A retrospective profile of musculoskeletal injuries of ultra-endurance triathletes in South Africa

By

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I, Courtney Dean Momberg, 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 dad and mom, Troy and Janice Momberg. You have guided and moulded me into the person I am today. Your unconditional love, support and encouragement has allowed me to reach my goals. I cannot describe my gratitude for everything that you have provided me with. I love you both dearly.

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Abstract

Aim

The aim of this study was to determine the injury profile of ultra-endurance triathletes in South Africa.

Background

An ultra-endurance triathlon comprises a combination of swimming, cycling and running; the distances covered are a 3.8km swim, 180km cycle and a 42.2km run all in succession. Ultra-endurance triathlon has grown in popularity since its inception in the 1970s. However, there is insufficient data relating to injuries in the South African context especially related to age and gender.

Methods

This Institutional Research Ethics Committee of the Durban University of Technology approved study included 100 active members of My Training Day and ultra-endurance triathletes associated with My Training Day that were training and taking part in the 2017 South African ultra-endurance triathlon (2017 South African Ironman Race). After signing the informed consent form and letter of information, participants completed an online questionnaire on training and injury profiles. All data captured was anonymous and confidential. Data was described using frequency tables for categorical data and summary statistics for continuous data. Odds ratios were reported and a p value < 0.05 was considered statistically significant. For triathletes reporting injuries, linear regression was used for factors associated with injury severity.

Results

Questionnaires were returned by 86 ultra-endurance triathletes, of which 71 were deemed viable giving a response rate of 71%. The past and periodic (day of the race) prevalence of ultra-endurance triathlon-related musculoskeletal injury was 46.5% and 9.85% respectively. The most common site of injury in the year leading up to the 2017 ultra-endurance race was the posterior compartment of the lower limb, being the hamstring / calf (36.4%), while there was an equal split of injuries on race day with the shoulder, hamstring / calf, knee / quadriceps region all having the same percentage

(28.6%). Of the 71 participants 66.2% were male and 33.8% were female. The most common age group was 30 to 34 years (25.7%). The majority of the participants started participating in ultra-endurance triathlons between 24 and 29 years of age (32.4%). There was no significant difference in age between those who had injuries prior to the event and those who did not ($p = 0.079$). There was no statistically significant difference in prior injury prevalence between males and females ($p = 0.395$). There was a borderline non-significant difference indicating younger athletes were at higher risk for injury on race day ($p = 0.069$). Females had a higher risk of injury on race day ($p = 0.039$).

Conclusions and recommendations

The results concur with previous research and add further insight into factors predisposing triathletes to injury. The most common injuries require investigation to develop preventative interventions to reduce injuries in triathletes. Further research into age and gender interactions as risk factors for injury is needed in South Africa. Health professionals require education about ultra-endurance triathlon-related injuries to improve preventative and curative interventions.

Key terms

Triathlon-related, ultra-endurance triathletes, injury profile, musculoskeletal injuries, prevalence, age, gender.

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List of Symbols and Abbreviations

%	Percentage
IREC	Institutional Research and Ethics Committee
p	Level of significance
ITB	Iliotibial band
ITBS	Iliotibial band syndrome
PFPS	Patellofemoral pain syndrome
MTSS	Medial tibial stress syndrome
VO2max	Maximal oxygen uptake
≥	Greater than or equal to
≤	Less than or equal to
SD	Standard deviation
IBM SPSS	Software package used for statistical analysis

CHAPTER 1: INTRODUCTION

1.1 Introduction

This chapter will introduce the topic of ultra-endurance triathlons and the demographics that will be considered to create a background for the study. It will also give the aim, objectives and rationale of the study.

1.2 Background

An ultra-endurance triathlon is a multiple-stage competition involving the completion of three continuous endurance disciplines starting with swimming (3.86km), then cycling (180.25km) then running (42.2km) in immediate succession. Most ultra-endurance triathlons have a 17 hour time limit. Since its inception in the 1970s participation in ultra-endurance triathlon has grown exponentially (Kienstra et al., 2017). McHardy, Pollard and Fernandez (2006) suggested that the draw towards training and competing in triathlon is due to the variety of disciplines involved in the sport. However, Clements, Yates and Curran (1999) and Vleck and Garbutt (1998) suggest this variety contributes to triathlon-related musculoskeletal injury. The nature of ultra-endurance triathlon events means that a triathlete experiences a wider variety of racing conditions and physiological stresses than those found in an individual sport of similar duration (Dallam et al., 2005).

It should be noted that there is a vast difference between standard triathlon and ultra-endurance triathlon in terms of distances covered and therefore overall time out on the course. Regular triathlons generally involve between a sprint (750m swim, 20km cycle, 5km run) or Olympic-distance (1.5km swim, 40km cycle, 10km run). The significantly increased distance in both training and on race day for ultra-endurance triathlons brings in a different set of risk factors for injury.

The prevalence of musculoskeletal injury among triathletes is noted to vary from 47% (Korkia et al., 1994) to 91% (O’Toole et al., 1989). However, in the literature there is no commonality of terminology used to describe injury as well as different parts of the body. This lack of agreement between studies focused around triathlon-related injury, makes comparing and determining injury profiles in the triathlon arena challenging (McHardy et al., 2006).

Ultra-endurance triathlon is a sport where the triathletes compete in gender and age categories ranging from 18 years of age through to masters triathletes in their 70s and 80s. The gender difference in ultra-endurance performance and injury rate has attracted substantial attention over the last 25 to 30 years. Running has been the main focus when looking at and comparing gender differences (Coast et al., 2004; Cheuvront et al., 2005; Hoffman, 2008). Less emphasis has been placed on gender differences in swimming, cycling or triathlon performance (Lepers, 2008; Sultana et al., 2008). Ultra-endurance triathlon has and still is a male dominated sport, although the number of women triathletes has increased and continues to do so (Lepers, Knechtle and Stapley, 2013). This increase allows for more accurate research into the injuries and potential difference in injuries between male and female ultra-endurance triathletes.

Gosling, Gabbe and Forbes (2008) reviewed triathlon-related musculoskeletal injuries and found that there is a substantial gap in the literature that describes injury prevalence, injury profiles and recommendations for preventative measures of injuries in triathlon participants.

The growing popularity of ultra-endurance triathlons has resulted in a wide variety of athletes training and competing in these events. Therefore, it is important for manual therapy professions (e.g. chiropractic) to understand the athlete’s needs more effectively in order for these athletes to receive optimum musculoskeletal care and enhance the management of ultra-endurance triathlon athletes.

1.3 Research aim and objectives

1.3.1 Research problem

Several injury profiles have been conducted on swimming, cycling and running events but none on a combination of all three respective disciplines at ultra-distances which is the case in ultra-endurance triathlon. Ultra-endurance triathlon events may produce a significantly different injury profile to individual discipline marathon events, which was the research problem investigated by this study.

1.3.2 Aim of study

The aim of this study was to develop an injury profile of ultra-endurance triathletes in South Africa using an electronic questionnaire and to determine whether age and gender are risk factors for injury.

1.3.3 Objectives

- Objective One was to determine the profile (prevalence [past and periodic], location and severity) of musculoskeletal injuries in ultra-endurance triathletes in South Africa during one season.
- Objective Two was to determine the selected risk factors, being age and gender, for injuries occurring in ultra-endurance triathletes in South Africa.
- Objective Three was to determine whether there are correlations between injury profile and selected risk factors (age, gender and occupation) for injury.

1.4 Rationale and benefits of the study

Ultra-endurance triathlon has developed into a popular sport on both a professional and recreational level worldwide (Gosling et al., 2010). McHardy et al. (2006) suggested that the risk of injury in triathlon is considerable as injuries can occur due to an individual discipline or due to the nature of triathlon (amalgamation of all three sports).

Ultra-endurance triathlon represents an interesting model to study and further increase the literature on age and gender interaction in endurance performance (Bernard et al., 2009; Lepers, 2008).

There has been limited research directed towards South African triathletes (Ellapen et al., 2011) and even less regarding age and gender. Additional research looking at the epidemiology of South African triathlon-related injuries would assist ultra-endurance triathletes in becoming more competitive, having fewer injuries and therefore being able to compete and train more effectively and for longer (Gosling et al., 2008).

It is hoped that this research will assist in furthering the literature on prevalence and age and gender related to injuries, and in turn assist in preventing and decreasing primary, secondary and tertiary injury among ultra-endurance triathletes.

This research could benefit physical health-care professionals in injury prevention and health promotion of triathletes competing in ultra-endurance events. This is particularly relevant to chiropractic care, which is an increasingly utilised form of first line treatment (Daniels, 2010).

1.5 Limitations of the study

Participants many not have completed the questionnaire honestly and openly regarding the reality of their injuries at the time when they completed the questionnaire. This study only included information from triathletes that accepted the invitation to participate in this study, therefore, the results only apply to that sample and cannot be generalised to the population of triathlon athletes as a whole.

1.6 Outline of chapters

This chapter provided an introduction to the study, presenting the study's context and setting, the aim and objectives as well as the limitations and benefits of the study which are also described.

Chapter 2 provides an expansion of the current literature in this field in order to expand the reader's understanding of the rationale behind the study.

Chapter 3 details the study design, which includes the materials and methods.

Chapter 4 presents the results and the discussion of these results in the context of the current literature. The results and discussion of results were included in one chapter for ease of reading and so as to be able to present results and discussion of results sequentially.

Chapter 5 concludes the study and offers recommendations for future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the current literature in order to enhance the reader's understanding of the rationale behind studying the injury profile of ultra-endurance triathletes. This chapter also provides the reader with a brief overview of the incidence and type of common injuries experienced by ultra-endurance triathletes. The chapter further discusses risk factors, namely, age and gender, which have been identified in the literature as predisposing triathletes to injury, and reviews the various mechanisms of injury pertaining to each discipline of a triathlon and the triathlon as a whole.

2.2 Ultra-endurance

Ultra-endurance events are defined as events that have a duration of more than six hours (Zaryski and Smith, 2005). These competitions rely on sufficient long-term preparation, adequate nutrition, accommodating to environmental stressors, and mental toughness (Zaryski and Smith, 2005).

Endurance athletes need to be able to alternate periods of intensive training with periods of recovery. An imbalance in this approach caused by excessive training and insufficient recovery leads to a breakdown in tissue repair mechanisms and eventually to overuse injuries (Cosca and Navazio, 2007). An important component of ultra-endurance training is its effect on the anatomical structures of the human body (Cosca and Navazio, 2007).

2.3 Ultra-endurance triathlon

Ultra-endurance triathlon is a competitive sport consisting of swimming, bicycling and running. Ultra-endurance triathlon started in Hawaii in the late 1970s with around 50 participants. Currently, more than 50 000 triathletes take part in ultra-endurance distance races throughout the world (Kienstra et al., 2017). Ultra-endurance triathlon has developed into a popular sport among both recreational and professional triathletes (Andersen et al., 2013; Burns et al., 2003).

The physiological strains placed on the body caused by swimming, cycling and running consecutively are unique. They require the triathlete to develop physical and physiological features that are a combination of those found in endurance swimming, cycling and running specialists (Sleivert and Rowlands, 1996).

An ultra-endurance triathlon is a multiple-stage event involving the completion of three sequential endurance disciplines starting with swimming (3.86km), then cycling (180.25km) then running (42.2km) in immediate succession. Triathletes compete for fastest overall course completion time, including timed transitions between the individual swim, cycle, and run components (Kleanthous, 2016). Athletes partaking in ultra-endurance triathlons compete in age and gender categories and most ultra-endurance triathlons have a strict time limit of 17 hours to complete the race (Sharwood et al., 2004).

Ultra-endurance triathlon is considered a modern sport among endurance events. Swimming, cycling and running have been extensively researched, however, the combination of the three disciplines creates specific difficulties (Migliorini, 2011). Alternating between the three disciplines, and the variables of endurance distances, environmental conditions, complexity of training and the unique muscular balance required are some of the reasons why ultra-endurance triathlon has become the focus of endurance sport related studies involving physiology, traumatology, biomechanics and training technique (Migliorini, 2011).

Consequences of participation in long distance triathlons can be a degree of muscle damage as a result of the physical exertion required. This can be characterised by muscle soreness, loss of muscle function, and reductions in aerobic capacity (Laursen, 2011; Suzuki et al., 2006). Ultra-endurance athletes may also be susceptible to exercise-associated medical conditions which, among others, include exercise-induced asthma, exercise-associated collapse, overtraining syndrome and nutritional conditions including hypernatraemia (Cosca and Navazio, 2007).

Compared to single endurance sporting events of similar duration, ultra-endurance triathletes experience a range of conditions and physiological loads that are higher and more complex (Dallam et al., 2005 and Migliorini, 2011). An understanding of the injuries obtained during triathlon competition and training could assist in improving training techniques, identifying risk factors, developing suitable intervention strategies and developing race day medical facilities that are specific to triathlon (Gosling et al., 2010).

2.4 Prevalence of triathlon-related musculoskeletal injuries

Ultra-triathlon training predisposes triathletes to overuse / chronic injuries (Korkia et al., 1994; Vleck and Garbutt, 1998; Burns et al., 2003; Shaw et al., 2004).

Ultra-endurance triathlon requires the triathlete to train and compete in more than one sporting discipline. Therefore, different physiological aspects of the musculoskeletal system are stressed and rested in alternating patterns. The multi-disciplinary sport allows the athlete to train for one sport while recovering from another. However, the stress, strain and repetitive motions that occur while the triathlete trains for three endurance disciplines may lead to musculoskeletal injuries due to repetitive overuse (Trent, 2017).

Studies have reported that between 47% and 75% of ultra-endurance triathletes experience overuse injuries (Collins et al., 1989; Korkia et al., 1994; Wilk et al., 1995; Cipriani et al., 1998; Vleck and Garbutt, 1998). This is attributed to the nature of ultra-endurance triathlon and the physiological demands required. Epidemiological literature reflects that running is the discipline of ultra-endurance triathlon associated with the highest percentage of musculoskeletal overuse injuries (Collins et al., 1989; Migliorini, 2011). Numerous studies have proposed that the second transition between the cycle and running discipline is a high risk for both low back and musculoskeletal knee injuries (Klion and Jacobson, 2018; Migliorini, 2011).

The knee, ankle, foot and lower back are the most common anatomical sites indicated as major injury sites (O'Toole et al., 1989; Korkia et al., 1994; Manninen and Kallinen, 1996; Vleck and Garbutt, 1998; Cipriani et al., 1998; Clements et al., 1999; Migliorini and Bomprezzi, 2003; Egermann et al., 2003; Burns et al., 2003; Migliorini, 2011).

Gosling et al. (2008) identified reasons as to why researchers provided unreliable injury epidemiological data. These include:

- Recall periods of greater than one year (Mouton, 1996; Gosling et al., 2008).

- The inability to distinguish between injuries sustained in training and competing (Shaw et al., 2004; Villavicencio et al., 2006; Gosling et al., 2008).
- Selection bias for those athletes either with or without injury (Villavicencio et al., 2006; Gosling et al., 2008).
- Incomplete response rates for surveyed populations (Burns et al., 2003; Egermann et al., 2003; Shaw et al., 2004; Villavicencio et al., 2006; Gosling et al., 2008).
- Failure to use consistent injury definitions (Vleck and Garbutt, 1998; Egermann et al., 2003, Shaw et al., 2004; Villavicencio et al., 2006; Gosling et al., 2008).

2.5 Area of injury

Due to the complexity of training and competing in ultra-endurance triathlon, musculoskeletal injuries can occur at various sites. The most common areas of injury are the neck, shoulder, lower back, knee, ankle, Achilles tendon and foot (O'Toole et al., 1989; Egermann et al., 2003; Ellapen et al., 2011), with the knee being the most commonly injured according to Vleck and Garbutt, (1998) and Ellapen et al. (2011).

Several studies have surveyed triathletes' injuries or pain complaints (Collins et al., 1989; O'Toole et al., 1989; Egermann et al., 2003; Shaw et al., 2004; Ansell, Rivett, and Callister 2012; Andersen et al., 2013).

Ultra-endurance triathletes competing in the ultra-endurance triathlon in Hawaii were studied by O'Toole et al. (1989). The results showed that 85% of the injuries sustained were overuse injuries. In this sample, 91% of the participants suffered an overuse injury in the last 12 months with the most common area of injury being the back (O'Toole et al., 1989). Collins et al. (1989) obtained data from 600 triathletes competing in a triathlon event. The study reported that 49% of the triathletes surveyed sustained an injury. In this study the most common area of injury was the knee, shoulder, and ankle (Collins et al., 1989).

Andersen et al. (2013) conducted a study investigating overuse problems and acute injuries among ultra-distance triathletes throughout a training season leading up to a major event. They found the prevalence of overuse injuries to be 56%. The average prevalence of substantial overuse problems was 20%. The conclusion from that study was that the prevalence of overuse problems in ultra-distance triathletes is high, while the acute injury prevalence appears to be less than previously reported. The lower leg and lower back were the areas most effected by injury, with the knee being the most common site of injury (Andersen et al., 2013).

In a study compiled by Ansell et al. (2012), 1 250 ultra-endurance triathletes taking part in the Australian Ironman were questioned. The majority (86.1%) reported overuse injuries that were related to training or competing in the 12 months prior to the study. Ansell et al. (2012), reported that the most common anatomical site of injury was the knee (35.1%), however, lower back injuries (34.1%) also had a high prevalence (Ansell et al., 2012).

Egermann et al. (2003) surveyed 656 triathletes of the Ironman Europe 2000 triathlon. The results reflected that 74.8% of triathletes reported a minimum of one injury during their time competing in triathlons. The knee, ankle, foot and lower back were reported as the areas most effected by injury (Egermann et al., 2003).

Vleck et al. (2010) studied injuries in the British National Squad where overuse injuries were sustained by 72.2% of the triathletes. The Achilles tendon, calf and hamstring were the area’s most effected by injury.

A French triathlon league was surveyed by Galera et al. (2012). Just over half of the 788 triathletes (52.4%) who responded to the survey reported being injured during the past season. The anatomical sites most frequently reported were the ankle (20.6%), knee (18.3%), thigh (15%), lumbar region (12.6%) and shoulder (8,3%) (Galera et al., 2012).

In the majority of the studies on prevalence of musculoskeletal injuries with ultra-endurance triathletes, the knee was found to be the anatomical site with the most injuries. Johnson (2012) recruited 380 triathletes for his study. His aim was to look at the injuries that were causing triathletes to stop training for a minimum of four days. The most common site of injury was the knee (34%).

Shaw et al. (2004) surveyed 258 triathletes in Australia and found that 62% of the study population had experienced an injury in the last twelve months. Lower limb injuries were found to be the most common, specifically the knee at 32%. In addition, the following studies had knee as the most common site of injury ranging from 25% (Andersen et al., 2013; Ansell et al., 2012) to 84% (O'Toole et al., 1989).

Related to injuries of the lower limb, several studies have shown that running is the most common cause of injury. Collins et al. (1989) reported that 62% of injuries sustained were related to running, the only weight bearing activity. Clements et al. (1999) found that of the participants with knee injuries, the majority had sustained the injury while running.

Other common anatomical sites for injury in ultra-endurance triathletes according to the literature are neck and lower back, foot and ankle as well as shoulder. Villavicencio et al.'s (2006) study reflected that the prevalence of neck pain and back pain was 48.3% and 67.8%, respectively. Additionally, O'Toole et al. (1989) found in their study that 72% of triathletes reported low back pain or sciatica in a 12-month period.

In addition to the above, Gosling et al.'s (2008) review of musculoskeletal injuries related to triathlon highlighted knowledge gaps in triathlon literature that explain injury incidence, injury profiles and recommendations for preventative measures of injuries in triathletes.

