletal injury profile of League squash players in the eThekwini Municipality

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	Male	Female				
3	Height	M					
4	Weight	Kgs					
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	Do you suffer with any of the following conditions?	Asthma		Diabetes			
		Epilepsy		Rheumatoid Arthritis			
		Hyper/Hypo-Thyroidism		Osteoporosis			
		Other (Specify):		High Blood Pressure			
				None			
8	On **average,** how much alcohol, if any, do you consume per **week**?	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			

10	How many years have you been playing squash?			years	
11	What is the highest level you have competed at?	Club	Provincial	National	
12		Practice skills:		Hrs	

	On **average**, how many hours per week do you:	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 hrs)	Cycling:	Hrs
		Gym (cardiovascular):	Hrs
		Gym (weights):	Hrs
		Kettle bells/boot camps:	Hrs
		Pilates:	Hrs
		Running:	Hrs
		Yoga:	Hrs
		Other (Specify):	Hrs

Section B: Squash History and Training

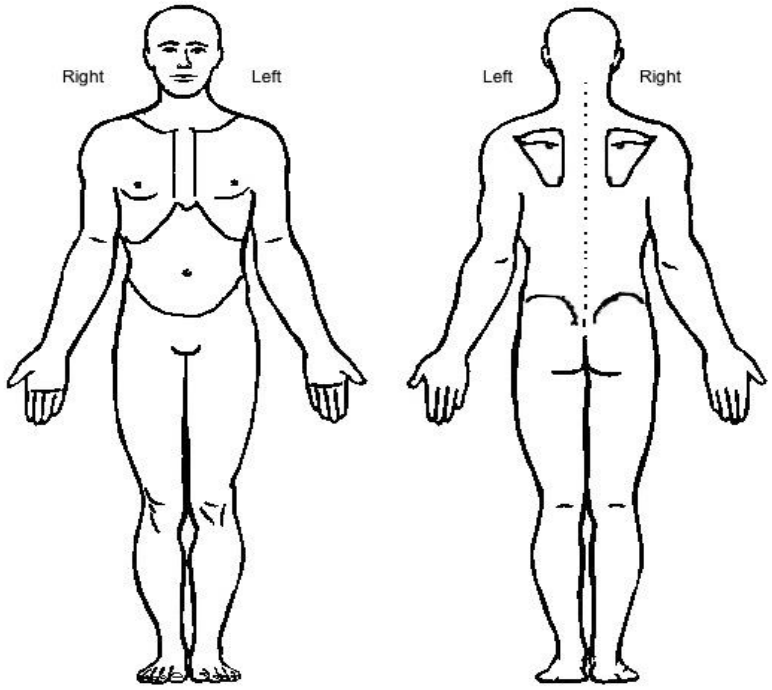
Section C: Equipment

14	What is the head size/diameter of your racket? (Square inches)	470 cm^2 (Small)
		96-105 sq. in. (Traditional)
		495cm^2 (big)
15	What is the weight of your racket? (grams)	<140g (Light)
		140-160g (Medium)
		>160g (Heavy)
16	What tension are the strings on your racket? (pounds/lbs)	<26 lbs (Soft)
		26-28 lbs (Medium)
		>28 lbs (Hard)
17	Is your racket grip the correct size for your hand?	Yes
		No
18	Do you have a vibration dampener on your strings/built into your racket?	Yes
		No
19	What shoes do you wear while playing squash?	Squash shoes
		Running shoes/cross trainers
		Other
20	How do you grip your racket while playing a forehand?	Low Grip
		Middle Grip
		Semi-Western Grip

Section D: Squash injuries over the past 12 months

This section requires you to answer questions related to pain that you have experienced while playing squash over the past 12 months only- Please do not include pain or injuries from over 12 months ago.

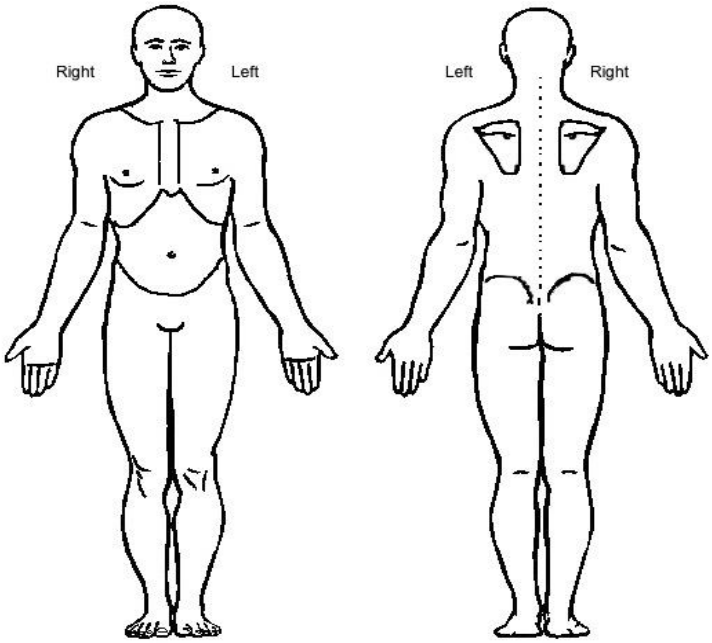
<table>
<tr><td>21</td><td>Did you experience any pain over the last 12 months?</td><td>No:</td><td colspan="3">If no, please proceed to Section E over the page</td></tr>
<tr><td></td><td></td><td colspan="4">Yes</td></tr>
<tr><td>22</td><td>Where have you experience pain over the last 12 months?

Please mark all the areas you have felt pain with an X</td><td colspan="4"> 
</td></tr>
<tr><td>23</td><td>What would aggravate/make the pain worse?
(You may select more than 1)</td><td colspan="2">Backhand</td><td colspan="2">Forehand</td></tr>
<tr><td></td><td></td><td colspan="2">Running</td><td colspan="2">Serving/smashing</td></tr>
<tr><td></td><td></td><td colspan="4">Other (Specify):</td></tr>
<tr><td>24</td><td>Were you ever forced to retire from a league match due to pain in the past 12 months?</td><td>No</td><td colspan="3"></td></tr>
<tr><td></td><td></td><td>Yes</td><td>If yes, how many times?</td><td colspan="2"></td></tr>
<tr><td>25</td><td>Were you unable to practice or participate in a league match due to your current pain in the past 12 months?</td><td>No</td><td colspan="3"></td></tr>
<tr><td></td><td></td><td>Yes</td><td>If yes, how long were you unable to practice or play?</td><td colspan="2"></td></tr>
<tr><td>26</td><td>How did you sustain the injury that caused your pain?
(You may select more than 1)</td><td colspan="2">Gym/cross training</td><td colspan="2">Incorrect equipment</td></tr>
<tr><td></td><td></td><td colspan="2">No warm-up/stretching</td><td colspan="2">Old Age</td></tr>
<tr><td></td><td></td><td colspan="2">Overuse</td><td colspan="2">Unknown</td></tr>
<tr><td></td><td></td><td colspan="2">Slip/Fall</td><td colspan="2">Other (Specify):</td></tr>
</table>

27	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):	
28	Were you happy with the treatment/advice you received?		Yes		No

Section E: Current Squash Injuries

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

29	Do you **currently** experience any pain while playing squash?	No	If **no**, the questionnaire is complete-- thank-you!
		Yes	
30	Where do you **currently** feel pain when you play squash? **Please mark all the areas you feel pain with an X**		
31	What aggravates/makes the pain worse? (You may select more than 1)	Backhand	Forehand
		Running	Serving/smashing
		Other (Specify):	
32	Has your current pain forced you to retire during a league match?	No	
		Yes	If **yes**, how many times?
33	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?
34	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):
35	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):
36		Yes	

	Were you happy with the treatment/advice you received?	No	

Appendix I: Letter of Information to focus group members

Dear Participant,

Welcome to my study, I appreciate you participating in it!

The title of my study is:

An epidemiological study of musculoskeletal injuries in league squash players in the eThekwini municipality.

Procedure:
The purpose of the focus group is to assess, discuss and make any relative changes to the Pre-Focus Group Questionnaire as appropriate. An agreed upon date, venue, and time will be arranged via telephonic communication with all the members of the focus group. Prior to the commencement of the official focus group meeting, each participant will be required to fill in a confidentiality letter, as well as to sign a code of conduct. The focus group meeting will be chaired and minuted by the researcher. Any suggestions or amendments that are proposed by any participant will be scrutinized by the group and voted on. Only with a unanimous vote will an amendment be implemented. A list of amendments that are implemented will be made and used to adjust the questionnaire.

Benefits:

The results of the study will be forwarded to the club coaches to allow for improvements in training to be made.