2.6 Epidemiology of ultra-endurance triathlete injuries

Acute musculoskeletal injuries are rare in ultra-endurance triathlons compared to overuse injuries (Korkia et al., 1994; Vleck et al., 2010). Added to this, most acute injuries are reported to be minor. Blisters, contusions and abrasions are some of the most common acute musculoskeletal race day injuries (Gosling et al., 2010). Serious acute musculoskeletal injuries are largely caused by falls while training for or competing in the cycle leg of the ultra-endurance triathlon (Migliorini, 2011). Factors such as technical errors, triathletes making errors in judgement or simply accidental in nature, are reasons for falls on the bike. (Migliorini, 2011). A large percentage of triathlon races include cycle sections on an open road and triathletes may also be in danger of being involved in traffic accidents (Migliorini, 2011).

The majority of ultra-endurance triathletes appear to suffer from overuse injuries as opposed to acute injuries (Massimino et al., 1988; O'Toole et al., 1989; Wilk et al., 1995). Injuries that commonly affect endurance swimmers, cyclists and runners can and usually do effect endurance triathletes (Migliorini, 2011).

Ansell et al. (2012), and O'Toole et al.'s (1989) studies both reported a high prevalence of overuse injuries. However, in contrast, Burns et al. (2003) reported a low percentage of overuse injuries.

While there is a marked deviation in injury rates between ultra-endurance triathlon injury studies, the knee and low back are consistently stated to be the most frequently injured sites (Vleck and Garbutt, 1998; Massimino et al., 1988; Manninen and Kallinen, 1996).

2.7 Risk factors for injury

The aetiology of ultra-endurance triathlon injury may be multifactorial, with the risk factors for injury either being extrinsic or intrinsic in nature. Extrinsic risk factors refer to those factors that are independent of the triathlete while intrinsic risk factors relate to those that are inherent to the triathlete. Identifying which risk factors place a triathlete at greater risk of musculoskeletal damage is important, as from there it can possible to prevent and reduce the incidence of triathlon-related injury. Awareness of intrinsic and extrinsic risk factors offers the triathlete knowledge to prevent injury (Bahr and Krosshaug, 2005).

The first stage in identifying risk factors is injury surveillance (Finch, 2006). The second stage emphasises the importance of understanding the aetiology of injuries (Finch, 2006), i.e., the mechanism of injury. The injury mechanism and discipline of triathlon at the time of the injury is important information in understanding risk factors for triathlon and developing preventative protocols (Gosling et al., 2008).

2.7.1 Intrinsic risk factors

Intrinsic risk factors related to ultra-endurance triathlon comprise individual factors specific to a triathlete that contribute to their injury (Gosling et al., 2008). These include factors such as age (Burns et al., 2003), gender (Egermann et al., 2003), anthropometric characteristics (Vleck and Garbutt, 1998), triathlon experience (Villavicencio et al., 2006), presence or absence of previous injury (Korkia et al., 1994), and biomechanics of each discipline of the triathlon (Manninen and Kallinen, 1996; Gosling et al., 2008).

2.7.2 Extrinsic risk factors

Extrinsic factors are external factors that previous studies have found to have a link to triathlon injuries, including: training hours per week (O'Toole et al., 1989), training distance per week (Massimino et al., 1988), training sessions per week (Vleck and Garbutt, 1998), training intensity (Manninen and Kallinen, 1996), training load increases (Manninen and Kallinen, 1996), presence or absence of a coach (Collins et al., 1989), medical care (Egermann et al., 2003), strength training (Korkia et al., 1994), running surface (Korkia et al., 1994), athletic status (Villavicencio et al., 2006), triathlon competition distance (Korkia et al., 1994) and participation in other sports (Collins et al., 1989;Gosling et al., 2008).

2.7.3 Risk factors with associated injuries in accordance with each discipline

2.7.3.1 Swimming risk factors

The first leg of a triathlon starts with swimming and usually involves a mass start (McHardy et al., 2006). Triathlete's line up to start the race and they jostle for position into the first buoy which may cause the possibility of accidental collisions between the triathletes (Dallam et al., 2005).

Triathletes wear wetsuits to prevent hypothermia or abnormally low body temperature (Trappe et al., 1995) because the water is often at a temperature ranging between 13ºC and 32ºC (Dallam et al., 2005). The use of a wetsuit gives the triathlete more buoyancy and therefore, they experience less drag in the water (McHardy et al., 2006). It has been proposed that the better buoyancy and less friction through the water could possibly lead to a decrease in injuries (De Lucas et al., 2000).

Shoulder injuries are the most frequent musculoskeletal complaint in competitive swimmers (Van Dorssen and Stubbe, 2017). The majority of shoulder injuries are due to overuse or as a result of repetitive micro trauma (Coetzee, 2014). The propulsion phase of the swim stroke results in maximum forces through the upper extremity as well as extreme ranges of motion which can lead to injury (De Martino and Rodeo, 2018). The prevalence of injuries caused by swimming is low (Strock et al., 2006).

Burns et al. (2003) estimated that a small percentage of around 2% of triathlete injuries are related to swimming.

2.7.3.2 Swimming injuries related to risk factors

The majority of swimming injuries attained by triathletes are related to the shoulder region and are usually problems such as tendonitis or impingements (Strock et al., 2006). Gosling et al. (2010) reported 33 cases of injuries during the swim discipline in a season, giving a rate of 3.24 injuries per 1000 race starts, and 27 reported injuries as a result of the swimming action, giving a rate of 2.65 injuries per 1000 race starts which is relatively low.

Elbow injuries can occur during swimming and are usually due to overuse or poor swimming techniques (Weldon and Richardson, 2001). Common injuries to the elbow include triceps brachii strain and triceps brachii synovitis (Coetzee, 2014). Gosling et al. (2010) reported that as few as 6% of all injuries during a triathlon season are related to the elbow.

In some swimmers the knee has been flagged as a common area for injury (Divyanka and Dahiya, 2018). Injuries to the knee while swimming are primarily overuse in nature and often result from the breaststroke kick, as strain is placed on the medial collateral ligament (Divyanka and Dahiya, 2018). To add to this the repetitive motion during freestyle not only puts strain on the knee but could also result in tendonitis of the ankle extensor tendons (Wanivenhaus et al., 2012).

2.7.3.3 Cycling risk factors

Traumatic injuries are more commonly associated with the cycling discipline and these injuries normally include abrasions, contusions and lacerations as a result of falls (Migliorini, 2011). Overuse injuries conversely arise from an overload of the muscles, tendons or ligaments that occur as a result of trying too hard, fatigue, lack of fitness or previous injury.

Injuries from the cycling discipline of the triathlon are relatively uncommon compared to the running discipline (Cipriani et al., 1998; Burns et al., 2003), although Gosling et al. (2010) reported injuries from the cycle discipline as 3.5 times greater than the swimming discipline. From the literature it is evident that cycling injuries are usually caused by overuse factors or poor ergonomics such as incorrect bike set up (Mills, Korporaal and Jones, 2006). To expand on this the height and position of the triathletes seat, the handlebar height and position and pedal are all vitally important when training for and competing in endurance distances (Strock et al., 2006). A seat position that is too high can result in tight hamstrings or posterior knee pain while a seat that is too low could result in patellofemoral syndrome, patellar tendonitis, or iliotibial band syndrome (ITBS) (Baker and Juhn, 2000). The majority of cycling injuries have been attributed to the knee, specifically ITBS (Strock et al., 2006).

The forward flexed trunk position on the bike results in stress being placed on the neck and lower back regions while cycling (McHardy et al., 2006). Aerobars (tribars used by the majority of elite triathletes) force the triathlete to sit forward on the bike hence increasing the flexion of the thoracic and lumbar regions (Cipriani et al., 1998). This increased forward flexion of the lumbar spine results in the cervical spine being in full extension when riding (McHardy et al., 2006). Neck pain results from the triathlete extending their neck to be able to see the road ahead (McHardy et al., 2006).

This is associated with decreased thoracic spine mobility and results in a greater activation of the cervical extensor muscles to gain visibility, with negative impact on the cervical facet joints (McHardy et al., 2006).

While cycling the lumbar sacral spine is in a flexed position. This sitting position is maintained for long periods of time during endurance races and training sessions, increasing the intradiscal pressure thus predisposing the triathlete to lower back pain and possible injury (Manninen and Kallinen, 1996).

Pedalling using the incorrect gear, excessive hill climbing, and incorrect cleat placement, may overload the knee, specifically the patellofemoral joint (McHardy et al., 2006). Patellofemoral dysfunction is common in ultra-endurance triathletes that use a higher gear and for this reason cycle at a lower cadence (McHardy et al., 2006).

The second transition of an ultra-endurance triathlon from the cycle leg to the run leg is a phase in the race where the professional triathletes have the upper hand on the amateur or less experienced triathletes. The factors that play a role during this phase are less muscle fatigue, minor energy expense in the transition and a faster adaptation to the correct running technique and therefore the correct running biomechanics (Millet et al., 2000). In ultra-endurance triathlon the longer cycling period results in more time being required to regain the neuromuscular and elastic proficiency of the lower limb muscles for the correct running style (Migliorini, 2000; Migliorini and Bomprezzi 2003). In the transition phase mentioned above, there is period of time before the running technique can reach its ideal level. During this time, while training and competing, the inability of the lower limb to transfer the load forces through the locomotor apparatus, can result in the forces being transmitted into the lumbar-sacral region and to the knee (Migliorini, 2000; Chapman et al., 2007). The change from the muscles lengthening on the bike to shortening on the run, and from the unloaded cycling phase to the loaded running phase is a high injury phase during the ultra-endurance triathlon (Migliorini and Bomprezzi, 2003).

2.7.3.4 Cycling injuries related to cycling risk factors

Iliotibial band syndrome is a common injury that inexperienced ultra-endurance triathletes can experience (McHardy et al., 2006). Iliotibial band syndrome tends to affect those triathletes with a seat that is too low as well as a result of excessive hill climbing (Baker and Juhn, 2000). The reason behind this is that the ITB tendon makes contact with the bony condyle at around 30 degrees of flexion (Comfort and Abrahamson, 2010). This leads to repetitive friction of the ITB over the lateral condyle of the femur leading to inflammation of the tendon and possibly the bursa (Flato et al., 2017).

The Achilles tendon is susceptible to injury with repetitive hill climbing and this can be exaggerated when the foot is in the incorrect position, usually due to incorrect cleat placement (McHardy et al., 2006). Incorrect posture on the bike leads to poorly operating biomechanics with forces not moving through the biomechanical chain properly (Brown, 2002). This can result in issues such as patellofemoral pain syndrome, characterised by incorrect patella tracking in the femoral groove (Brown, 2002), or is due to irritation of surrounding structures (Coetzee, 2014).

Regarding the wrist or hand, an ulnar nerve lesion occurs more frequently that of the median nerve (Bales et al., 2012; Comfort and Abrahamson, 2010). Compression of the ulnar nerve occurs as it passes into the hand through Guyon’s canal (Brubacher and Leversedge, 2017). This results in sensory and motor changes. Numbness in the hand and the weakness in grip strength is commonly referred to as ‘cyclist’s palsy’ (Brubacher and Leversedge, 2017). Compression of the ulnar nerve caused by direct pressure while gripping the handle bars is common in both ultra-endurance triathletes and cyclists (Brubacher and Leversedge, 2017).

2.7.3.5 Running risk factors

The triathlete’s ability to run proficiently is generally accepted as the discipline of the race that reflects the overall race outcome (Bonacci et al., 2010).

According to literature, the majority of injuries experienced by ultra-endurance triathletes are caused while training for or competing in the running leg of the triathlon (Collins et al., 1989; Burns et al., 2003).

It has been stated that running ability is often the best predictor of an ultra-endurance triathlete’s performance (O’Toole et al., 1989), but increased training hours in running have been linked to higher injury prevalence. There is a fine balance between these two aspects (Burns et al., 2003).

Injuries during the run leg of an ultra-endurance triathlon are related to muscle fatigue, lactic acid build up and muscle tightness as a result of the swim and cycle legs that precede the run (Strock et al., 2006). Fatigue causes a decreased maximum force that the muscle can produce (Cipriani et al., 1998). The decreased force is predominantly in the plantar flexors during the swim discipline and in the hip flexors during the cycle discipline (Cipriani et al., 1998).

Due to the cycle leg being before the run, there is a lack of co-ordination caused by altered muscle recruitment patterns of the lower limbs (Heiden and Burnett, 2003; Chapman et al., 2007; Hausswirth and Brisswalter, 2008 Bonacci et al., 2010; Migliorini, 2011). Ultra-endurance triathlete’s exhibit a different gait while running compared to marathon runners due to a shorter stride (Migliorini, 2011). This shorter stride is due to a decreased hip range of motion, less thigh extension and hip flexion as well as an anterior pelvic tilt (Scarfe, 2011).

While cycling, knee extension decreases the muscular length required, due to the flexed position on the bike. This results in optimal power generation in this muscle group which takes place at longer muscle lengths in cyclists compared to runners

(Scarfe, 2011). These changes in the locomotor apparatus have been linked to decreased running technique within triathlon (Tew, 2005) and a decreased running economy (Bonacci et al., 2010).

2.7.3.6 Running injuries related to running risk factors

It has been predicted that an estimated 27% to 70% of runners will sustain an injury in a 12-month period of consistent running (Hreljac and Ferber, 2006; Collado and Fredericson, 2010). In triathletes, the knee has been documented as the most common region for injuries as is seen throughout this current study, being responsible for 30% of all training-related injuries (Tuite, 2010). Anterior knee pain is the most frequent type of knee pain and most often experienced while running (Pink et al., 1994). The reason for this is that during running the knee displays a 95-degree arc of motion and the forces exerted through the knee are approximately 4.7 to 6.9 times body weight at the patellar tendon, and approximately 7.0 to 11.1 times body weight at the patellofemoral joint (Pink et al., 1994).

The diagnosis of patellofemoral pain syndrome (PFPS), “runner’s knee,” implies pain originating from the patella and retinaculum but by definition excludes other intra-articular or peripatellar abnormalities (Van Linschoten and Koëter, 2012). Patellofemoral pain syndrome makes up approximately 25% of injuries attained to the knee (Collado and Fredericson, 2010). The cause of patellofemoral pain syndrome is multifactorial, resulting from a complex interaction among intrinsic anatomic and external training factors. It is not clearly understood and may have multiple origins especially in a multifactorial sport such as ultra-endurance triathlon (Collado and Fredericson, 2010).

A common injury related to the run leg is ITBS; the posterior border of the ITB impinges against the lateral epicondyle just after foot strike in the gait cycle. This is often related to ITB issues attained on the cycle leg and is common in non-elite triathletes (Migliorini, 2000, Migliorini and Bomprezzi 2003). As mentioned earlier, irritation results when the ITB brushes over the greater trochanter. This repetitive friction increases with abrupt increases in distance, running on a road or surface with a camber, running on a track in the same direction repetitively and leg length inconsistencies (Spiker et al., 2012). Weakness of the lateral gluteal muscles while running results in a hip drop, resulting in incorrect eccentric abduction of the femur, an unsupported pelvic girdle, and muscle tightness (Paluska, 2005; Fredericson and Wolf, 2005).

Medial tibial stress syndrome (MTSS), known more commonly as shin splints, is a common lower leg injury among runners and can often be exaggerated by the cycle leg of a triathlon (Moen et al., 2009). Medial tibial stress syndrome is defined as an overuse injury causing pain and discomfort over the posteromedial tibial border. The majority of the time MTSS arises while running and produces cyclic loading (Craig, 2009).

Running-induced stress fractures are common among endurance runners and ultra-endurance triathletes (Millet, G.P. and Millet, G.Y. 2012). Stress fractures are most commonly related to the tibia with the anterior tibial crest having the worst prognosis and the posteromedial cortex being the most common location (Harrast and Colonno, 2010).

Achilles tendinopathy and pain in the area of the Achilles tendon is common in triathletes. The Achilles is an area that is stressed and strained in both the cycle and running disciplines and therefore an area at risk of injury for ultra-endurance triathletes. Similar to that of a patellar tendinopathy, the process of Achilles tendinopathy is proposed to be degenerative in nature (Spiker et al., 2012).

2.8 Demographics

Ultra-endurance triathlon as a sport presents the opportunity to examine and investigate the effects of age and gender on ultra-endurance performance. It allows for both demographics, and the differences associated with them, to be captured and analysed in the same individuals across all three separate disciplines as well as the combination of all three (Bernard et al., 2009; Lepers et al., 2010; Lepers and Maffiuletti, 2011; Lepers, Knechtle and Stapley, 2013).

Age and gender interaction in ultra-endurance performance can be affected by the nature and duration of the physical task performed. Differences associated with gender in triathlon performance are also known to differ between the modes of locomotion (Lepers, Knechtle and Stapley , 2013).

2.8.1 Age

2.8.1.1 Age-related changes that may affect ultra-endurance triathletes

From a physiological point of view, a decrease in maximal oxygen consumption (VO2max) is the major contributor to the decline in performance with advancing age (Tanaka and Seals, 2003; Lepers and Stapley, 2016). VO2max declines by approximately 10% per decade after thirty years in healthy sedentary adults. Past studies have suggested that in master's athletes, the rate at which their VO2max declines is smaller than that of sedentary adults (Heath et al., 1981). It has also been suggested that as master's endurance triathlete's age further, the declines in the lactate threshold and locomotor efficiency decrease in performance. However, it is to a lesser extent than that of VO2max (Tanaka and Seals, 2003; Lepers and Stapley, 2016).

Tanaka and Seals (2003) suggested that maximal cardiac output and maximal arterio-venous oxygen difference decrease in master athletes. Rivera et al., (1989) and Ogawa et al. (1992) proposed that the reason for this was the reduction in both maximal heart rate and maximal stroke.

Power et al. (2010) looked at masters athletes from a neurological point. They suggested that master runners conserved the number of functioning motor units past their sixth decade of life. This study provided evidence that continued chronic activity late into life has beneficial effects not only on the muscle fibres but on the motoneuron units too. The same group of researchers also showed that world champion master athletes in their ninth decade of life had a superior number of surviving motor units, better neuromuscular transmission stability and more excitable muscle mass when compared to age-matched controls (Power et al., 2016).

Migliorini (2000) found that with ultra-endurance triathlon, those at the highest risk for injury were in the younger age categories. Migliorini (2000) also suggested that ultra-endurance distances were a risk factor for injury and that in the shorter distance triathlon events the prevalence of injury was substantially lower than that reported in the endurance triathlon events. One of the factors that could explain the higher injury rate in younger triathletes is the lack of musculoskeletal maturity and starting ultra-endurance sport too early. This combined with the lack of running experience, having taken part in swimming or cycling instead, can potentially lead to a higher injury prevalence in younger ultra-endurance triathletes (Migliorini, 2000).

Despite the systemic and bone health benefits of high-impact aerobic exercise such as running, the belief persists that running is associated with increased risk of osteoarthritis (Zlotnicki et al., 2016). Ageing is associated with a decline in muscle mass, bone density and maximal aerobic capacity. However, with age comes experience, which may play a superior role in triathlon than in other sports as triathletes need to master not one sport but three (Migliorini, 2000).

2.8.1.2 Age category performance at ultra-endurance triathlon

At the world championship ironman triathlon in Hawaii, the number of master triathletes have increased dramatically and now represent more than half of the total field for males and more than 45% of the total field for females (Lepers et al., 2013).

Several factors could play a role in why there has been such an increase in master triathletes competing in ultra-endurance events, specifically triathlon: the increase in life expectancy with modern day medicine, better training facilities and programmers that can be suited to all ages, as well as masters triathletes that have been able to retire and focus more on training and competing at a higher level (Lepers et al., 2013). Another factor to consider is the relative increase in participation of older ironman triathletes as a result of a relative decrease in ironman triathletes in the younger age groups below the age of 40 (Migliorini, 2000).

Two factors that could potentially play an important role with regards to age of ultra-endurance triathletes, is the age of peak performance and age with highest incidence rate for injury. Findings report that the age of peak performance for the ultra-endurance events is higher than that of the Olympic or sprint distances (Lepers et al., 2013). The age group with the highest risk for injury in ultra-endurance sport is the younger age groups (Migliorini, 2000).