Risks/ Discomforts/Costs:

There are no risk/discomforts or costs involved from your participation in this 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:

Researcher: Stephen Hawkesworth (B.tech Chiropractic) 0780218591

Supervisor: Dr Garrick Haswell (M Tech: Chiropractic) 0837821007

Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the

Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

The purpose of this focus group is to validate the use of the Squash Injury Questionnaire, which will be used to gather information from the league squash players. The discussion will focus on the necessary alterations to the questionnaire in order to make it efficient and accurate.

Your participation in this focus group is much appreciated and please note that your comments and contributions to the questionnaire will remain confidential. At any point in the discussion feel free to disagree and give reasons for doing so, as this will assist the research process. The results of this focus group will be used for research purposes only.

Thank-you for your participation!

Yours sincerely,

Stephen Hawkesworth Dr G. Haswell (M Tech: Chiropractic)

Researcher Supervisor

Appendix J: Informed Consent Form for Focus Group members

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Stephen Hawkesworth, about the nature, conduct, benefits and risks of this study- Research Ethics Clearance Number:
- I have 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 researches, I agree that the data collected during this study can be processed in a computerised system by the researcher. The information from this focus group will be made public in terms of a journal publication, which will in no way identify any participants of this research
- All information contained in the research documents and any information discussed during the focus group meeting will be kept confidential. This is especially binding to any information that may identify any of the participants in the research process.
- None of the information shall be communicated to any other individual or organization outside of this focus group as to the decisions of this focus group.
- 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.

<u>Please circle the appropriate answer</u>

1- Have you read the participant information sheet? YES NO

2- Have you had the opportunity to ask questions regarding this study? YES NO

3- Have you received satisfactory answers to your questions? YES NO

4- Have you had the opportunity to discuss this study? YES NO

5- Have you received enough information about this study? YES NO

6- Who have you spoken to regarding this study? _

7- Do you understand the implications of your involvement in this study? YES NO

8- Do you understand that you are free to withdraw from this study at any time, without giving a reason for withdrawing, and without affecting your future health? YES NO

9- Do you agree to voluntarily participate in this study? YES NO

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

Thank You!

Focus group member: _____ Signature: _____

Researcher's name: _____ Signature: _____

Appendix K: Code of conduct and confidentiality for members of the focus group

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

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 focus 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 organization outside of this specific focus group as to the decisions of this focus group.

3. The information from this focus 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 L: Letter of Information for Pilot Study

LETTER OF INFORMATION

Dear Participant,

Welcome to the Pilot Study of my research, I appreciate you participating in it.

The title of my study is:

An epidemiological study of musculoskeletal injuries in league squash players in the eThekwini municipality.

Brief Introduction and Purpose of the Study:

I am conducting research on squash injuries among league squash players within the eThekwini Municipality. The purpose of this study is to achieve a greater awareness of the injuries acquired in squash, as this understanding will help with the management of such injuries thereafter.

Procedure:

For the pilot study the researcher recruits three-five participants that meet the inclusion criteria for the main study. The pilot study participants will be subject to the same procedure as the participants of the main study. The purpose of the pilot study is to allow the researcher to identify any potential discrepancies in the procedure, using a small sample of respondents prior to the conduction of the main study.

You will be required to complete a questionnaire about squash injuries, where and how they occur. The average time for the questionnaire to be completed is 10 minutes.

Benefits:

The results of the study will be forwarded to the club coaches to allow for improvements in training to be made.

Risks/ Discomforts/Costs:

There are no risk/discomforts or costs involved from your participation in this 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:

Researcher: Stephen Hawkesworth (B.tech Chiropractic) 0780218591

Supervisor: Dr Garrick Haswell (M Tech: Chiropractic) 0837821007

Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the

Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

The purpose of this pilot study is to validate the use of the Squash Injury Questionnaire, which will be used to gather information from the players.

Your participation in this pilot study is much appreciated and note that your contributions will remain confidential. At any point in the pilot study feel free to ask questions with regards to the questionnaire. The results of this pilot study will be used for research purposes only.

Yours sincerely,

Stephen Hawkesworth Dr G. Haswell (M Tech: Chiropractic)

Researcher Supervisor

Appendix M: Informed Consent Form for Pilot Study

CONSENT

Statement of Agreement to Participate in the Pilot Study:

• I hereby confirm that I have been informed by the researcher, Stephen Hawkesworth, 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.