With an increase in age, there is a trend for master's athletes to shift away from shorter and faster distance events where maximal oxygen consumption is important to the longer, slower distance events, where endurance plays a bigger role. Shaw and Ostrow (2005) suggested that fulfilment, good health, keeping fit and the social aspect of exercise are the primary reasons for sport involvement with advancing age. However, Lepers et al. (2013) stated that master's triathletes that are more achievement-oriented, aspects such as competition, personal challenge and skill development are the main drive behind their involvement in ultra-endurance triathlons.

Younger triathletes may be more frequently drawn to the shorter distances such as sprint and half ironman distance triathlons. One of the reasons suggested for this trend was that since 2000, the sprint distance triathlon became an Olympic sport, and it may have amplified the popularity of the short distance triathlon in the younger triathlete population (Lepers et al., 2013).

2.8.1.3 Age performance changes through different disciplines

With advancing age, literature suggests that total triathlon performance declines in curvilinear fashion. However, when triathlon performance is divided into its three disciplines and analysed, the age-related decline is less in cycling compared to running and swimming performances (Lepers et al., 2013).

The decline in locomotor efficiency in master athletes remains contentious and may hinge on the locomotion mode being analysed. For instance, a rise or a possible drop in efficiency with advancing age has been detected (Sacchetti et al., 2010; Louis et al., 2012; Brisswalter et al., 2014). There is also inconsistency in findings regarding the energy cost to master athletes of running. Allen et al. (1985) did not observe any differences in running economy between young and master athletes. However, Sultana et al. (2008) reported finding that the energy cost of running in master triathletes was significantly higher when compared to their young counterparts. It has been suggested that the potentially higher energy cost of running in master athletes is connected to the weaker muscle power, although a long-lasting running exercise regime seems to preserve the spring-like mechanism of master athletes (Pantoja et al., 2016). The discrepancy of the results may be ascribed to the different age and fitness level of the tested master athletes.

Stiefel et al. (2013) compiled data regarding the age of the top 10 finishers in the Hawaiian ultra-endurance triathlon as well as all the qualifiers in 2010. The results reflected that the age of peak ultra-endurance triathlon performance was 32.2 years for men and 33 years for women with no sex difference.

Knechtle et al. (2012) suggested that the changes associated with age and triathlon are also related to the duration and distance of the triathlon competition. For example, the extent of decline in cycling and running performances with advancing age for short triathlons is far less when compared to that of the longer ultra-endurance distance races (Knechtle et al., 2012). However, Lepers et al. (2013) suggested that masters' triathletes have shown improvements in performance across the three disciplines as well as triathlon as a whole over the past three decades.

2.8.1.4 Injuries related to age

In a study conducted in relation to the 2014 South African ultra-endurance race, Holtzhausen et al. (2018) reported that a total of 2 331 athletes started the race, of which, 179 athletes (7.7%) reported to the race medical areas for attention. The mean age of the patients was 37.7 years (range 21-63 years). Younger athletes between the ages of 18 to 24 years had the highest percentage requiring medical attention (14.7%), followed by athletes in the 25 to 29 year age group (12.8%). Athletes between the ages of 18 to 24 years had a significantly higher incidence of medical encounters than older athletes. Even though younger age is suggestive of less experience, it does not necessarily reflect the association. This finding may be explained by self-selection of older, more experienced athletes with less career injuries, that older athletes possibly focus more on participation than winning, or address injuries earlier, before they escalate.

A study by Gosling et al. (2010) describes the rate and profile of injuries seen for medical assistance during an ultra-endurance triathlon race series. Injury rates varied considerably between the age groups, with junior elite and the youngest competitors at increased risk of injury. This contradicts research conducted by Burns et al. (2003) who looked at age and years of triathlon experience. The study reflected that those ultra-endurance triathletes who sustained a pre-season injury were older than those who did not. However, in the study, age did not appear to be the most important factor, whereas ongoing participation in triathlon did appear to be related to an increased risk of overuse injury. Burns et al.'s (2003) study showed that the median number of years of triathlon experience for the group injured during the pre-season was significantly higher than the non-injured group.

2.8.2 Gender

2.8.2.1 Gender related differences that may affect ultra-endurance triathletes

According to Lepers, Knechtle and Stapley (2013), physiological and morphological characteristics may play a role in the gender differences seen in ultra-endurance triathlon performance. There is less available data with regards to females in ultra-endurance triathlon. This could be attributed to the smaller number of female participants in the sport (Lepers, Knechtle and Stapley, 2013).

Studies have shown that in both males and females, VO2max, lactate threshold and running economy act similarly as determinants of endurance performance (Lepers, Knechtle and Stapley, 2013). However, Joyner (1993) and Bunc et al. (1996) proposed that for gender differences in VO2max among athletes, females had more body fat when compared to their male counterparts (13% compared to 5 %). In another study on gender differences the haemoglobin concentration of athletes was 5% to 10 % lower in females than in males (Shaskey and Green, 2000). A study comparing lactate threshold, indicated that there was no difference between elite males and females because mitochondrial adaptations in the skeletal muscles of both males and females appeared to be the same (Wiswell et al., 2001). The average running economy, judged by the average oxygen consumption by groups of elite male and female athletes, was comparable and therefore played the same role in determining success in endurance performance in both males and females (Yasuda et al., 2008).

Knechtle et al. (2010a) suggested that male triathletes possess a greater muscle mass, have more muscular strength, and a lower relative body fat percentage than female triathletes. For this reason males could potentially be faster as low body fat percentage has been associated with quicker performance in ultra-endurance triathlon, with males on average having 8% less body fat than females (Knechtle et al., 2010a).

Morphological characteristics that could potentially be related to gender differences in motion and injuries are gender differences in muscle activity during locomotion, and gender-specific morphology of the pelvis and thighs (Ferber et al., 2003). For instance, the increased hip width to femoral length ratio observed in females has been suggested to increase hip adduction and lead to potential injuries of the knee and hip regions (Ferber et al., 2003). However, the relationship between hip and pelvis anthropometrics and the gender differences in lower extremity motion has not been well defined (Schache et al., 2005). Given that there are gender differences in joint kinematics, it is likely that gender differences in underlying muscle activities are also present. During certain tasks such as side-step movement or a stop-jump, females have been reported to display greater quadriceps activity (Chappell et al., 2002; Sigward and Powers, 2007) with reduced activity in the gluteus maximus and medius muscles (Zazulak et al., 2005) compared to males, resulting in a hip drop and strain placed on the contralateral side to the inhibited gluteus medius muscle (Chappell et al., 2002; Sigward and Powers, 2007). While gender variations in muscle activity have been identified in running (Von Tscharner and Goepfert, 2003), it is unclear whether the differences in muscle activity are associated with the joint kinematic differences (Whittington et al., 2007).

2.8.2.2 Gender performance differences at ultra-endurance triathlons

Most of the literature on differences between genders has focused on running (Coast et al., 2004; Cheuvront et al., 2005; Hoffman, 2008). However, less focus has been placed on the possible gender difference in swimming, cycling or triathlon performance (Lepers et al., 2008; Sultana et al., 2008). Several studies have recognised the greater age-related decline in ultra-endurance triathlon performance shown by females. Non-physiological factors such as low rates of participation of older female triathletes may, however, have contributed to this outcome (Knechtle, Knechtle and Lepers, 2011; Lenherr et al., 2012), although, according to the USA Triathlon Association, the number of females training for and competing in triathlon has increased, independent of age (USA Triathlon, 2012). However, the rates of female participation does seem to decline with an increase in triathlon distance. For example, in ultra-endurance triathlons female participation remains relatively low, representing less than approximately 10% of overall participants. (Lepers, Knechtle and Stapley, 2013; Deaner, 2013).

2.8.2.3 Gender performance changes through different disciplines

Gender differences in ultra-endurance performance for elite athletes is commonly close to 10% (Cheuvront et al., 2005), except for ultra-endurance swimming where females tend to decrease the gap with males (Lepers and Maffiuletti, 2011; Eichenberger et al., 2012).

As discussed previously VO2max plays an important role in terms of endurance performance. Cheuvront et al. (2005) suggested that men have a greater VO2max when compared to their women counterparts. This is due to several factors such as having larger hearts, larger haemoglobin concentration, decreased body fat, and larger muscle mass. Joyner and Coyle (2008) identified two other factors that restrict endurance performance, namely, an athlete's running economy and the lactate threshold, both which seem to not differ between men and women

The gap between elite males and females is of biological origin and therefore will most likely not decrease naturally. The gender difference in endurance performance increases with an increase in age. Hunter and Stevens (2013) and Senefeld et al. (2016) reported this for running, while Lepers and Maffiuletti, (2011) and Lepers et al. (2013) observed this for triathlon. This is, however, still contentious for swimming (Senefeld et al., 2016), as differences in swimming with an increase in age appears to be less than that of running, cycling and triathlon. A potential reason for this is that women have a greater depth in numbers of marathon swimmers (Senefeld et al., 2016).

Both physiological and morphological factors contribute to explaining these findings. The time difference between first place and tenth place, known as the performance density, has gradually been enhanced for international races over the past two decades for both males and females, with performance density now being the same for both sexes (Lepers et al., 2013).

Due to the lower participation rate and lack of depth among women master competitors in ultra-endurance triathlons, the gap between the genders in endurance performance is more than likely going to amplify (Hunter and Stevens, 2013).

Overall, the literature of gender differences in triathlon injuries is limited. It is not known precisely whether the gender differences may be related to training behaviours, or to biological differences such as bone density and weight, hormonal differences, ligamentous laxity and muscular strength.

2.8.2.4 Injuries related to gender

Several studies investigating gender differences related to injuries have suggested that females are at a higher risk of sustaining a running injury. Of these the most common are PFPS, ITBS, or an injury to the gluteus medius muscle (Taunton et al., 2002; Geraci and Brown, 2005). Gender differences have been marked as a potential risk factor for injuries, especially running injuries (Ferber et al., 2003; Schache et al., 2005. While running, females exhibit greater frontal and transverse plane motions compared to males. This results in increased peak hip internal rotation and adduction (Ferber et al., 2003), and an increased peak knee valgus or abduction (Malinzak et al., 2001; Ferber et al., 2003). This increased non-sagittal plane motion has been suggested as contributing to a variety of running injuries (Fredericson et al., 2000; Leetun et al., 2004; Niemuth et al., 2005; Noehren et al., 2007).

Ristolainen et al. (2009) suggested that the knee had been the main focus of most studies focusing on injuries between the genders, while only slight attention had been directed towards overall injury rates between the genders. A study focused on injuries related to gender and specific location of injuries concluded that female athletes were more prone to injuries affecting the hip, lower leg and shoulder, while males were more prone to injuries of the thigh and shoulder (Sallis et al., 2001). In contrast, Satterthwaite et al. (1999) suggested that in marathon runners, males were more likely to injure the hamstring and calf regions than females.

At both the 2013 and 2014 Ironman South Africa triathlon, male patients comprised 79% and female patients 21% of the total number of athletes treated (Ironman South Africa, 2013). No statistical difference between female and male medical encounter rates were found in this study as of all the competitors that started the race, 82% were male and 18% female. Further studies are needed to identify possible gender-specific modifiable risk factors in ultra-endurance athletes (Holtzhausen et al., 2018).

2.9 Conclusion

As far as the researcher is aware, the research conducted by Ellapen et al. (2011) and Coetzee (2014) has been the only research related to triathletes in South Africa. However, the majority of this research has been on the shorter triathlon distances and has not taken age and gender into account for potential risk factors for injury. Research investigating the prevalence of South African triathlon-related musculoskeletal injuries will help ultra-endurance triathletes in both training, competing and prevention of injuries (Ellapen et al., 2011).

There is a need to educate medical professionals such as chiropractors and physiotherapists on the injury profile and possible risks associated with age or gender of these athletes, so that they are better prepared to treat and design interventions to prevent injuries in ultra-endurance triathletes (Ansell et al., 2012).

From a South African perspective, this study has importance due to this country having a very active population as a result of both the suitable warm climate as well as being a sport driven nation. From the results one can concur that the South African ultra-endurance triathletes in this study vary across all age groups and gender.

The increase in popularity of ultra-endurance triathletes internationally, but more importantly in South Africa, across both age and gender, the lack of literature on ultra-endurance triathlete injuries and the potential of finding associations between injury and demographic factors (i.e. age and gender), are all important factors contributing to the need of this injury profile study.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter describes the research methodology and procedure, and the questionnaire used to collect data for this study. The statistical analysis is also discussed in this chapter.

3.2 Methods

3.2.1 Research study design

This research was a cross-sectional, retrospective study which documented ultra-endurance triathlon-related musculoskeletal injuries. Based on this design the study was approved by Durban University of Technology Institutional Research Ethics Committee (IREC) (Appendix A).

3.2.2 Study population

The sample population was ultra-endurance triathletes that were registered with My Training Day or associated with My Training Day in South Africa that were actively training throughout the year leading up to, as well as competing in, the 2017 South African ultra-endurance triathlon. Participation was by voluntary informed consent (Appendix K). My Training Day is one of the biggest triathlon coaching academies in South Africa, with 11 coaches coaching over 300 athletes from South Africa and internationally. Training programmes are designed to suit the individual athlete, then training and races are planned and monitored/analysed throughout the year, mainly via online interaction and web applications (My Training Day, 2017).

This study attempted to get the highest possible response rate so the sampling procedure involved inviting all ultra-endurance triathletes from across South Africa who were members of My Training Day and who had already taken part in the 2017 South African ultra-endurance triathlon event, to take part in this study. This ensured that the sampling included ultra-endurance triathletes from all parts of South Africa and represented the general population of ultra-endurance triathletes in South Africa and not specifically triathletes from one province. This commonality implied that the results of the study were applicable and generalisable to groups of ultra-endurance triathletes from all parts of South Africa.

3.2.3 Participant recruitment

Permission was obtained from My Training Day (Appendix B) to participate in the study and to distribute the online survey to their triathletes. All triathletes eligible to take part in the study were contacted via email and were only contacted once.

3.3 Participant sampling

3.3.1 Population size

At the time of IREC approval from the Durban University of Technology, 100 My Training Day members were registered for the 2017 South African ultra-endurance triathlon. A maximum response rate (full sample) was attempted due to the small population size. With a realistic 10%-15% attrition rate anticipated (Schoenbach and Rosamond, 2000), and the need for some triathletes to participate in the expert group and the pilot study, a sample rate of 70% (70 triathletes of the total sample) was established as the minimum response rate to complete data collection and to ensure validity and minimal bias in the sample.

3.3.2 Inclusion criteria

- All athletes that participated in the 2017 South African ultra-endurance (South African Ironman race – 02nd April 2017) event that were over the age of 18 years.
- Any person that was registered with or affiliated to My Training Day from the date of IREC approval.

3.3.3 Exclusion criteria

- Any person who declined the invitation to participate or who did not any person who did not voluntarily agree by clicking yes on the online survey with the letter of information and informed consent to participate in the main study.
- Participants of the expert or pilot study groups.

3.4 Measurement tool

3.4.1 Questionnaire development

The research measurement tool was a descriptive, cross-sectional retrospective survey to obtain data from the population of ultra-endurance triathletes in South Africa. After questionnaire development, and upon approval of the study by IREC, an expert group and a pilot study were conducted to determine the validity of the questionnaire.

Validity of a questionnaire includes: face validity, construct validity, content validity and criterion validity. The definitions of these concepts and how they were addressed in the questionnaire follows (definitions taken from Bernard and Bernard, 2012).

Face validity: The questionnaire measures what it is intended to measure.

Content validity: The content of the questionnaire is considered effective, well rounded enough and represents the entire range of possible concepts the questionnaire should cover.

Construct validity: The ability of the questionnaire to actually measure the concept being studied.

Criterion validity: When a particular tool produces similar results when compared with another tool already known to be trustworthy. This type of validity was addressed as part of this current research and has only been included for completeness in discussing validity.

Questionnaires have been shown to be a valid and reliable way to extrapolate information. The use of a questionnaire for this study is effective, practical and allows a large amount of information to be collected from a group of people in a short period of time and in a relatively cost-effective way. A questionnaire-based survey can be carried out by the researcher or by any number of people with limited effect to its validity and reliability. The results of questionnaires can be analysed scientifically and objectively by either a researcher or through the use of a software package. When the data has been quantified, it can be used to compare and contrast with other research and may be used to measure change as well as add to the related literature.

The original questionnaire was adapted from Coetzee (2014) (see Appendix C for approval). The pre-pilot group questionnaire (Appendix G) consisted of three sections, i.e. sections A, B and C. The questions in Section A addressed the demographics and race history. Section B focused on injuries leading up to the 2017 South African ultra-endurance triathlon and Section C focused on injuries obtained on the race day of the South African ultra-endurance triathlon. Both sections B and C involved location, severity, injury duration, number of injuries and treatment.

This method of data collection may have exhibited some bias (Mouton, 1996) with the potential for some ultra-endurance triathletes reporting more injuries or exaggerating their severity, whereas healthy triathletes may have considered this study of no value and therefore not agreed to participate.

3.5 Research tool

3.5.1 Expert group

An expert group can be defined as “A group of interacting individuals having some common interest or characteristics, brought together by a moderator, who uses the group and its interaction as a way to gain information about a focused issue” (Masadeh, 2012). Expert groups conduct reviews in the early stages of questionnaire formulation to help with the structuring and the development of the questions. The expert group was composed of individuals who evaluated the questionnaire (Appendix G) for potential problems, and misunderstandings, before conducting the study. There was a structured discussion with regards to each question, and the errors in the questionnaire (Appendix F) were noted and corrected. All members of the expert group were given a letter of information, an informed consent form (Appendix E) and a code of conduct (Appendix D). The pre-pilot questionnaire was discussed at the expert group.

3.5.2 Procedure for the expert group

The researcher contacted potential participants who were interested and willing to participate in the focus group meeting. The researcher sent the details regarding location, time and the expected duration of the meeting to these participants. Upon arrival, the researcher welcomed them and, before commencement of the meeting, indicated that all procedures from that point forward would be voice recorded. The participants were thereafter asked to read and sign the letter of information and informed consent (Appendix E) and the code of conduct (Appendix D). The participants were free to ask questions or voice concerns they may have had prior to the completion of the documents. The researcher informed the participants that at any point a participant could ask a question or raise a concern with regards to the research or procedure of the meeting and that all comments would be regarded as equally valid. The researcher went through each question individually and received feedback from the members of the expert group. Once every member was happy with the question and a unanimous decision had been made, the researcher moved on to the next question. The researcher took notes on all comments and recommendations made during the expert group meeting. Once the focus group meeting had been completed and all discussions agreed upon, all the documents were collected by the researcher. The participants of the focus group were thanked and offered refreshments.

The changes and recommendations made and discussed by the expert group are listed in Appendix F. The changes to the pre-pilot group questionnaire from the expert group led to the development of the pilot study questionnaire (Appendix H)

3.5.3 Inclusion criteria for the expert group

- The researcher and the research supervisor.
- Chiropractor.
- Two chiropractic students, currently completing their Masters degrees at the Durban University of Technology.
- A person proficient in the research field.
- An ultra-endurance triathlete.
- Participants who read and signed the letter of information and informed consent (Appendix E) and code of conduct (Appendix D).

3.5.4 Pilot study

The term pilot study refers to a micro version of a full-scale study, also called a ‘feasibility’ study, as well as the specific pre-testing of a particular research instrument such as a questionnaire or interview schedule. Pilot studies are a crucial element of good study design. Pilot studies fulfil a range of important functions and can provide valuable insights for other researchers (Van Teijlingen and Hundley, 2010).

The pilot study is usually conducted once the pre-pilot study group questionnaire (Appendix G) has been developed and critiqued by the focus group. The objective is to determine how long the questionnaire takes to complete and how the questions are perceived and understood by members of the study population.

The pilot study questionnaire was distributed in the same manner as the main study, i.e. electronically. The pilot study was conducted on two, selected, ultra-endurance triathlete participants, after provisional ethical approval was granted for the study. The selected participants were required to read and complete the letter of information (Appendix J), informed consent (Appendix K) and the pilot study questionnaire (Appendix H). The researcher was available via email or phone to answer any questions the participants may have had. Once completed, final alterations were made to the questionnaire.

No further changes were made to the pilot study group questionnaire by the pilot study participants, therefore, the pilot study group questionnaire (Appendix H) became the final questionnaire (Appendix I) for the main study.

3.5.5 Inclusion criteria for pilot study

- Participants were required to be over the age of 18 and to have taken part in the 2017 South African Ironman triathlon.
- Completion of a letter of information (Appendix J) and informed consent form (Appendix K) by the participant.

3.5.6 Exclusion criteria for pilot study

- Any participants not meeting the above criteria and/or unwilling to sign the required documents for the pilot study.

3.5.7 Main study

Once final approval was granted by IREC (Appendix A), and My Training Day had granted permission (Appendix B) for the study to be conducted, the researcher administered the questionnaires (Appendix I) via email to the triathletes who met the inclusion criteria.

The triathletes that were eligible and agreed to take part in the study were sent the questionnaire via the use of Survey Monkey, an online survey tool. The questionnaire started with the letter of information (Appendix J) followed by the letter of informed consent (Appendix K). On opening the document an electronic yes and no button appeared. For the triathlete to start the questionnaire they were required to click on ‘yes’ which meant they had agreed to the letter of information and had given consent to take part in the study. If they selected the ‘no’ button they were immediately taken off the survey and thanked for their time.

Data was collected over the period October 2017 to March 2018, a period of six months. The electronic method of data collection was chosen in preference to posted questionnaires or questionnaires delivered by a neutral third party. The reasons for this included the decreased return rate of questionnaires in studies where postal surveys are utilised (Lapane et al., 2007), affecting the viability of the sample and biasing the results, the ability to collect data from different provinces of South Africa via the electronic online survey, and being able to ensure that the completed questionnaires were returned immediately and directly to the researcher on completion.

Participants worked through the questionnaire systematically and once completed were thanked for their participation and time. The completed questionnaire was immediately returned to the Survey Monkey data base where the researcher could access it. The researcher had a private Survey Monkey account with a username and password which were required to access the site, ensuring that all data captured was confidential and only seen by the researcher and later by the statistician. This information was safely stored on an external device at Durban University of Technology. Throughout the entire research process the researcher was available via email or telephone to answer any questions.

The participants were not required to divulge any personal information regarding their identity. The letter of information and letter of informed consent were included the questionnaire and therefore were answered and returned with the online survey.

All completed questionnaires were analysed by the researcher, saved onto an Excel spreadsheet and into an SPSS format and then forwarded to the statistician. The data was then analysed by the statistician, returned to the researcher and this information was then converted into Chapter 4, which presents and gives a short discussion on the results of the study. The number issued to the participant's questionnaire was used on the data sheet to maintain confidentiality. The questionnaires were all coded and no names were recorded in this study to keep the participants' identity confidential and anonymous.

3.6 ETHICAL CONSIDERATIONS

- The participants were not asked to divulge any personal information; all questionnaires were coded to ensure confidentiality.
- The collected research data will be kept safely in the Chiropractic Department for a period of five years, and then deleted.
- Permission was obtained from the founder of My Training Day (Appendix B), and every participant by means of a letter of information (Appendix J) and informed consent (Appendix K).
- Participation in the study was voluntary and no coercion was used.
- To ensure the ethical principle of autonomy, each participant was required to read a letter of information (Appendix J) and complete the informed consent form (Appendix K) which was collected by the researcher.
- If at any point while answering the questionnaire, the participant felt discomfort in answering certain questions, they were free to withdraw from the study without prejudice.
- There were no risks involved in completing the questionnaire and the participants were not harmed.
- There was no discrimination in terms of race and gender. All members of the population who met the study inclusion criteria were asked to participate in the study.
- Participation in the study was voluntary and no remuneration was awarded to the participants.

- A copy of the dissertation will be available on the Durban University of Technology library website with a link sent to My Training Day for them to be able to access it.

3.7 DATA ANALYSIS

The data was coded and entered on an Excel spread sheet. The data was analysed using IBM SPSS version 24 software. The level of statistical significance was set at $p \leq 0.05$. Descriptive and inferential methods were used to analyse the objectives. Prevalence of injury and characterisation of the risk factors was initially described using frequencies and percentages with 95% confidence intervals. Continuous variables were described using means and standard deviations if normally distributed. In order to assess the associations between risk factors and injury, bivariate analysis was conducted with Pearson's chi square tests for categorical risk factors and t-tests for continuous variables. Multiple logistic regression analysis was used to arrive at a final risk factor set which was adjusted for the effect of confounding. Odds ratios and 95% confidence intervals were reported (Esterhuizen, 2018).

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results obtained from the data collection process. This chapter includes both the results and discussion in relation to the original study objectives. This facilitates more comprehensive reporting and analysis of the respective objectives.

Bar graphs and tables are used to graphically present the data, with a short description accompanying each bar graph or table. The results and discussion are organised as they relate to the respective objectives (one to three) of this research study.

This chapter reports the characteristics of South African ultra-endurance triathletes with regards to age and gender. The training demographic profile details a variety of training parameters, followed by discussion of injuries in terms of location, severity, duration and treatment. The past and periodic prevalence of the injuries are subsequently presented. Finally, the associations between injury profile and selected risk factors (age and gender) for injury are identified.

After the three primary objectives have been discussed, there is a section discussing questions that were part of the questionnaire, but did not relate directly to the objectives. They add background information regarding ultra-endurance triathletes' training regime to better understand the results discussed in objectives one to three.

4.2 Statistical methodology

IBM SPSS version 25 was used to analyse the data. Descriptive analysis was presented as means and standard deviations for continuous variables, and frequencies and percentages for categorical variables. Prevalences are presented as estimates and 95% confidence intervals. Factors associated with injury were assessed using Pearson's chi square tests. A p value < 0.05 was considered as statistically significant.

4.3 Ultra-endurance triathlete participation

4.3.1 Population

A total of 100 questionnaires were sent out to participants, and 86 questionnaires were returned of which 71 were deemed viable by the statistician. This ensured the response rate was 71%. All 71 questionnaires were analysed for statistical purposes. The sample size (n) for this study was, therefore, 71.

4.3.2 Response rate

There were 100 active ultra-endurance triathletes in My Training Day at the time of IREC approval to commence data collection for this study. In order to gain as high a response rate as possible, to minimise bias, and to enable the findings to be generalised across international ultra-endurance triathlon populations, the whole population was invited to participate in the study (McHardy et al., 2006; Lapane, Quilliam and Hughes, 2007). The statistician indicated that a 70% and higher response rate was would be adequately from a statistical analysis point of view (Esterhuizen, 2018). The total sample size required for this study was a minimum of 70 participants. A total of 86 triathletes responded, however only 71 of the participants were considered for the study as 15 participants did not fully complete the questionnaire. Therefore, the minimum response rate required by IREC (70%) was attained.

4.3.3 Discussion of the response rate and study method: population size

By comparison to a previous study conducted on triathletes within the South African context, this study was able to achieve a significantly higher response than Ellapen et al. (2011). It should be noted that the study by Ellapen et al. (2011) was on triathletes participating in Olympic and sprint triathlon.

The response rate achieved for this study is higher than previous studies which have achieved response rates between 20.2% (Zwingenberger et al., 2014) to 55% (Shaw et al., 2004). This helps strengthen the validity and reliability of the results of this study. However, the response rate of this study was lower than Vleck et al. (2010), who attained 95% (ironman triathletes), but the sample size for this study was larger than those analysed by Vleck et al. (2010). The results from this current study could, therefore, reflect a truer clinical picture of triathlete injuries.

4.4 Objective One

To determine the profile (prevalence [past and periodic], location and severity) of musculoskeletal injuries in ultra-endurance triathletes in South Africa during one season.

Questions 14 to 26 of the research questionnaire (Appendix K) pertain to Objective One, excluding the questions on treatment received (questions 18, 19 and 23)

4.4.1 Past prevalence of musculoskeletal injuries in ultra-endurance triathletes in South Africa

Table 4.1 shows the past prevalence of musculoskeletal injuries that occurred in the year leading up to the ultra-endurance triathlon.

Of the 71 ultra-endurance triathletes, the majority of participants (53.5%) did not have any injuries in the year leading up to the 2017 event. However, 26.8% had one injury, and the rest had two or three injuries. Overall there were 33 (46.5%, 95% confidence interval 34.7% to 58.6%) who had at least one injury in the year leading up to the event.

Table 4.1: Injuries in the year leading up to the 2017 ultra-endurance triathlon

Number of prior injuries		Frequency	Percent
Valid	0	38	53.5
	1	19	26.8
	2	8	11.3
	3	6	8.5
	Total	71	100.0

4.4.1.1 Discussion

The results of this study reflect a lower prevalence of injuries than that of Andersen et al. (2013) who investigated overuse and acute injuries among iron-distance triathletes throughout a training season. The average prevalence of overuse problems was 56%. Galera et al. (2012) also reported a higher prevalence of injuries with just over half of the triathletes (52.4%) who responded to the survey reported having been injured at least once during the past season.

The prevalence rate of this study was close to but lower than the study of Burns et al. (2003) where 50% of triathletes sustained an injury in the 6-month pre-season at an injury exposure rate of 2.5 per 1000 training hours.

A reason for lower prevalence in this study could relate to a higher number of participants that took part in all three of the above studies. Further, Andersen et al. (2013), Galera et al. (2012) and Burns et al. (2003) all collected data on a weekly basis which could result in a more accurate capture of injuries.

4.4.2 Location of musculoskeletal injuries in the year leading up to the South African 2017 ultra-endurance triathlon

Regarding Injury One (the most severe injury) in the year leading up to the 2017 ultra-endurance triathlon, the majority 12 (36.4%) of the participants who reported injuries injured the posterior compartment of the lower limb, being the hamstring or calf. The least affected area for Injury One was the arm or elbow region with 1 (3.0%) participant (Table 4.2).

Regarding Injury Two (the second most severe injury), 4 (28.6%) of the participants injured the shoulder and 4 (28.6%) injured the hamstring/calf region. No injuries were recorded for the arm/elbow regions (Table 4.2).

Regarding Injury Three (the least severe injury), the same trend occurred as with Injury Two, with 2 (33.3%) of the participants injuring the shoulder and 2 (33.3%) injuring the hamstring/calf region. No injuries were recorded for the arm/elbow or knee/quadriceps regions (Table 4.2).

Table 4.2 represents the locations of injuries that occurred in the year leading up to the 2017 South Africa ultra-endurance triathlon.

Table 4.2: Location of injuries occurring in the year leading up to the 2017 ultra-endurance triathlon

	B - Shoulder		C - Arm / Elbow		F - Lower back		G - Hamstring / Calf		H - Knee / Quadriceps		I - Achilles / Ankle / Foot	
	n	%	N	%	n	%	n	%	n	%	n	%
area injured (1)	2	6.1%	1	3.0%	3	9.1%	12	36.4%	7	21.2%	8	24.2%
area injured (2)	4	28.6%	0	0.0%	2	14.3%	4	28.6%	2	14.3%	2	14.3%
area injured (3)	2	33.3%	0	0.0%	1	16.7%	2	33.3%	0	0.0%	1	16.7%

4.4.2.1 Discussion

The anatomical sites of injury reported in the current study were consistent with previous reports irrespective of whether the injury information was collected prospectively or retrospectively (Gosling et al., 2010). The triathlon injury literature states that the knee is a common site for injury ranging between 21.9% and 44% (Vleck et al., 2010; Ansell et al., 2012). Similarly, some studies classified injuries per region (e.g. lower limb), and these results indicate a dominance of knee injuries in that category: 19% (Burns et al., 2003) and 68.8% (Galera et al., 2012). This study found that knee injuries had a prevalence of 14.3% to 21.2% and were not the most common site for injury. However, hamstring and calf injuries, which had the highest prevalence ranging from 28.6% to 36.4% could involve knee injuries if one had to break down the general locations into specific diagnoses. Therefore, the findings of this study could be in keeping with other studies.

The results from this study, show a prevalence of lower back injuries ranging from 9.1% to 16.7% which correspond with studies which found low back injuries as a common site of pain ranging between 17.9% and 72% (O'Toole et al., 1989). Studies by Ellapen et al. (2011) and Ansell et al. (2012) similarly showed the low back to be a common site of pain at 16.9% and 34.1%, respectively.

By contrast, the results indicate that shoulder injuries represent up to 33.3% of injuries within the prior year leading up to the South African 2017 ultra-endurance triathlon. A potential correlation could be that the majority (42.3%) of the triathletes found that swimming was their weakest discipline and potentially linked to the relative amount of training devoted to swimming training compared to cycling and running (Collins et al., 1989; O'Toole et al., 1989; Manninen and Kallinen, 1996; Vleck and Garbutt, 1998). Factors such as the South African warm climate could also play a role as more time is spent outdoor swimming which could place strain on the shoulder region compared to studies in other countries.

4.4.3 Severity of musculoskeletal injuries in the year leading up to the South African 2017 ultra-endurance triathlon

The severity of Injuries One to Three is shown in Table 4.3 as an average on a scale of 1 to 100.

Of the 33 participants in Injury One, the mean standard deviation (50) was 54 ± 24. The mean for Injury Two, with 13 participants was 43 ± 23 and the mean ± 50 for Injury Three, with 6 participants was 46 ± 21.

Table 4.3: Severity of the injuries occurring in the year leading up to the South African 2017 ultra-endurance triathlon

	Valid N	Mean	Standard Deviation±
What was the severity of this injury? 1	33	54	24
What was the severity of this injury? 2	13	43	23
What was the severity of this injury? 3	6	46	21

4.4.3.1 Discussion

The severity scale of this study found a mean ranging from 43 to 54. The severity of the injuries acquired were moderate, taking into account that 1 is the least degree of severity and 100 is the the highest degree. These results correlate with a study conducted using the Kee and Seo Pain Rating Scale to determine the intensity of musculoskeletal pain experienced by the triathletes (Ellapen et al., 2011).

In contrast, Andersen et al. (2013) recorded lower severity scores. As in the current study, the severity score of Andersen et al.'s (2013) study was rated from 0 to 100. The severity was calculated slightly differently in that the score for each anatomical region was calculated each time a questionnaire was completed. Average weekly severity score showed 27 for shoulder, 26 for lower back, 28 for thigh, 30 for knee and 32 for lower leg (Andersen et al., 2013).

4.4.4 Duration of musculoskeletal injuries in the year leading up to the South African ultra-endurance triathlon

Table 4.4 presents the duration of Injuries One to Three in the year leading up to the ultra-endurance triathlon

Of the 33 participants in Injury One, there was an even split with 11 (33.3%) injured for less than a month and 11 (33.3%) injured for less than three months. Two participants (6.1%) were injured for more than a year. Injury Two showed that of the 13 participants, the majority, 7 (53.8%), were injured for less than a month and a minority 2 (15.4%) for more than 6 months.

Injury Three showed that of the 6 participants the majority were injured for less than one month.

Table 4.4: Duration of injuries occurring in the year leading up to the South African 2017 ultra-endurance triathlon

		Count	Column N %
How long did you have the injury for? 1	Less than 1 month	11	33.3%
	Less than 3 months	11	33.3%
	More than 3 months	4	12.1%
	More than 6 months	5	15.2%
	More than a year	2	6.1%
How long did you have the injury for? 2	Less than 1 month	7	53.8%
	Less than 3 months	3	23.1%
	More than 3 months	1	7.7%
	More than 6 months	2	15.4%
How long did you have the injury for? 3	Less than 1 month	4	66.7%
	Less than 3 months	1	16.7%
	More than 3 months	1	16.7%

4.4.4.1 Discussion

The results correlate with Andersen et al. (2013) where 9% of all cases did not lead to any time loss, 34% were of minimal severity (1 to 3 days of time loss), 36% were mild cases (4 to 7 days), 19% were of moderate severity (8 to 28 days) and 3% of all cases were of more than 28 days' severity. There is a correlation in that the majority of injuries from the current study had a duration of less than 1 month, however, the time frames between the current study and Andersen et al. (2013) are different as there is less data regarding chronic injuries lasting longer than a month.

4.4.5 Prevalence of musculoskeletal injuries that occurred on the day of the South African 2017 ultra-endurance triathlon

Eleven of the participants started the 2017 event with an injury. Seven participants sustained an injury during the event (9.85%, 95% confidence interval 4.6 % to 20.7%). Of these 7, two already had an injury, so it is unclear whether these were new injuries. There were 8 injuries in the 7 athletes who were injured during the event (one athlete had two injuries at the event).

Table 4.5 reflects the number of participants that were injured on race day of the South African 2017 ultra-endurance race.

Table 4.5: Number of injuries on race day

Total participants	Number of injured ultra-endurance triathletes on race day (Frequency)	Number of injuries on race day	Percent
71	7	8	9.85%

4.4.5.1 Discussion

These results correlate with data captured from the 2014 South African ultra-endurance triathlon, where a total of 2 331 athletes started the race. During the event, 179 athletes (7.7%) reported to the race medical areas for attention. This represents 76.8 medical events per 1 000 race starters (Holtzhausen et al., 2018). Even though the number of triathletes recorded from the 2014 South African ultra-endurance triathlon was considerably higher, the percentages were very similar with 9.85% of the participants in this study obtaining an injury on race day.

4.4.6 Location of musculoskeletal injuries that occurred on the day of the South African 2017 ultra-endurance triathlon

Of the 7 participants that were injured on race day there was an equal split with 2 (28.6%) participants injuring the shoulder region, 2 (28.6%) injuring the hamstring / calf region and 2 (28.3%) injuring the knee / quadriceps region. Only one individual experienced two injuries on race day (Table 4.6).

Table 4.6: Location of musculoskeletal injuries

		Count	Column %
Injury 1	B - Shoulder	2	28.6%
	F - Lower back	1	14.3%
	G - Hamstring / Calf	2	28.6%
	H - Knee / Quadriceps	2	28.6%
Injury 2	I - Achilles / Ankle / Foot	1	100.0%

4.4.6.1 Discussion

Seventeen musculoskeletal diagnoses were recorded on the day of the 2014 South African ultra-endurance triathlon: 10 (4.7%) overuse injuries (low back pain, Achilles tendon pain, peroneal tendon pain, cervical muscle spasm, patellofemoral pain, and iliotibial band friction syndrome), and 7 (3.3%) acute traumatic injuries (muscle sprains, ankle sprains, and shoulder dislocation) (Holtzhausen et al., 2018). Even though the area of injury was more specific, and the cause of injury was determined (overuse or traumatic) by the researchers, the results correlate with the current study as lower back, knee, shoulder, ankle and Achilles tendon all correlate with the data captured by them (Holtzhausen et al., 2018).

4.4.7 Severity of musculoskeletal injuries that occurred on the day of the South African 2017 ultra-endurance triathlon

The severity of Injury One is shown below as an average on a scale of 1 to 100. The mean ± SD was 62 ± 34 (Table 4.7).

Table 4.7: Severity of musculoskeletal injuries that occurred on the day of the South African 2017 ultra-endurance triathlon

	Valid N	Mean	Standard Deviation
What was the severity of this injury? 1	7	62	34
What was the severity of this injury? 2	1	56	.

The severity of injuries on race day were considerably more numerous than the injuries in the year leading up to the South African ultra-endurance triathlon. A potential link for this could be an increased percentage of traumatic injuries. Zwingenberger et al. (2014) found that injuries during competition included contusions and abrasions (22%), muscle or tendon injuries (46%), and capsule or ligament injuries (32%). The cause of injuries was found to be overuse (70%) and acute trauma (30%). When comparing injury results from the 12-month period before the race to injuries on race day, the location does not differ; however, there is a far greater incidence of traumatic injuries (Zwingenberger et al., 2014).

4.4.8 Summary of Objective One

Looking at the past prevalence of injuries acquired during training (46.5%) compared to the periodic prevalence of injuries on race day (9.85%), this study found that injuries occurring in the training year leading up to the race were four times more prevalent than those injuries occurring on race day.