Please circle the appropriate answer

1- Have you read the pilot study information letter? YES NO

2- Have you had the opportunity to ask questions regarding this study? YES NO

3- Have you received satisfactory answers to your questions? YES NO

4- Have you received enough information about this study? YES NO

5- Who have you spoken to regarding this study? _

6- Do you understand the implications of your involvement in this study? YES NO

7- Do you understand that you are free to withdraw from this study at any time, without giving a reason for withdrawing, and without affecting your future health? YES NO

8- Do you agree to voluntarily participate in this study? YES NO

IF YOU HAVE ANSWERED NO TO ANY OF THE ABOVE PLEASE OBTAIN THE NECESSARY INFORMATION FROM THE RESEARCHER AND/OR SUPERVISOR BEFORE SIGNING. THANK YOU.

_____ _____ _____

Full Name of Participant Date Signature

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

_____ _____ _____

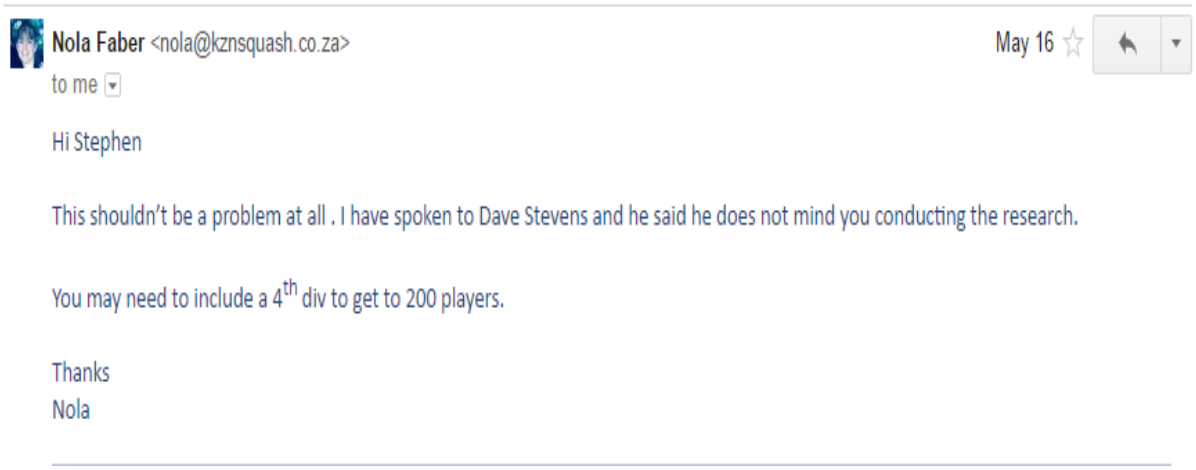
Full Name of Researcher Date Signature

(Below must be filled in for squash players younger than 18 years of age)

_____ _____ _____

Full Name of Parent Date Signature

Appendix N: Permission from the KZN Squash Union to perform study



Nola Faber <nola@kznsquash.co.za> May 16

to me

Hi Stephen

This shouldn't be a problem at all . I have spoken to Dave Stevens and he said he does not mind you conducting the research.

You may need to include a 4th div to get to 200 players.

Thanks
Nola

Appendix O: Changes to the Pre-focus group and pre-pilot study questionnaire

Section A: Player Information

- Added Question 10: Have you suffered from any non-squash related injuries? (Car accident, any broken bones?)

Section B: Squash History and Training

- Added question 12: What division do you currently play in? (First, Second, Third)

Section C: Equipment

- Added question 18: Which option best describes your racket? (Head-light, Head-heavy, Equal, Unsure)
- Added question 22: Do you play with an over-grip? (Yes, No, Unsure)
- Added question 25: What is the composition of your racket?
- Added question 26: What is the composition of your strings?
- Added question 27: Has your racket ever been repaired? (Yes, No, Unsure)
- Added question 28: What ball type do you train with?
- Added question 29: What ball type do you compete with?

Section D: Squash injuries over the past 12 months

- Added question 32: Which was your most severe injury of the above? (Please specify)
- Added statement: “The following questions apply to your most severe injury.”
- Added question 38: How long did you have the injury for?

Section E: Current squash injuries

- Added question 41: Which was your most severe injury of the above? (Please specify)
- Added statement: “The following questions apply to your most severe injury.”
- Added question 47: How long did you have the injury for?

Appendix P: Calculation to determine sample size

What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. Higher confidence level requires a larger sample size.
What is the population size? If you don't know, use 20000	186	How many people are there to choose your random sample from? The sample size doesn't change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	50 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other, the population probably is, too. If you don't know, use 50%, which gives the largest sample size.
Your recommended sample size is	**126**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you're more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.