Injury location for injuries recorded in the year leading up to the 2017 South African ultra-endurance event showed that the hamstring / calf (posterior lower limb), Achilles tendon / ankle, knee, lower back and shoulder made up the majority of the injuries. From a South African perspective this correlates with international studies of O'Toole et al. (1989), Vleck and Garbutt, (1998), Egermann et al. (2003), Ansell et al. (2012) and Andersen et al. (2013).

When comparing the above injuries to the injuries obtained on race day, the locations are very similar with shoulder, hamstring / calf and knee making up the majority of injuries.

The severity of injuries in the year leading up to the race compared to the severity on race day, show that the severity is worse on race day. This could correlate with a higher percentage of traumatic injuries.

4.5 Objective Two

To determine the selected risk factors, being age and gender, for injuries occurring in ultra-endurance triathletes in South Africa

The participants in this study were required to be over the age of 18 and had to have taken part in the 2017 South African ultra-endurance triathlon.

Questions 2, 3 and 4 of the research questionnaire (Appendix K) pertain to Objective Two.

4.5.1 Age

A total of 5 (7.1%) participants were between 18 and 24 years of age, 13 (18.3%) were between 25 and 29 years of age, 18 (25.7%) were between 30 and 34 years of age (most common age group), 5 (7.1%) were between the ages of 35 and 39, 11 (15.7%) were between 40 and 44 years of age, 6 (8.6%) were between 45 and 49 years of age, 9 (12.9%) were between 50 and 54 years of age, and 3 (4.3%) were between 55 and 59 years of age (the lowest age group) (Table 4.8 and Figure 4.1). One individual did not report age but was still included in the study, hence, the one missing statistic.

Table 4.8: Study participants described by age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 to 24	5	7.0	7.1	7.1
	25 to 29	13	18.3	18.6	25.7
	30 to 34	18	25.4	25.7	51.4
	35 to 39	5	7.0	7.1	58.6
	40 to 44	11	15.5	15.7	74.3
	45 to 49	6	8.5	8.6	82.9
	50 to 54	9	12.7	12.9	95.7
	55 to 59	3	4.2	4.3	100.0
	Total	70	98.6	100.0	
Missing		1	1.4		
Total		71	100.0		

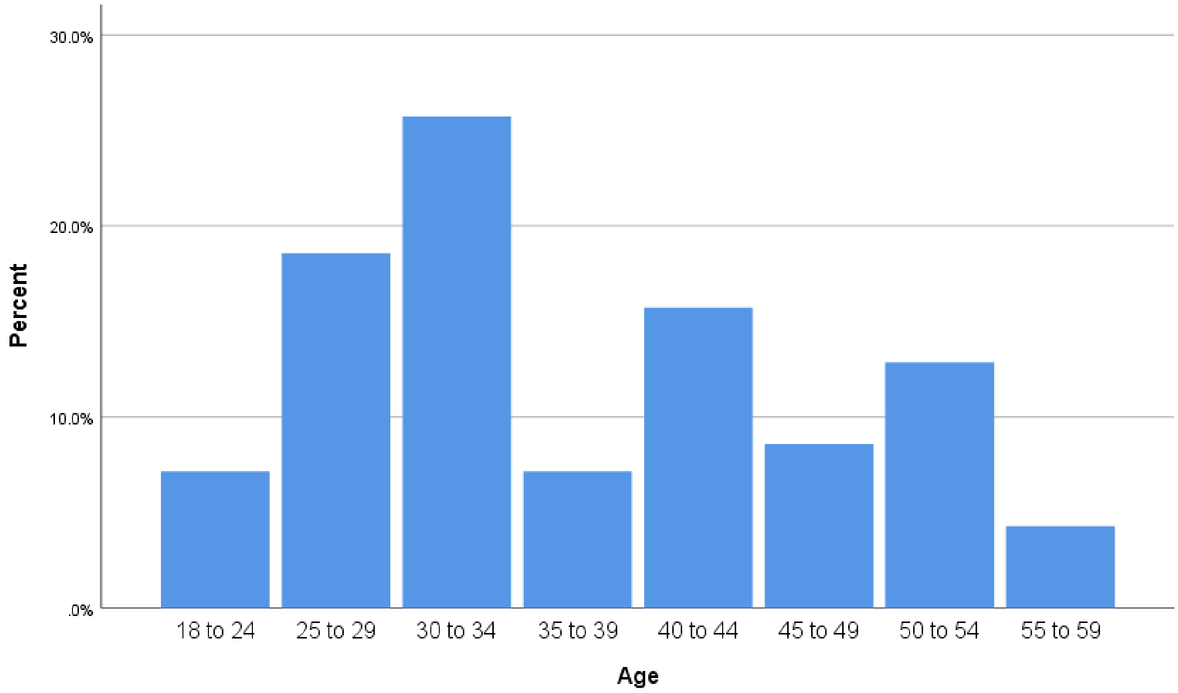

Figure 4.1: Study participants described by age

4.5.1.1 Discussion

The results of the current study correlate with the following studies. The average age of the study conducted by Clements et al. (1999) was 31 years with 79% being men and 21% women. The age of the participants was broken down into age groups that correlated to those of this study. Burns et al. (2003) collected data from 131 triathletes with an average age of 33.7 years. Coetzee (2014) collected data from triathletes in South Africa and had an average of 31.64 years of age with a minimum age of 18 and a maximum age of 64. In this current study the oldest triathletes ranged from 55 to 59 years of age, however, triathletes can and are still competing in the 70 and upwards categories.

4.5.2 Age of first participation in an ultra-endurance triathlon

Eleven (15.5%) of the participants started ultra-endurance events between the ages of 18 and 24. The majority of the athletes had been participating since they were between 24 and 29 years (32.4%) with the lowest percentage being in the group 50 to 54 years of age with 1 (1.4%) participant (Table 4.9 and Figure 4.2).

Table 4.9: Age of first participation in an ultra-endurance event

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 to 24	11	15.5	15.5	15.5
	25 to 29	23	32.4	32.4	47.9
	30 to 34	14	19.7	19.7	67.6
	35 to 39	9	12.7	12.7	80.3
	40 to 44	6	8.5	8.5	88.7
	45 to 49	7	9.9	9.9	98.6
	50 to 54	1	1.4	1.4	100.0
	Total	71	100.0	100.0	

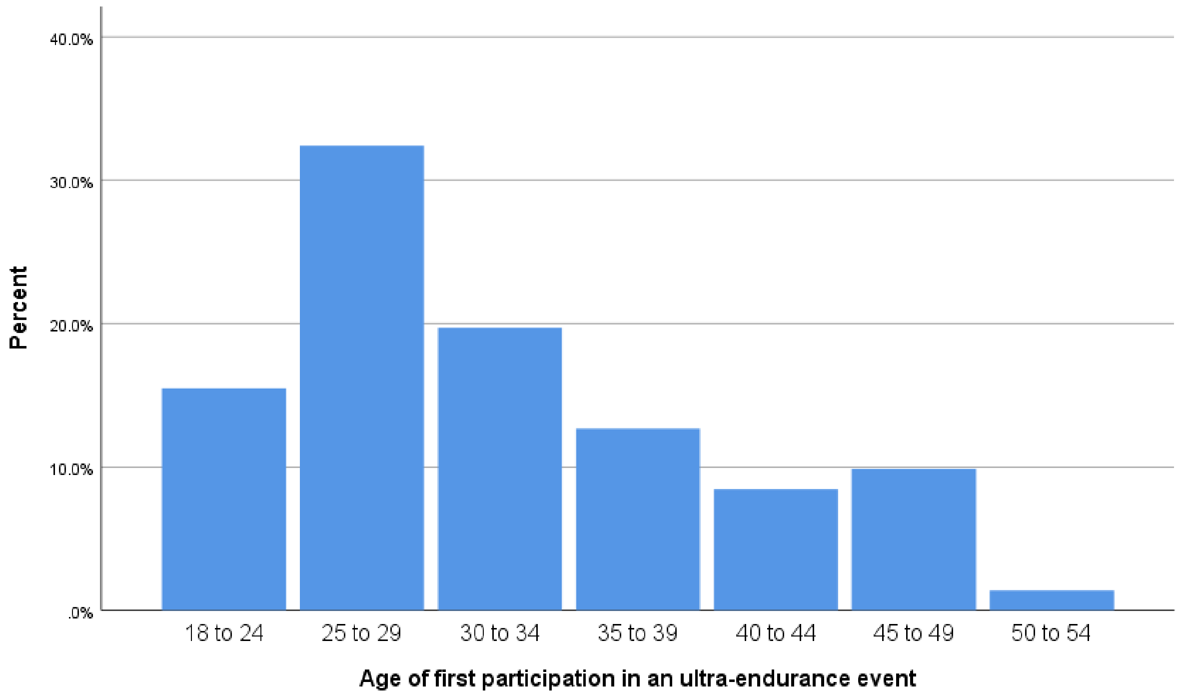

Figure 4.2: Age of first participation in an ultra-endurance event

4.5.2.1 Discussion

There is limited research on the age of ultra-endurance triathletes at their first ultra-endurance triathlon. However, it is reported that there has been an increase of masters triathletes competing in ultra-endurance triathlons for their first time (Lepers et al, 2013; Stiefel et al, 2013; Lepers and Stapley, 2016). This was not found in this study as the majority of the triathletes were found to be 34 years of age and younger with only 16 triathletes over the age of 40. Analysing the age of the triathletes in this study and the age of first participation, the majority started between the ages of 24 and 29, however, the age of the majority of the triathletes in the study is older ranging from 30 to 34 years of age.

4.5.3 Gender

Of the 71 ultra-endurance triathlete participants 47 (66.2%) were male and 24 (33.8%) were female (Table 4.10).

Table 4.10: Gender of participants

		Frequency	Percent
Valid	Female	24	33.8
	Male	47	66.2
	Total	71	100.0

4.5.3.1 Discussion

The triathlete sample surveyed in this study was considered to be representative of the triathlete population and not dissimilar to the gender data of triathlete samples described and presented in previous survey research studies both in South Africa (Ellapen et al., 2011) and internationally (O'Toole et al. 1989 [in Hawaii]; Collins et al. 1989 [in the USA]; Wilk et al. 1995 [in the USA]; Cipriani et al. 1998 [in the USA]; Clements et al. 1999 [in the United Kingdom]; Burns et al. 2003 [in Australia]; Shaw et al. 2004 [in Australia]; Korkia et al. 2004 [in Britain]; Manninen and Kallinen 1996 [in Japan]; Villavicencio et al. 2006 [in the USA]; Galera et al. 2012 [in France]; Ansell et al. 2012 [in Australia]).

In a local study conducted by Ellapen et al. (2011), 72.09% of the population were male and 27.91% female, indicating less female participation than the current study (33.8%).

4.5.4 Summary of Objective Two

The aim of Objective Two was to identify the demographics of the study population. The results in this study correlate with international studies (Korkia et al. 1994; Manninen and Kallinen, 1996; Villavicencio et al. 2006; Galera et al. 2012 and Ansell et al. 2012) as well as the South African studies of Ellapen et al. (2011) and Coetzee, (2014). In this study 66.2% of the ultra-endurance triathletes were male and 33.8%

were female. The age group that made up the majority of the participants was 30 to 34 years of age.

As the sport of ultra-triathlon has developed there has been an increase in both female and masters triathletes (Lepers et al., 2013). In 1986, masters triathletes (i.e. > 40 years) represented 31% of the total field for the males and 23% of the total field for females, while in 2010 master triathletes represented 56% of the total field for males and 47% of the total field for females (Lepers et al., 2013). Age of first participation was added to the demographics to check for any correlations between starting the sport of ultra-endurance triathlons at a young age and injuries. In this study there was a borderline non-significant result indicating that younger triathletes were more prone to injuries while competing with no difference between age and injuries in the year of training. The effect of starting ultra-endurance sport like ultra-triathlon at a young age is an aspect that could be looked at in more depth in future studies.

4.6 Objective Three

4.6.1 To determine whether there are correlations between injury profile and selected risk factors (age and gender) for injury

To answer Objective Three, numerous questions from the questionnaire (Appendix K) were statistically analysed.

4.6.2 Correlation between injury profile and the selected risk factors (age and gender) in the year leading up to the 2017 South African ultra-endurance triathlon

In the year leading up to the South African 2017 ultra-endurance triathlon, the age group with the most injuries was 30 to 34 years of age with 10 triathletes being injured, followed by 25 to 29 years of age with 8 triathletes being injured (Table 4.11). There was no significant difference in age between those who had injuries prior to the event and those who did not ($p = 0.079$), which was calculated using the Mann-Whitney U Test.

Of the male participants, 20 out of 47 reported injuries in the year leading up to the South African 2017 ultra-endurance triathlon, while of the female participants, 13 out of 24 reported injuries in the year leading up to the South African 2017 ultra-endurance triathlon. Although there were more male injuries in total, due to their higher participation rate in this study, females had a slightly higher percentage of injuries (Table 4.11).

However, there was no statistically significant difference in prior injury prevalence between males and females (p = 0.395) (Table 4.12). This was calculated using the Fishers exact test.

Table 4.11: Summary of injuries occurring in the different age and gender categories in the year leading up to the 2017 South African ultra-endurance triathlon

		Did you have any triathlon-related injuries in the year leading up to the 2017 South African ultra-endurance triathlon?			
		No		Yes	
		Count	Column N %	Count	Column N %
What is your age?	18 to 24	2	5.6%	3	9.1%
	25 to 29	4	11.1%	8	24.2%
	30 to 34	8	22.2%	10	30.3%
	35 to 39	5	13.9%	0	0.0%
	40 to 44	5	13.9%	6	18.2%
	45 to 49	4	11.1%	2	6.1%
	50 to 54	7	19.4%	2	6.1%
	55 to 59	1	2.8%	2	6.1%
What is your gender?	Female	11	29.7%	13	39.4%
	Male	27	70.3%	20	60.6%

Table 4.12: Injury prevalence between males and females in the year leading up to the 2017 South African ultra-endurance triathlon

			Did you have any injuries in the year prior to the event?		Total
			no	Yes	
What is your gender?	Female	Count	11	13	24
		Column %	29.7%	39.4%	34.3%
	Male	Count	26	20	46
		Column %	70.3%	60.6%	65.7%
Total		Count	37	33	70
		Column %	100.0%	100.0%	100.0%

p = 0.395

4.6.2.1 Discussion

In this study, there was no significant difference in age between participants who had injuries in the year leading up to the 2017 South African ultra-endurance triathlon and those who did not. This conflicts with the research of Migliorini (2000) who found that injury risk was greatest in elite competitors, in the youngest age categories, and in those competing in the greater distances, especially while running.

There was no difference in prior injury prevalence between males and females. Ansell et al. (2012), demonstrated a female gender bias specific to the hip/buttock/groin area only. Notably however, other authors have not reported a gender difference in injuries (Collins et al., 1989; O'Toole et al., 1989; Cipriani et al., 1998; Burns et al., 2003).

4.6.3 Correlation between injury profile and the selected risk factors (age and gender) on the day of the 2017 South African ultra-endurance triathlon race

During the South African 2017 ultra-endurance triathlon, of the 7 participants that sustained injuries, the majority (3) were between the ages of 18 and 24, the youngest age category. Interestingly there was a higher percentage of injuries from 34 years of age and younger than 35 years of age and older (Table 4.13).

There was a borderline non-significant difference between the groups in terms of age ($p = 0.069$), the trend suggesting that those who sustained an injury on the day were younger than those who did not. This was calculated using the Mann-Whitney U Test.

Of the 7 injuries reported on race day of the South African 2017 ultra-endurance triathlon, 5 were female participants and 2 were male (Table 4.13).

There was a statistically significant difference in injury prevalence between males and females ($p = 0.039$), with females being more likely to sustain an injury on the day (Table 4.14). This was calculated using the Fishers exact test.

Table 4.13: Summary of injuries occurring in the different age and gender categories during the 2017 South African ultra-endurance triathlon

		Did you sustain and injury on race day during the South African ultra-endurance triathlon?			
		No		Yes	
		Count	Column N %	Count	Column N %
What is your age?	18 to 24	2	3.3%	3	42.9%
	25 to 29	11	18.3%	1	14.3%
	30 to 34	16	26.7%	1	14.3%
	35 to 39	4	6.7%	0	0.0%
	40 to 44	10	16.7%	1	14.3%
	45 to 49	6	10.0%	0	0.0%
	50 to 54	8	13.3%	1	14.3%
	55 to 59	3	5.0%	0	0.0%
What is your gender?	Female	18	29.5%	5	71.4%
	Male	43	70.5%	2	28.6%

Table 4.14: Injury prevalence between males and females on the day of the 2017 South African ultra-endurance triathlon race

			Did you sustain and injury on race day during the South African ultra-endurance triathlon?		Total
			No	Yes	
What is your gender?	Female	Count	18	5	23
		Column %	29.5%	71.4%	33.8%
	Male	Count	43	2	45
		Column %	70.5%	28.6%	66.2%
Total		Count	61	7	68
		Column %	100.0%	100.0%	100.0%

p = 0.039.

4.6.3.1 Discussion

There was a borderline non-significant difference between the groups in terms of age, with younger participants being more prone to injury. This correlates with Holtzhausen et al. (2018) and Gosling et al. (2010). Holtzhausen et al. (2018) who reported that younger athletes between the ages of 18 to 24 years had the highest percentage requiring medical attention (14.7%), followed by athletes in the 25 to 29 year age group (12.8%). Athletes between the ages of 18 to 24 years had a significantly higher incidence of medical encounters than older athletes. Gosling et al. (2010) described the rate and profile of injuries seen for medical assistance during an ultra-endurance triathlon race series. Injury rates varied significantly by age group, with Elite / Junior Elite and the youngest competitors being at increased risk for injury.

In contrast to both the 2013 and 2014 Ironman South Africa triathlon, male participants comprised approximately 79% and female participants 21% of the total number of athletes that needed medical attention (Holtzhausen et al., 2018). No statistical difference between female and male medical encounter rates were found in this study (Holtzhausen et al., 2018).

4.6.4 Summary of Objective Three

Objective Three is concluded with a discussion of whether there are correlations between injury profile and selected risk factors (age and gender) for injury. There may be an association between gender and injury at the event as more females than males tended to sustain an injury at the event, but this was not true in the year leading up to the ultra-endurance triathlon. There was a trend for younger participants to sustain injuries prior to and during the event, but this was not statistically significant.

From a South African perspective, the study has importance due to this country having a very active population as a result of both the suitable climate as well as being a sport driven nation. Triathlon is now a major sport worldwide (Gosling et al., 2010), which is reflected in the South African context as the number of triathletes and ultra-endurance triathletes has increased dramatically (Ellapen et al., 2011). From the results one can concur that the demographics of South African ultra-endurance triathletes in this study vary across all age groups and genders. The overall literature around ultra-endurance triathlons in South Africa is limited especially with regards to age and gender interactions, and the results obtained from this study, being that younger triathletes are at a higher risk for injury during the year leading up to an ultra-endurance event and that female triathletes are more prone to injury while racing, can help both the triathletes as well as medical and support staff in training and racing.

4.7 Additional questions

The remaining results of the questions from the research questionnaire (Appendix K) are reported and discussed below. Their purpose was to add more background information about the ultra-endurance triathletes training regime to better understand the results that have been discussed in Objectives One to Three. Along with the training regimes, weaknesses regarding training beforehand and race day are discussed to see whether these correlate with the injuries that were reported by the participants.

4.7.1 Questions 5 and 6

Number of ultra-endurance triathlons started and finished.

These two questions are analysed together as they relate to one another.

Of the 71 participants the majority (35.2%) had started and completed one ultra-endurance event (Table 4.15), although 11% had started and completed 10 or more (Table 4.16). The two missing values in Table 4.16 were two triathletes that had started one ultra-endurance triathlon but did not complete the race.

Table 4.15: Question 5: Number of ultra-endurance triathlon races started

		Frequency	Percent
Valid	1	25	35.2
	2	12	16.9
	3	9	12.7
	4	3	4.2
	5	2	2.8
	6	5	7.0
	7	5	7.0
	8	1	1.4
	9	1	1.4
	10 or more	8	11.3
	Total	71	100.0

Table 4.16: Question 6: Number of ultra-endurance triathlon races finished

		Frequency	Percent
Valid	1	26	36.6
	2	10	14.1
	3	11	15.5
	4	3	4.2
	5	1	1.4
	6	5	7.0
	7	4	5.6
	8	1	1.4
	10 or more	8	11.3
	Total	69	97.2
Missing		2	2.8
Total		71	100.0

4.7.1.1 Discussion

This question correlates to experience in the sport of ultra-endurance triathlon. In the study by Burns et al. (2003) age did not appear to be an important factor in isolation. Ongoing participation in triathlon does appear to be associated with an increased risk of overuse injury. The median number of years of triathlon experience for the group injured during the pre-season was significantly higher (median 5.0 years) than the non-injured group (3.0 years) (Burns et al., 2003). Literature suggests that injury may be related to increased triathlon experience (Korkia, 1994), decreased triathlon experience or may not be related to triathlon experience at all (Vleck and Garbutt, 1998). Consequently, studies on these factors are still needed.

4.7.2 Questions 7 to 9: Time to complete each discipline

Question 7: Amount of time to complete the swim leg of the South African 2017 ultra-endurance triathlon

Of the 71 participants, the majority (23, 32.4%) finished the swimming leg of the South African ultra-endurance triathlon between 1 hour 15 minutes and 1 hour 30 minutes, 16 (22.5%) finished in under an hour being the fastest category while 2 (2.8%) participants took between 1 hour 45 minutes to 2 hours to complete the swim leg, being the slowest category (Figure 4.3).

Question 8: Amount of time to complete the cycle leg of the South African 2017 ultra-endurance triathlon

Of the 71 participants, the majority (30, 42.3%) completed the cycling leg of the South African ultra-endurance triathlon in a time of 5 and 6 hours, 6 (8.5%) completed in the fastest category of 4 to 5 hours, while 13 (18.3%) participants completed the cycle leg in the slowest category of 7 to 8 hours (Figure 4.4).

Question 9: Amount of time to complete the run leg of the South African 2017 ultra-endurance triathlon

Of the 71 participants, the majority (19, 27.1%) completed the run leg of the South African ultra-endurance triathlon in a time of 4 hours to 4 hours and 30 minutes, 13 (18.3%) completed in the fastest category being sub 4 hours, and 1 (1.4%) participant took more than 6 hours 30 minutes, the slowest category (Figure 4.5).

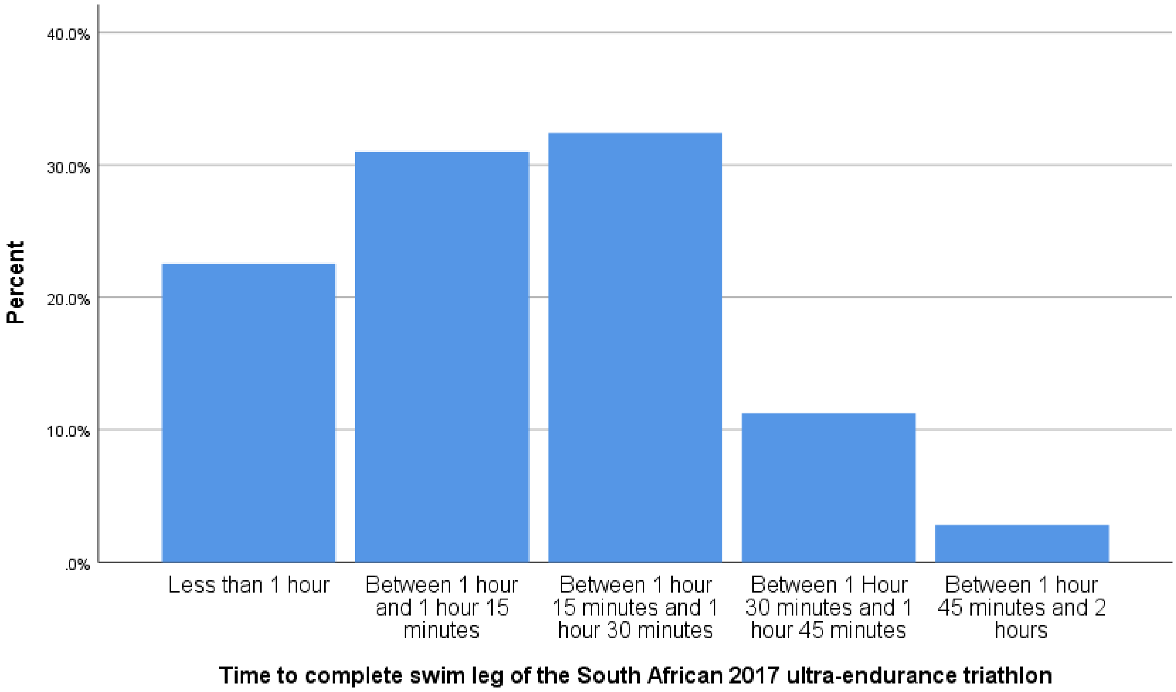

Figure 4.3: Time to complete swim leg

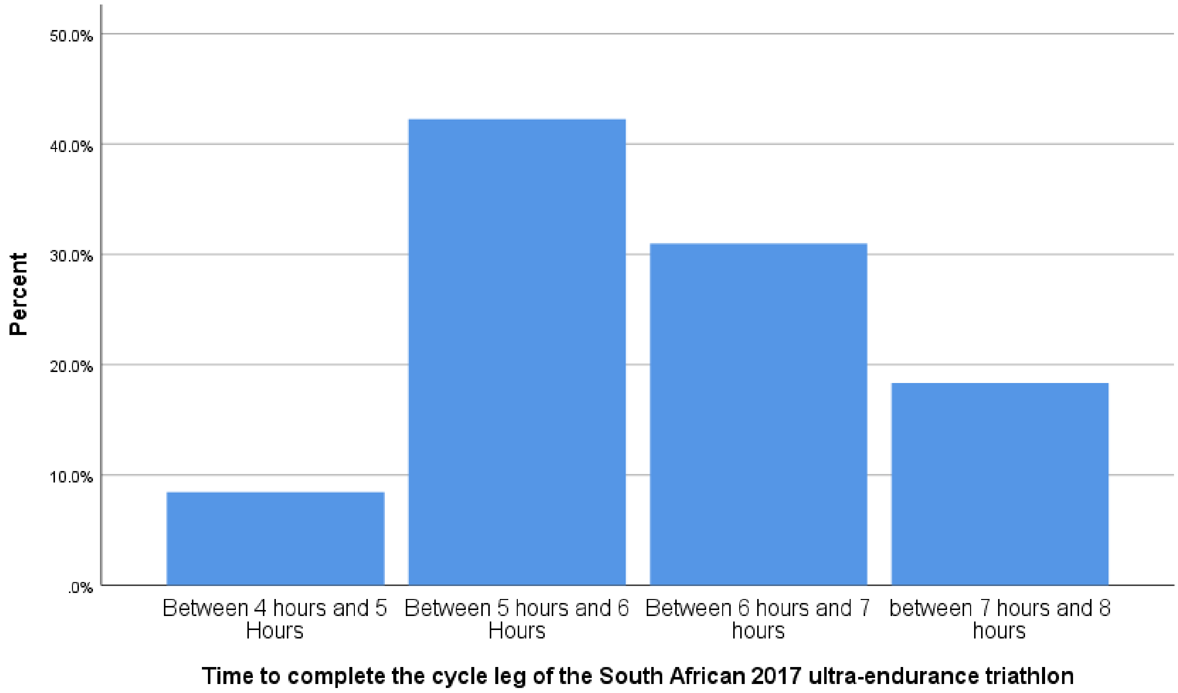

Figure 4.4: Time to complete cycle leg

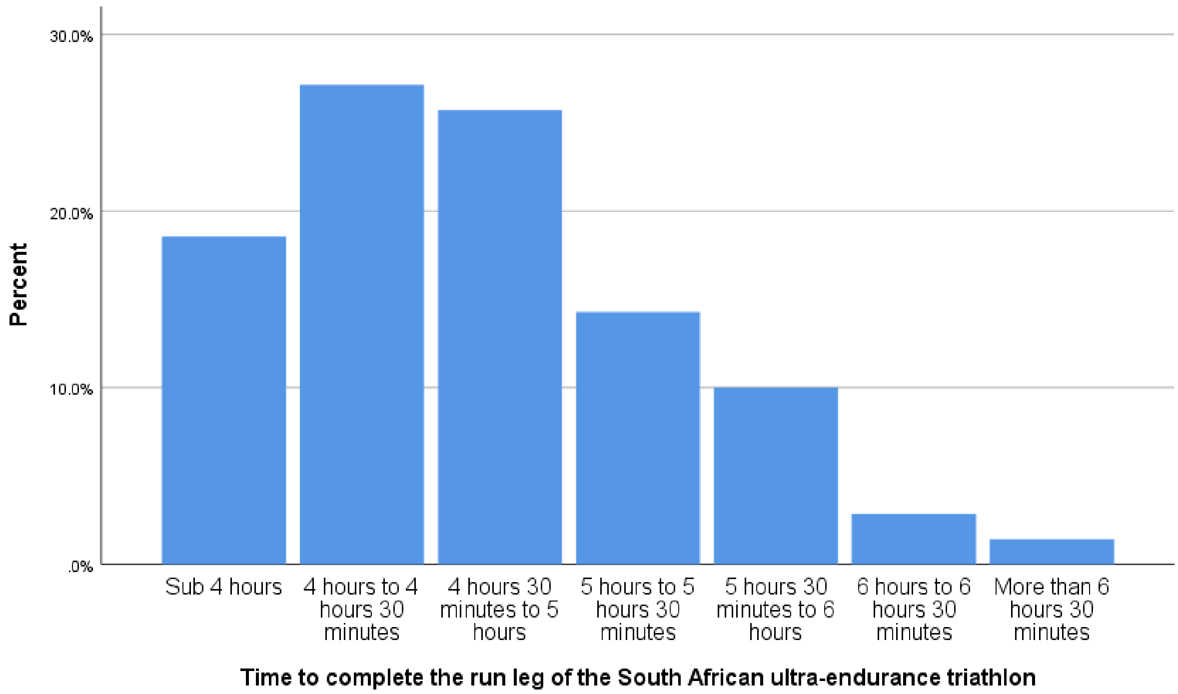

Figure 4.5: Time to complete run leg

4.7.2.1 Discussion of Questions 7 to 9

In a study looking at 41 000 finishers in 25 ironman triathlons, the average time to complete an ultra-endurance race was 12 hours and 35 minutes. Broken down into the three disciplines the average time for the swim (3.8km) was 1 hour 16 min, the cycle (180km) was 6 hours 25 min, and the run (42.2km) was 4 hours 54 min (runtri.com, 2011). Although not as specific, this data correlates with the swim and run leg of the triathletes in the current study with the majority of the participants completing the swim in 1 hour to 1 hour 30 minutes and the run between a time of 4 to 5 hours. The current study reflected that the majority of the participants finished the cycle leg in a time of 5 to 6 hours, slightly faster than the data captured by runtri.com (2011).

The reason that these questions were part of the questionnaire was to determine if there was a correlation between time taken to complete each leg and injuries on race day. With the small number of injuries on race day, statistically a correlation could not be made, however, this could potentially be looked into in future studies.

4.7.3 Questions 10 to 12

The following results reflect the amount of training done for each individual discipline (swim, cycle and run) during a peak training week.

4.7.3.1 Question 10

In terms of the swimming training, the majority (43, 60.6%) of the participants trained for 3 to 4 hours, 10 (14.1%) for 1 to 2 hours (the lowest category), while 1 (1.4%) trained for more than 8 hours a week (the highest category) (Table 4.17).

4.7.3.2 Question 11

In terms of cycling training, the majority (23, 32.4%) of the participants cycled 150km to 200km a week, 3 (4.2%) less than a 100km a week (the lowest distance) while 11 (15.5%) participants cycled more than 300km a week (the highest distance) (Table 4.17).

4.7.3.3 Question 12

In terms of running, the majority (29, 40.8%) of the participants ran 50km to 60km a week, 6 (8.5%) ran 10km to 20km a week (the lowest distance), while 2 (2.8%) ran more than a 100km a week (the highest distance) (Table 4.17).

Table 4.17: Training done for each discipline during peak training period

		Count	Column N %
Amount of swimming training done in one week during peak training period?	1 to 2 hours	10	14.1%
	3 to 4 hours	43	60.6%
	5 to 6 hours	14	19.7%
	7 to 8 hours	3	4.2%
	more than 8 hours	1	1.4%
Average amount of cycling training done in one week during peak training period?	Less than 100 kilometres	3	4.2%
	100 to 150 kilometres	10	14.1%
	150 to 200 kilometres	23	32.4%
	200 to 250 kilometres	16	22.5%
	250 to 300 kilometres	8	11.3%
	More than 300 kilometres	11	15.5%
Average amount of running training done in one week during peak training period?	10 to 20 kilometres	6	8.5%
	30 to 40 kilometres	22	31.0%
	50 to 60 kilometres	29	40.8%
	70 to 80 kilometres	8	11.3%
	80 to 100 kilometres	4	5.6%
	More than a 100 kilometres	2	2.8%

4.7.3.4 Discussion

The majority of participants in this study swam for 3 to 4 hours, cycled 150km to 200km (7 to 8 hours) and ran 50km to 60km (4 to 5 hours) weekly.

In comparison, the triathletes in Zwingenberger et al's (2014) study had slightly lower median weekly training hours with 12.3 (2 swimming, 5 cycling, 3.75 running).

There were correlations with Knechtle et al. (2010b) who found mean hours of 13.9 (2.4 swimming, 7.5 cycling, 4.0 running) for women and 14.8 (2.5 swimming, 8.0 cycling, 4.0 running) for men. Gulbin and Gaffney (1999) found higher mean weekly hours of training with 15.6 (2.7 swimming, 8.5 cycling, 4.4 running). The ratio between cycling and running hours of this study was comparable with those found by Knechtle et al. (2010b) and Gulbin and Gaffney (1999), however there were more swimming training hours in this study than those studies.

A relationship between training load and injuries has been found in some studies (O'Toole et al., 1989; Korkia et al., 1994; Manninen and Kallinen, 1996; Vleck and Garbutt, 1998; Shaw et al., 2004), but not in others (Burns et al., 2003; Cipriani et al., 1998; Collins et al., 1989; Egermann et al., 2003; Villavicencio et al., 2006). Many running studies have also found that higher training loads are linked to greater risk of injury (Hreljac and Ferber, 2006).

4.7.4 Question 13

What would you consider your weakest discipline to be?

Of the 71 participants, the majority (30, 42.3%) found that swimming was their weakest discipline, 22 (31.0%) that running was their weakest discipline, while the minority (19, 26.8%) found that cycling was their weakest discipline (Figure 4.6).

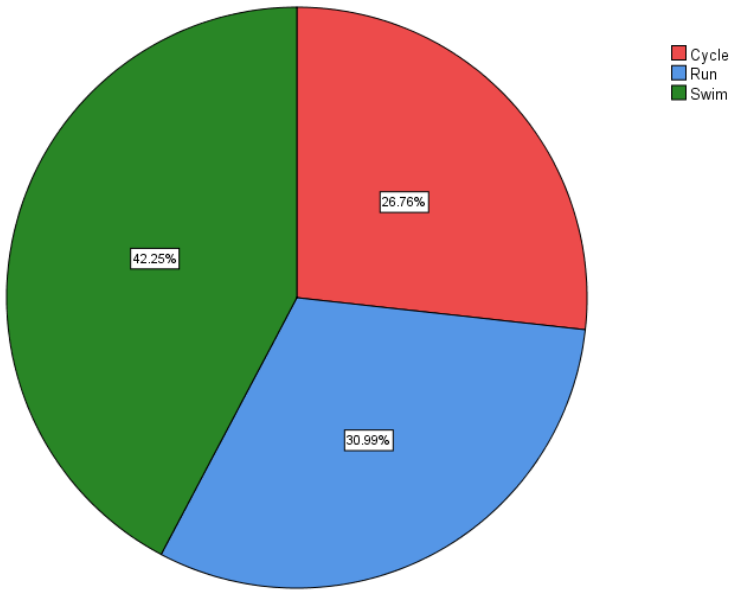

Figure 4.6: Pie chart of weakest discipline

4.7.4.1 Discussion

The majority of triathletes come from a running or cycling background (Gulbin and Gaffney, 1999; Baker and Juhn, 2005) and find that the swim leg can often be the weakest and hardest discipline to train for due to not having participated in the sport before taking up triathlon. There could be a potential correlation between the swim being the weakest discipline of the majority of the triathletes in this study and the increased training hours devoted to swimming training. This in turn could relate to the relatively high percentage of injuries recorded in the shoulder region in the year leading up to the ultra-endurance triathlon.

4.7.5 Questions 18, 23 and 27

These questions refer to whether the ultra-endurance triathletes received treatment for the injuries obtained in the year leading up to the South African ultra-endurance triathlon.

Of the 33 participants reporting Injury One, the most severe injury, the majority (32, 97.0%) received treatment, with the minority (1, 3.0%) not receiving treatment. Of the 13 participants reporting Injury Two, the majority (12, 92.3%) received treatment, with the minority (1, 7.7%) not receiving treatment. For Injury Three, all 6 (100%) participants received treatment (Table 4.18).

Table 4.18: Treatment for injuries occurring in the year leading up to the 2017 ultra-endurance triathlon

		Count	Column N %
Did you receive treatment for this injury? 1	No	1	3.0%
	Yes	32	97.0%
Did you receive treatment for this injury? 2	No	1	7.7%
	Yes	12	92.3%
Did you receive treatment for this injury? 3	Yes	6	100.0%

Of the 46 participants reporting injuries one and two, the majority (25) of the participants sought treatment from a physiotherapist and 11 participants from a chiropractor (Table 4.19).

Table 4.19: Treatment received by health care practitioners for injuries occurring in the year leading up to the 2017 ultra-endurance triathlon

		Count	Column N %
If answered YES to treatment, from whom did you receive treatment ?	Biokineticist	1	3.0%
	Chiropractor	9	27.3%
	General Practitioner	1	3.0%
	Orthopaedic surgeon	1	3.0%
	Other	1	3.0%
	Physiotherapist	20	60.6%
If you answered YES to question 17, from whom did you receive treatment ?	Biokineticist	1	10.0%
	Chiropractor	2	20.0%
	Orthopaedic surgeon	1	10.0%
	Other	1	10.0%
	Physiotherapist	5	50.0%

4.7.5.1 Discussion

Clements et al. (1999) found that triathletes sought treatment as follows: 27% from a physiotherapist; 11% from a general practitioner; 17% from a podiatrist; 17% from a chiropractor and 22% did not seek treatment.

In the study by Korkia's et al. (1994), professional help was sought immediately after the injury by 9% of the athletes, 4% from hospital accident and emergency, 4% from physiotherapist and 1% from a general practitioner.

Coetzee's (2014) results show that the majority (40%) of the participants received treatment from a chiropractor. Treatment was also received from a physiotherapist and a biokineticist.

The results from the current study correlate with those of Clements et al. (1999), but contrast with those of Coetzee (2014) as the majority of the participants in his study sought treatment from a chiropractor. Nevertheless, one can conclude that physiotherapists are the most common medical practitioner seen by triathletes, but chiropractors are represented better in South African than overseas.

4.7.6 Question 29

What was your most challenging discipline on race day of the 2017 South African ultra-endurance triathlon?

The majority of participants (54.41%) found that the run leg was the most challenging discipline, followed by the cycle leg (23.53%) and lastly by the swim leg (22.06%) (Figure 4.7).

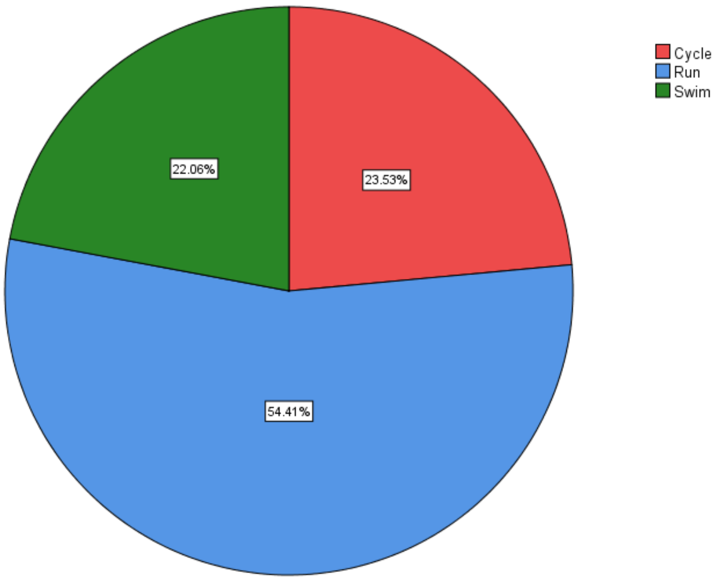

Figure 4.7: Pie Chart of most challenging discipline on race day

4.7.6.1 Discussion

The run is seen to be the most challenging discipline on race day from a physiological and psychological perspective (Cipriani et al., 1998). Triathletes have already been racing for several hours, upper body would have been fatigued from the swim, with lower back and legs having taken strain from the cycle (Strock et al., 2006). Approximately 70% of injuries suffered during training and competing in triathlons are related to running (Collins et al., 1989; Burns et al., 2003).

4.7.7 Questions 34 and 38

What discipline caused the injury on the day of the 2017 South African ultra-endurance triathlon?

Of the 7 injuries on race day, 3 (42.9%) occurred on the run leg, 2 (28.6%) on the cycle leg and 2 (28.6%) on the swim leg (Table 4.20).

Table 4.20: Discipline in which the injuries occur during the 2017 South African ultra-endurance triathlon

		Count	Column N %
What discipline caused the injury? 1	Cycle	2	28.6%
	Run	3	42.9%
	Swim	2	28.6%
What discipline caused the injury? 2	Run	1	100.0%

4.7.7.1 Discussion

With a small sample of triathletes in this study suffering injuries on the day of the race, the run causing the most injuries cannot be statistically significant, however, numerous studies have found the running discipline to cause the highest percentage of injuries (Collins et al., 1989; Clements et al., 1999; Burns et al., 2003; Strock et al., 2006).

4.7.8 Questions 35 and 39

Did the injury on the day of the 2017 South African ultra-endurance race cause you to drop out of the race?

Of the 7 participants that were injured on race day, 6 (85.7%) did not drop out of the triathlon, while 1 (14.3%) participant was forced to retire, injured (Table 4.21).

Table 4.21: Dropout rate due to injury on race day

		Count	Column N %
Did this injury cause you to drop out of the race? 1	No	6	85.7%
	Yes	1	14.3%
Did this injury cause you to drop out of the race? 2	No	1	100.0%

4.7.8.1 Discussion

Even though the severity of injuries on the day of the race was higher than that during the year leading up to the race, only one triathlete was forced to drop out due to injury.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, conclusions, based on the outcomes from the collected primary data, are drawn. Limitations to the study and recommendations for further studies related to this are discussed.

5.2 Main findings

The prevalence of ultra-endurance triathlon injuries is relatively frequent, concurring with the international literature on ultra-endurance triathlon injuries. This retrospective cross-sectional study determined that the posterior lower limb comprising the hamstring / calf region is the most common anatomical site of injury in training during the year leading up to the ultra-endurance triathlon. The shoulder, posterior limb and knee were the most common sites for injury on the day of the ultra-endurance race. Variables that increase the risk of a triathlete getting injured related to younger age both in the year leading up to the race as well as on race day. The results reflect that females are more prone to injuries on the day of the race. It is also evident from these findings that injuries on race day had a higher severity than injuries occurring in the year leading up to the ultra-endurance triathlon. Physiotherapists were the most commonly sought health care professionals for treatment.

Generally speaking, there is limited literature on ultra-endurance triathletes, even more so in South African. The reason for this study was to increase the literature pool on the sport of ultra-endurance triathlon in South Africa. Followed on from that, the study was aimed at seeing whether age and gender are risk factors for injury to ascertain further information to better educate both the ultra-endurance triathletes as well as the medical practitioners involved in the sport such as physiotherapists and chiropractors so that better treatment and management solutions can be put in place.

From this research study one can ascertain that the younger age group participants are at a higher risk of injury. There could be numerous reasons for this such as starting the sport too early or a lack of musculoskeletal maturity. It has also been determined in this study that females are at a higher risk of injury on race day. Could extrinsic risk factors such as conditions on the day play a role in this? There is a vast difference in the number of males and females competing in the sport with males outnumbering their female counterparts. Further research into age and gender in the sport of ultra-endurance triathlon will be beneficial.

5.3 Limitations

Sufficient data was captured with regards to prevalence of injuries occurring in the year before the ultra-endurance race, however, the number of injuries that occurred on the day of the race were not sufficient to give statically significant results.

The challenge involved with self-reporting of injuries by triathletes in a questionnaire study is acknowledged, firstly as a result of recall bias (Burns et al., 2003), and secondly as a result of memory deterioration (Mouton, 1996). This is further compounded by the triathlete's interpretation of injury and the variation of the injury site between athletes (Burns et al., 2003). As a result of these limitations, the information gained by this form of data collection should be interpreted with some caution (Burns et al., 2003). Future studies of a similar nature should attempt to address any aspects of this research which may impact participant bias.

Sites for injury are generalised to an anatomical area on the body. Specific diagnosis would allow for more accurate results, however, achieving this nationally would prove to be difficult.

Improved sample size is always a positive consideration for future studies whether or not they are regionally or nationally demarcated.

5.4 Recommendations

Most recent studies of triathletes are primarily focused on overuse or traumatic injuries, including back pain, and concern has been expressed by some authors that investigation of the long-term consequences of participation in this sport is needed (Villavicencio et al., 2006). Although there is a marked variation in injury rates between studies, the knee is consistently found to be the most commonly injured site. This has implications for further research and for educating health professionals and triathletes, particularly to assist them in the prevention and management of injury in this sport (Ansell et al., 2012).

With the limited literature to date, the researcher's knowledge has investigated age of first participation in ultra-endurance triathlon and perceives a need to consider whether starting ultra-endurance sport at a young age could lead to an increased risk of injury.

Following a group of athletes for a longer period than one season will also allow for more in-depth data and analysis.

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Appendices

Appendix A: Full IREC approval

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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

2 November 2017

IREC Reference Number: **REC 75/17**

Mr C D Momberg
Unit 3; 18 Greenacre Place
Kloof
Durban
3610

Dear Mr Momberg

A retrospective profile of musculoskeletal injuries of ultra-endurance triathletes in South Africa

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

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

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

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.

Yours Sincerely,

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2017 -11- 02
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix B: Permission from My Training Day

DUT
DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

Date 09.11.2016

To whom it may concern

Dear Sir,

Re: Your involvement in my research on Iron Man Competitors

Proposed research title : Injury profile on Iron Man competitors in South Africa

I, Courtney Momberg, will be doing my research dissertation on Iron Men competitors. I am looking to put together an injury profile of athletes that are competing in Iron man.

This proposed research will address the injuries involved in the sport and attempt to correlate the injuries with risk factors for injury. Thus this study aims to contribute to the injury identification process, which could lead to improved injury prevention methods by the chiropractic profession as we are musculoskeletal specialists.

The research done will attempt to better the knowledge of injuries that occur pre, during and post-race, ultimately providing further information that can be used prevent injuries and have a positive effect on the sport in South Africa. The final dissertation will be available to members of My Training Day Squad. What I require, would be permission from you to send out my electronic questionnaire to willing participants and access to these participants. The research involves participants answering an electronic questionnaire once off and sending it back to me, that is it. The questionnaire should take no more than 10 – 15 minutes to answer.

Your participation in this research would be greatly appreciated.

I, [redacted] manager /regional director / club chairman of My Training Day, with an ID number: [redacted] hereby give permission for you, Mr Courtney Momberg to access and distribute a questionnaire though my offices. This is limited only to your research questionnaire and letter of information for the persons interested in participating in the study. No material will be distributed that is no related to the research.

Signature : [redacted]

Date : 10 / 11 / 2016

Witness Name : [redacted] Witness Signature : [redacted]

Date : 10 / 11 / 2016

Appendix C: Permission from Dr Coetzee

Date 31.08.2016

Dear Dr. Coetzee

Re: The use of your questionnaire in my research on Iron Man Competitors

Proposed research title: Injury profile on Iron Man competitors in South Africa

I, Courtney Momberg, am writing to ask if I may please have your permission to use your questionnaire that was used in your 2013 dissertation, 'An injury profile of Amateur and Semi-professional Kwa-Zulu Natal triathletes'. I will be conditioning an injury profile on Iron Man competitors using a questionnaire. Your questionnaire will be adapted accordingly, in order to fit in to my research.

Your permission on this matter would be greatly appreciated.

I, [redacted]__________________, with an ID number: ______[redacted]__________ hereby give permission for you, Mr Courtney Momberg to use and adapt my questionnaire for your research. This is limited only to your research questionnaire and letter of information for the persons.

Signature: [redacted]______________________________

Date: 1/9/16.

Witness Name: [redacted]________________ Witness

Signature: [redacted]______________

Date: 1/09/16

Appendix D: Code of Conduct

<u>Code of Conduct and Confidentiality Statement</u>

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

<u>As a member of this committee I agree to abide by the following conditions:</u>

1. All information contained in the research documents and any information discussed during the expert group meeting will be kept private and confidential. This is especially binding to any information that may identify any of the participants in the research process.
2. None of the information shall be communicated to any other individual or organisation outside of this specific expert group as to the decisions of this expert group.
3. The information gathered from this expert group by the researcher will be made public in terms of a dissertation and journal publication. The researcher will ensure that any participants in the expert group and research remain anonymous and confidential.
4. The expert group may be either voice or video recorded, as a transcript of the proceedings will need to be made. The data will be stored securely under password protection.
5. All data generated from this focus group (including the recording) will be kept for 15 years in a secure location at Durban University of Technology and thereafter will be destroyed.

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

______________________	______________________
Full name of the participant	Signature
______________________	______________________
Full name of the Witness	Signature
______________________	______________________
Full name of the Researcher	Signature
______________________	______________________
Full name of Supervisor	Signature

Appendix E: Letter of information and informed consent for members of expert group

<u>Letter of information and informed consent for members of expert group</u>

Dear Participant

Welcome to my research study

Title of the Research Study: A retrospective profile of musculoskeletal injuries of ultra-endurance triathletes in South Africa.

Principal Investigator/s/researcher: Courtney Momberg (BTech: Chiropractic)

Co-Investigator/s/supervisor/s: Dr. Grant Matkovich (MTech: Chiropratic)

Brief Introduction and Purpose of the Study:

With the increase in popularity of the Iron Man sport locally and internationally, across both age and gender, the lack of literature on this ultra-endurance sport and the potential of finding associations between injury and demographic factors being age and gender are why the research is being done. The purpose of the study is to compile an injury profile of Ironman injuries with respect to age and gender risk factors.

Study objectives:

1. The first objective was to determine the profile (prevalence (past and periodic), location and severity) of musculoskeletal injuries in ultra-endurance triathletes in South Africa during one season.
2. The second objective was to determine the selected risk factors, being age and gender, for injuries occurring in ultra-endurance triathletes in South Africa.
3. The third objective was to determine whether there are correlations between injury profile and selected risk factors (age, gender and occupation) for injury.

Outline of the Procedures: Please read and complete the informed consent letter and the code of conduct and confidentiality statement prior to commencement of the focus group meeting. Each member of the focus group will receive a copy of the questionnaire before the discussion begins. During the focus group meeting, the questions will be discussed according to the structure of the questionnaire and members of the focus group should feel free to make recommendations and voice their opinion on any advice they have that may improve the questionnaire. The focus group meeting will be recorded for the researcher to look back on the comments made during the meeting and will be able to make suggested alterations.

Risks or Discomforts to the Participant: There are no foreseeable risks, discomforts or adverse consequences to the focus group participants.

Benefits: The focus group is valuable in ensuring validity of the questionnaire.

Reason/s why the Participant May Be Withdrawn from the Study: You may withdraw from the study at any time.

Remuneration: Participation in the study is voluntary and no remuneration will be awarded to the participants in the focus group.

Costs of the Study: There are no costs associated with participating in the study

Confidentiality: All information discussed during the focus group meeting will be kept confidential and used for research purposes only.

Research-related Injury: Not applicable to this study as it is a questionnaire based study.

Persons to Contact in the Event of Any Problems or Queries:

Please contact the researcher, Courtney Momberg (084 4006 673), Supervisor: Grant Matkovich (082 568 3986) or the Institutional Research Ethics administrator on 031 2375.
Complaints can be reported to the Director: Research and Postgraduate Support, Prof S. Moyo on 031 373 2577 or moyo@dut.ac

CONSENT

Statement of Agreement to Participate in the Research Study:

I…………………………………….., ID number…………………………………………., have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by……………………………………………… to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I, therefore voluntarily agree to participate in this study.

Full name of the participant	Date	Time	Signature

I, Courtney Momberg, hereby confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full name of the Researcher	Date	Signature

Full name of the Witness	Date	Signature

Full name of the Legal Guardian (If applicable)	Date	Signature

Appendix F: Corrections to pre pilot questionnaire

Student name: Courtney Momberg
Student number: 21124525
Ethical Clearance Number: 75/17

Title: A retrospective profile of musculoskeletal injuries of ultra-endurance triathletes in South Africa

<u>Outcome from the focus group meeting (19/09/17)</u>

The suggestions and recommendations made by the focus group participants are noted below:

For section A: Demographics and race history, the following statements were recommended:

- Age was categorized into the age groups that participate in the ultra-endurance race. (Question 1)
- Age of first participation was categorized into the age groups that participate in the ultra-endurance race. (Question 3)
- Number of ultra-endurance races started and finished was put into answers ranging from 1 to 10 instead of writing down your own answer. (Question 4 and 5)
- Time to complete ultra-endurance race was divided into average time for all three disciplines instead of an overall total (Question 6)
- The question 'What would you consider your weakest discipline to be?' was added. (Question 8)

For Section B: Injuries leading up to the 2017 ultra-endurance triathlon, the following statements were recommended

- Selecting whether or not you had injuries leading up to the 2017 race. If yes continue with section B, if No move to Section C (Default setting has been made on the survey tool.

- Adding in 3 identical questions to accommodate for those athletes who experienced more than one and for more accurate data capture.
- Adding in a severity scale for all three injuries. (Question 16, 21, 25)

Section C: Injuries on race day of the South African ultra-endurance triathlon.

- Adding in ‘Most challenging discipline on race day’ (Question 29).
- Adding in images for location of injury on race day (Question 32 and 36)

<u>Outcome from the pilot study (23/10/17):</u>

Section A: Demographics and race history

- Correcting a technical issue with the letter of consent button on the survey, ensuring that participants who do not give their full consent are immediately removed from the survey.

- Changing the wording of question 8 to make it less confusing.

Section B: Injuries leading up to the 2017 ultra-endurance triathlon.

- Adding in a shortcut link for the beginning of section B. i.e. if the participant had no injuries and they select no, they are automatically taken to section C.

Appendix G: Pre-pilot group questionnaire

An injury profile of Ironman competitors in South Africa.								
Please mark an X indicating your choice where applicable. Some questions are open-ended and will entail a more detailed answer								
Section A								
1. Age								
2. Gender	Male			Female				
3. Age of first participation in an Ironman event.								
4. Number of full Ironman races started.								
5. Number of full ironman races completed.								
6. Time to complete 2017 Ironman race	7 – 10 hours		11 -14 hours		15 – 17 hours		Did not finish	

Section B							
7. Did you have an injury before the race?	Yes			No			
If YES answer rest of section B. If NO move onto section C.							
8. Was this injury diagnosed by a medical professional?	Yes			No			
9. How long have you had this injury for?	Less than 3 months		More than 3 months		More than 6 months		More than 1 year
10. Did this injury have a	Yes			No			

negative effect on your race?								
11. Did this injury cause you to drop out of the race?	Yes				No			
12. Did you receive treatment for this injury?	Yes				No			
13. By whom were you treated?	Chiropractor		Physiotherapist		Medical doctor		Other	

Section C								
14. Most challenging discipline to train for	Swim			Cycle			Run	
15. Most challenging discipline on race day	Swim			Cycle			Run	
16. Were you injured during the race?	Yes				No			
If answer to 16 is YES, answer 17 and 18.								
17. Was this injury diagnosed by a medical professional?	Yes				No			
18. Have you received treatment for this injury	Yes				No			
19. By whom were you treated?	Chiropractor		Physiotherapist		Medical doctor		Other	
20. What discipline caused the injury?	Swim		Cycle		Run			
21. Did this injury cause you to drop out of the race?	Yes				No			

22. Have you suffered with this injury before?	Yes		No	

Appendix H: Pilot study questionnaire

An injury profile of ultra-endurance triathletes in South Africa

LETTER OF INFORMATION

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) -
LETTER OF INFORMATION

Dear Participant

Brief Introduction and Purpose of the Study:

Outline of the Procedures:

Risks or Discomforts to the Participant:

Benefits:

1

An injury profile of ultra-endurance triathletes in South Africa

LETTER OF INFORMED CONSENT

DUT DURBAN UNIVERSITY OF TECHNOLOGY — INSTITUTIONAL RESEARCH ETHICS COMMITTEE

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) - CONSENT LETTER

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Mr Courtney Momberg, about the nature, conduct, benefits and risks of this study – Research Ethics Clearance Number: IREC 75/17
- 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 details regarding my sex and age will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my 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.

1. I give full consent to be a part of this research study

◯ Yes

◯ No

An injury profile of ultra-endurance triathletes in South Africa

Section A : Demographics and race history

2. What is your age?

- ◯ 18 to 24
- ◯ 25 to 29
- ◯ 30 to 34
- ◯ 35 to 39
- ◯ 40 to 44
- ◯ 45 to 49
- ◯ 50 to 54
- ◯ 55 to 59
- ◯ 60 to 64
- ◯ 65 to 69
- ◯ 70 to 74
- ◯ 74 to 79

3. What is your gender?

- ◯ Female
- ◯ Male

4. Age of first participation in an ultra-endurance event?

- ◯ 18 to 24
- ◯ 24 to 29
- ◯ 30 to 34
- ◯ 35 to 39
- ◯ 40 to 44
- ◯ 45 to 49
- ◯ 50 to 54
- ◯ 55 to 59
- ◯ 60 to 64
- ◯ 65 to 69
- ◯ 70 to 74
- ◯ 75 to 79

5. Number of ultra-endurance triathlon races started

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10 or more

6. Number of ultra-endurance triathlon races finished

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 or more

7. Amount of time to complete swim leg of the South African 2017 ultra-endurance triathlon?

- Less than 1 hour
- Between 1 hour and 1 hour 15 minutes
- Between 1 hour 15 minutes and 1 hour 30 minutes
- Between 1 Hour 30 minutes and 1 hour 45 minutes
- Between 1 hour 45 minutes and 2 hours
- More than 2 hours

8. Amount of time to complete the cycle leg of the South African 2017 ultra-endurance triathlon?

- Between 4 hours and 5 Hours
- Between 5 hours and 6 Hours
- Between 6 hours and 7 hours
- between 7 hours and 8 hours
- Between 8 hours and 9 hours
- More than 9 hours

9. Amount of time to complete the run leg of the South African ultra-endurance triathlon?

- Sub 4 hours
- 4 hours to 4 hours 30 minutes
- 4 hours 30 minutes to 5 hours
- 5 hours to 5 hours 30 minutes
- 5 hours 30 minutes to 6 hours
- 6 hours to 6 hours 30 minutes
- More than 6 hours 30 minutes

10. Amount of swimming training done in one week during peak training period?

- 1 to 2 hours
- 3 to 4 hours
- 5 to 6 hours
- 7 to 8 hours
- more than 8 hours

11. Average amount of cycling training done in one week during peak training period?

- Less than 100 kilometers
- 100 to 150 kilometers
- 150 to 200 kilometers
- 200 to 250 kilometers
- 250 to 300 kilometers
- More than 300 kilometers

12. Average amount of running training done in one week during peak training period?

- ◯ 10 to 20 kilometers
- ◯ 30 to 40 kilometers
- ◯ 50 to 60 kilometers
- ◯ 70 to 80 kilometers
- ◯ 80 to 100 kilometers
- ◯ More than a 100 kilometers

13. What would you consider your weakest discipline to be?

- ◯ Swim
- ◯ Cycle
- ◯ Run

An injury profile of ultra-endurance triathletes in South Africa

Section B : Injuries leading up to the 2017 ultra-endurance triathlon

All the questions in this section relate to events that occurred in the year leading up to the South African 2017 ultra-endurance race.

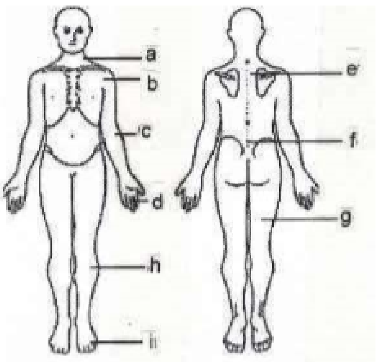
14. Did you have any triathlon related injuries in the year leading up to the 2017 South African ultra-endurance triathlon?

◯ Yes

◯ No

Please answer the following questions on the THREE most severe injuries that you have sustained in the year leading up to the 2017 South African Ultra-endurance triathlon. If you only sustained ONE please leave injury 2 and 3 clear, if you only sustained TWO injuries please leave injury 3 clear. If you did sustain THREE injuries please answer all three.

INJURY ONE



15. From the image above please indicate which area you injured

◯ A - Neck

◯ B - Shoulder

◯ C - Arm / Elbow

◯ D - Wrist / Hand

◯ E - Upper back

◯ F - Lower back

◯ G - Hamstring / Calf

◯ H - Knee / Quadriceps

◯ I - Achilles / Ankle / Foot

16. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

17. How long did you have the injury for?

- ◯ Less than 1 month
- ◯ Less than 3 months
- ◯ More than 3 months
- ◯ More than 6 months
- ◯ More than a year

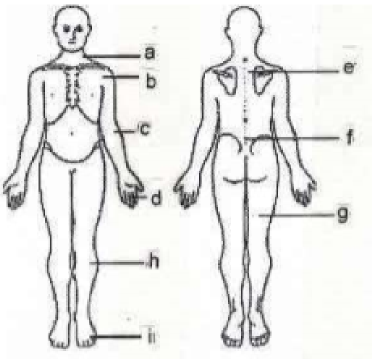
18. Did you receive treatment for this injury?

- ◯ Yes
- ◯ No

19. If you answered YES to question 17, by whom did you receive treatment from?

- ◯ Chiropractor
- ◯ Physiotherapist
- ◯ Biokineticist
- ◯ General Practitioner
- ◯ Orthopedic surgeon
- ◯ Other

INJURY TWO



20. From the image above please indicate which area you injured

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

21. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

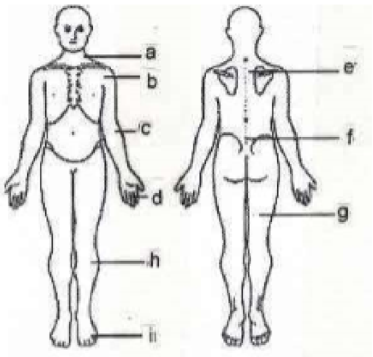
22. How long did you have the injury for?

- ◯ Less than 1 month
- ◯ Less than 3 months
- ◯ More than 3 months
- ◯ More than 6 months
- ◯ More than a year

23. Did you receive treatment for this injury?

- ◯ Yes
- ◯ No

INJURY THREE



24. From the image above please indicate which area you injured

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

25. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

26. How long did you have the injury for?

- ◯ Less than 1 month
- ◯ Less than 3 months
- ◯ More than 3 months
- ◯ More than 6 months
- ◯ More than a year

27. Did you receive treatment for this injury?

- ◯ Yes
- ◯ No

28. If you answered YES to question 17, by whom did you receive treatment from?

- ◯ Chiropractor
- ◯ Physiotherapist
- ◯ Biokineticist
- ◯ General Practitioner
- ◯ Orthopedic surgeon
- ◯ Other

9

An injury profile of ultra-endurance triathletes in South Africa

Section C : Injuries during 2017 South African ultra-endurance triathlon race

All the questions in this section relate to events that happened on the 2017 South African ultra-endurance race day.

29. What was your most challenging discipline on race day?

- ◯ Swim
- ◯ Cycle
- ◯ Run

30. Did you start the South African 2017 ultra-endurance triathlon with an injury?

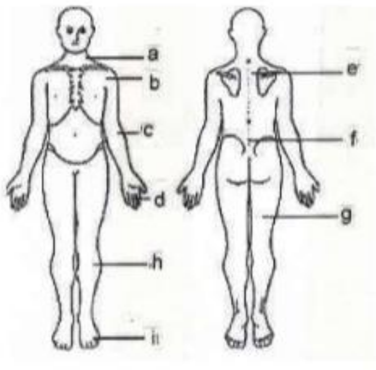
- ◯ Yes
- ◯ No

31. Did you sustain and injury on race day during the South African ultra-endurance triathlon?

- ◯ Yes
- ◯ No

Please answer the following questions on the TWO most severe injuries that you sustained on race day while competing in the 2017 South African Ultra-endurance triathlon. If you only sustained ONE please leave injury 2 clear, if you sustained TWO injuries please answer both.

INJURY ONE



32. From the image above please indicate which area you injured

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

33. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

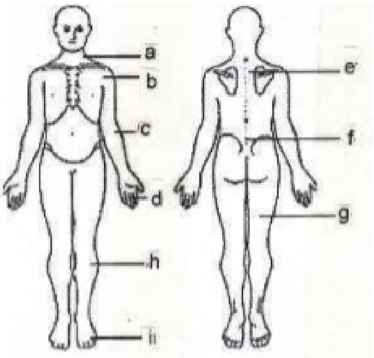
34. What discipline caused the injury?

- ◯ Swim
- ◯ Cycle
- ◯ Run

35. Did this injury cause you to drop out of the race?

- ◯ Yes
- ◯ No

INJURY TWO



36. **From the image above please indicate which area you injured**

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

37. **What was the severity of this injury? 1 being the least severe and 10 being the most severe**

0 5 10

38. **What discipline caused the injury?**

- ◯ Swim
- ◯ Cycle
- ◯ Run

39. **Did this injury cause you to drop out of the race?**

- ◯ Yes
- ◯ No

Thank you kindly for your participation in this study. Its is greatly appreciated.

Appendix I: Final questionnaire

An injury profile of ultra-endurance triathletes in South Africa

LETTER OF INFORMATION

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) - LETTER OF INFORMATION

Dear Participant

Brief Introduction and Purpose of the Study:

Outline of the Procedures:

Benefits:

Confidentiality:

1

An injury profile of ultra-endurance triathletes in South Africa

LETTER OF INFORMED CONSENT

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) - CONSENT LETTER

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Mr Courtney Momberg, about the nature, conduct, benefits and risks of this study – Research Ethics Clearance Number: IREC 78/17
- 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 details regarding my sex and age will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my 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.

1. I give full consent to be a part of this research study

- ◯ Yes
- ◯ No

2

An injury profile of ultra-endurance triathletes in South Africa

Section A : Demographics and race history

2. What is your age?

- ◯ 18 to 24
- ◯ 25 to 29
- ◯ 30 to 34
- ◯ 35 to 39
- ◯ 40 to 44
- ◯ 45 to 49
- ◯ 50 to 54
- ◯ 55 to 59
- ◯ 60 to 64
- ◯ 65 to 69
- ◯ 70 to 74
- ◯ 74 to 79

3. What is your gender?

- ◯ Female
- ◯ Male

4. Age of first participation in an ultra-endurance event?

- ◯ 18 to 24
- ◯ 24 to 29
- ◯ 30 to 34
- ◯ 35 to 39
- ◯ 40 to 44
- ◯ 45 to 49
- ◯ 50 to 54
- ◯ 55 to 59
- ◯ 60 to 64
- ◯ 65 to 69
- ◯ 70 to 74
- ◯ 75 to 79

5. Number of ultra-endurance triathlon races started

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10 or more

6. Number of ultra-endurance triathlon races finished

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10 or more

7. Amount of time to complete swim leg of the South African 2017 ultra-endurance triathlon?

- ◯ Less than 1 hour
- ◯ Between 1 hour and 1 hour 15 minutes
- ◯ Between 1 hour 15 minutes and 1 hour 30 minutes
- ◯ Between 1 Hour 30 minutes and 1 hour 45 minutes
- ◯ Between 1 hour 45 minutes and 2 hours
- ◯ More than 2 hours

8. Amount of time to complete the cycle leg of the South African 2017 ultra-endurance triathlon?

- ◯ Between 4 hours and 5 Hours
- ◯ Between 5 hours and 6 Hours
- ◯ Between 6 hours and 7 hours
- ◯ between 7 hours and 8 hours
- ◯ Between 8 hours and 9 hours
- ◯ More than 9 hours

9. Amount of time to complete the run leg of the South African ultra-endurance triathlon?

- ◯ Sub 4 hours
- ◯ 4 hours to 4 hours 30 minutes
- ◯ 4 hours 30 minutes to 5 hours
- ◯ 5 hours to 5 hours 30 minutes
- ◯ 5 hours 30 minutes to 6 hours
- ◯ 6 hours to 6 hours 30 minutes
- ◯ More than 6 hours 30 minutes

10. Amount of swimming training done in one week during peak training period?

- ◯ 1 to 2 hours
- ◯ 3 to 4 hours
- ◯ 5 to 6 hours
- ◯ 7 to 8 hours
- ◯ more than 8 hours

11. Average amount of cycling training done in one week during peak training period?

- ◯ Less than 100 kilometers
- ◯ 100 to 150 kilometers
- ◯ 150 to 200 kilometers
- ◯ 200 to 250 kilometers
- ◯ 250 to 300 kilometers
- ◯ More than 300 kilometers

12. Average amount of running training done in one week during peak training period?

- ◯ 10 to 20 kilometers
- ◯ 30 to 40 kilometers
- ◯ 50 to 60 kilometers
- ◯ 70 to 80 kilometers
- ◯ 80 to 100 kilometers
- ◯ More than a 100 kilometers

13. What would you consider your weakest discipline to be?

- ◯ Swim
- ◯ Cycle
- ◯ Run

Section B : Injuries leading up to the 2017 ultra-endurance triathlon

All the questions in this section relate to events that occurred in the year leading up to the South African 2017 ultra-endurance race.

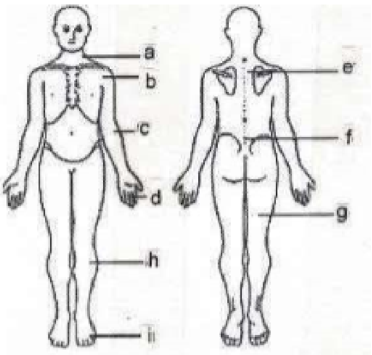
14. Did you have any triathlon related injuries in the year leading up to the 2017 South African ultra-endurance triathlon?

◯ Yes

◯ No

Please answer the following questions on the THREE most severe injuries that you have sustained in the year leading up to the 2017 South African Ultra-endurance triathlon. If you only sustained ONE please leave injury 2 and 3 clear, if you only sustained TWO injuries please leave injury 3 clear. If you did sustain THREE injuries please answer all three.

INJURY ONE



15. From the image above please indicate which area you injured

◯ A - Neck

◯ B - Shoulder

◯ C - Arm / Elbow

◯ D - Wrist / Hand

◯ E - Upper back

◯ F - Lower back

◯ G - Hamstring / Calf

◯ H - Knee / Quadriceps

◯ I - Achilles / Ankle / Foot

16. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

17. How long did you have the injury for?

- Less than 1 month
- Less than 3 months
- More than 3 months
- More than 6 months
- More than a year

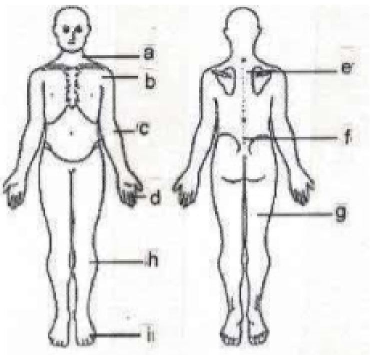
18. Did you receive treatment for this injury?

- Yes
- No

19. If you answered YES to question 17, by whom did you receive treatment from?

- Chiropractor
- Physiotherapist
- Biokineticist
- General Practitioner
- Orthopedic surgeon
- Other

INJURY TWO



20. From the image above please indicate which area you injured

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

21. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

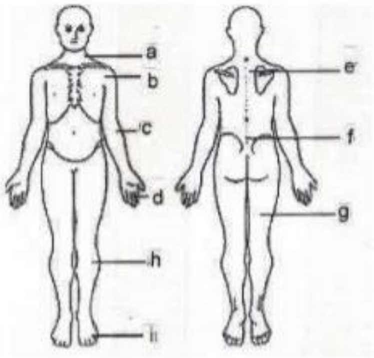
22. How long did you have the injury for?

- ◯ Less than 1 month
- ◯ Less than 3 months
- ◯ More than 3 months
- ◯ More than 6 months
- ◯ More than a year

23. Did you receive treatment for this injury?

- ◯ Yes
- ◯ No

INJURY THREE



24. From the image above please indicate which area you injured

- A - Neck
- B - Shoulder
- C - Arm / Elbow
- D - Wrist / Hand
- E - Upper back
- F - Lower back
- G - Hamstring / Calf
- H - Knee / Quadricepts
- I - Achilles / Ankle / Foot

25. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

26. How long did you have the injury for?

- Less than 1 month
- Less than 3 months
- More than 3 months
- More than 6 months
- More than a year

27. Did you receive treatment for this injury?

- Yes
- No

28. If you answered YES to question 17, by whom did you receive treatment from?

- Chiropractor
- Physiotherapist
- Biokineticist
- General Practitioner
- Orthopedic surgeon
- Other

An injury profile of ultra-endurance triathletes in South Africa

Section C : Injuries during 2017 South African ultra-endurance triathlon race

All the questions in this section relate to events that happened on the 2017 South African ultra-endurance race day.

29. What was your most challenging discipline on race day?

◯ Swim

◯ Cycle

◯ Run

30. Did you start the South African 2017 ultra-endurance triathlon with an injury?

◯ Yes

◯ No

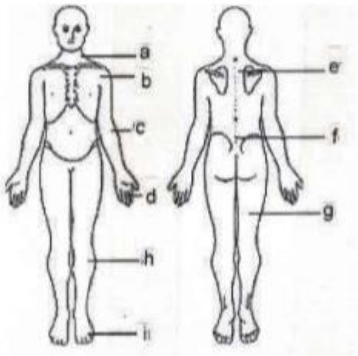
31. Did you sustain and injury on race day during the South African ultra-endurance triathlon?

◯ Yes

◯ No

Please answer the following questions on the TWO most severe injuries that you sustained on race day while competing in the 2017 South African Ultra-endurance triathlon. If you only sustained ONE please leave injury 2 clear, if you sustained TWO injuries please answer both.

INJURY ONE



32. From the image above please indicate which area you injured

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

33. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

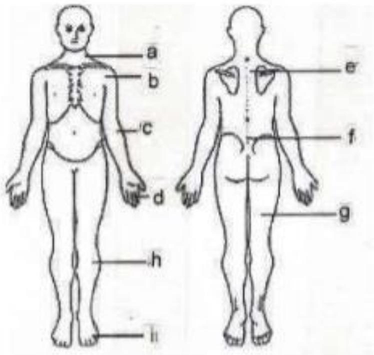
34. What discipline caused the injury?

- ◯ Swim
- ◯ Cycle
- ◯ Run

35. Did this injury cause you to drop out of the race?

- ◯ Yes
- ◯ No

INJURY TWO



36. From the image above please indicate which area you injured

- ◯ A - Neck
- ◯ B - Shoulder
- ◯ C - Arm / Elbow
- ◯ D - Wrist / Hand
- ◯ E - Upper back
- ◯ F - Lower back
- ◯ G - Hamstring / Calf
- ◯ H - Knee / Quadricepts
- ◯ I - Achilles / Ankle / Foot

37. What was the severity of this injury? 1 being the least severe and 10 being the most severe

0 5 10

38. What discipline caused the injury?

- ◯ Swim
- ◯ Cycle
- ◯ Run

39. Did this injury cause you to drop out of the race?

- ◯ Yes
- ◯ No

Thank you kindly for your participation in this study. Its is greatly appreciated.

Appendix J: Letter of information to Ultra-endurance triathletes

LETTER OF INFORMATION

Dear Participant

Welcome to my study, thank you for agreeing to participate in this study

Title of the Research Study: A retrospective profile of musculoskeletal injuries of ultra-endurance triathletes in South Africa.

Principal Investigator/s/researcher: Courtney Momberg (BTech: Chiropractic)

Co-Investigator/s/supervisor/s: Dr. Grant Matkovich (MTech: Chiropratic)

Brief Introduction and Purpose of the Study:
With the increase in popularity of the Iron Man sport locally and internationally, across both age and gender, the lack of literature on this ultra-endurance sport and the potential of finding associations between injury and demographic factors being age and gender are why the research is being done. The purpose of the study is to compile an injury profile of Ironman injuries with respect to age and gender risk factors.

Outline of the Procedures:
The total population of eligible competitors that are registered with or affiliated to My Training Day with in South Africa and that are participating in the South African Ironman 2017 event will be approached to participate in the study. The participants will be briefed about the study and questionnaire as a whole. The athletes of My Training Day that are participating in the Ironman race will be sent the questionnaire using an electronic survey. The answered questionnaire will then be returned to the researcher and analysed. For the duration of the study, the researcher will be available to answer any questions you may have via email or telephone. The questionnaires will be coded; no names will be recorded in this study to keep the participant's identity confidential and anonymous.

Risks or Discomforts to the Participant:
There are no risks or discomforts involved with your participation in this study. As a voluntary participant in this research study, you are free to withdraw from the study at any time, without giving a reason.

Benefits:
To educate medical professionals such a chiropractors and physiotherapists on the injury profile and possible risks associated with age or gender of these athletes, so they are better prepared to treat and design interventions to prevent injuries and improve the management and treatment of Ironman athletes. The research will increase the amount of literature available on ultra-endurance training and racing in South Africa.

Reason/s why the Participant May Be Withdrawn from the Study:
Non-compliance. There will be no adverse consequences towards you should you choose to withdraw.

Remuneration:
Participation in the study is voluntary and no remuneration will be awarded to the participants
Costs of the Study:
There is no cost associated with participating in this study

Confidentiality:
All the information is confidential and the results will be used for research purposes only. Your participation is voluntary and failure to participate will not result in any adverse consequences

Research-related Injury:
You are only required to fill in the electronic questionnaire therefore there is no risk to injury.

Persons to Contact in the Event of Any Problems or Queries:
Please contact the researcher, Courtney Momberg (084 4006 673), Supervisor: Grant Matkovich (082 568 3986) or the Institutional Research Ethics administrator on 031 2375.
Complaints can be reported to the Director: Research and Postgraduate Support, Prof S. Moyo on 031 373 2577 or moyo@dut.ac

Appendix K: Letter of Informed consent for ultra-endurance triathletes

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) - CONSENT LETTER

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Mr Courtney Momberg, about the nature, conduct, benefits and risks of this study – Research Ethics Clearance Number: IREC 75/17
- 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 details regarding my sex and age will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my 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.