The epidemiology of musculoskeletal injuries in trail runners in the eThekwini Municipality of KwaZulu-Natal

By

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Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic

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I, Maxine-Lee Millar, 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

To my parent's, Cindy and Rob; my sister, Melissa; my brother, Robbie and Gavin. I hope I have made you proud.

ACKNOWLEDGMENTS

I would like to give my sincerest thanks to the following individuals:

To Dr. Desiree Varatharajullu and Dr. Ashura Abdul-Rasheed, my supervisors, thank you for all your support, advice, time, putting up with my impatience, and seeing this dissertation through to the end. I am so grateful for everything. Thank you.

To Dr. Charmaine Korporaal, thank you for your unwavering support, not only to myself but every single chiropractic student that passes through DUT. You unselfishly offer all your time to whoever may need it, as well as provide a shoulder to lean on through difficult times. Thank you for helping me through this course.

To Linda Twiggs and Dr. Jyotika Basdav, thank you for all your help and patience with me during clinic, and the lovely coffee chats during reception shifts. I will miss you both.

To Tonya Esterhuizen for the statistical analysis and all your help and advice during my research study.

To every lecturer, clinic assistant, fellow chiropractic intern, administrative, cleaning and security staff at DUT, your every bit counts. Thank you for all your time, effort and help.

To my parents, who have sacrificed so much for me and supported me through everything, thank you. I love you both alot and I would be lost without you. Thank you for helping me fulfill my dreams.

To my siblings, Milly and Robbie, thank you for always being a shoulder for me to lean on and for all the late night calls to keep me going. I love you both very much.

To my best friend Kelly, even though you were halfway across the world, you gave me so much love and support and always put a smile on my face. Thank you for being there for me, always.

Lastly, to my angel, Gavin. Thank you for everything. You have held my hand through it all, from start to finish and always encouraged me to follow my dreams. Thank you for being you. I love you more than you know and I cannot wait to start my life with you.

ABSTRACT

AIM: The aim of this study was to determine the point and period prevalence of musculoskeletal injuries, the injury profile, associated risk factors and the impact of musculoskeletal injuries on trail runners who participated in selected trail races in the eThekwini municipality of KwaZulu-Natal.

SUBJECTS: Participants from various trail running races volunteered to participate in the study after the completion of a trail race.

METHODOLOGY: Participants were approached individually following the completion of a minimum of a 10 kilometre trail race. Each participant read a letter of information and signed an informed consent form before completing the questionnaire. A total of 197 completed informed consent and post-pilot questionnaires were collected and placed in separate sealed ballot boxes. A code was allocated to each questionnaire before data was captured on a spreadsheet for statistical analysis.

RESULTS: In total, 145 questionnaires were statistically analysed. The results revealed that only ethnicity and how often the participant's trail ran per month were significant predictors of developing an injury. White participants were five times more likely to be injured compared to African participants and those who ran more than 10 times a month were 4.65 times more likely to be injured than those who ran less than five times a month. The most common past injuries sustained by trail runners was shown to be predominantly due to trauma, and were located in the knee, ankles and ITB regions. Current injuries were shown to be equally due to trauma and overuse, with predominant location being in the same anatomical regions as past injuries.

CONCLUSION: The majority of the data collected was in line with the literature on running; however, most of those studies were done on road runners. The findings of this study were unique to trail runners in KwaZulu-Natal. Further studies are required on trail runners in other regions of South Africa to determine a clearer injury profile.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

DEFINITIONS

ECCENTRIC CONTRACTION

Force generation in a lengthening muscle during joint movement (Schmidt Easthope *et al.,* 2010)

EPIDEMIOLOGY

The study of causes, effects, and patterns of health conditions within a population group (Woodward, 2013)

EXTRINSIC FACTOR

Environmental factors including distance run per week, running frequency per week, terrain, and running shoe (Buist *et al.,* 2010)

INCIDENCE

The number of new cases of a condition within a specified period of time (Woodward, 2013)

INTRINSIC FACTOR

Personal factors including, age, gender, BMI and previous injury (Buist *et al.,* 2010)

MUSCULOSKELETAL INJURY

Discomfort, pain or damage to a part of the body which may be due to training or competition and may have required medical attention or resulted in a cessation of training (Junge *et al.,* 2008)

KINETIC CHAIN

Joints and segments which have an effect on one another during movement (Milliaropoulos, Mertyri and Tsaklis, 2015)

MANAGEMENT

Treatment of the injury or area of complaint as well as addressing the overall health and care of the athlete in order to ensure appropriate healing, recovery, rehabilitation and return to sports performance (Hyde & Gengenbach, 2007)

OVERUSE INJURY

Occurs when repetitive sub-maximal loads are applied to the musculoskeletal system over a long period of time without allowing adequate structural adaptation to take place (Schmitz *et al.,* 2014)

PERIOD PREVALENCE

The proportion of the population having a condition over a period of 12 months (Woodward, 2013)

POINT PREVALENCE

The proportion of the population having a condition at the time of the study (Woodward, 2013)

PREVALENCE

The proportion of the population having a condition (Dorland's, 2007)

RUNNING RELATED INJURY

An injury acquired due to or whilst participating in running (Buist *et al.,* 2010)

TERRAIN

A stretch of land, especially with regard to its physical features (Voloshina & Ferris, 2015)

TRAIL RUNNING

Runs performed in an off-road context such as sand, rock, grass and water, involving uphill and downhill displacements (Schmidt Easthope *et al.,* 2010)

TRAUMA

A physical injury, wound, cut, bruise, contusion or laceration to a part of the body (Dorland's, 2007)

TREATMENT

Direct therapies or interventions utilised to address a particular injury or area of complaint (Hyde & Gengenbach, 2007)

ABBREVIATIONS

BMI	Body Mass Index
IREC	Institutional Research and Ethics Committee
ITB	Iliotibial Band
KG	Kilogram
KM	Kilometre
KZN	KwaZulu-Natal
M	Metre
VO_{2max}	Maximal Oxygen Uptake

CHAPTER ONE: INTRODUCTION

1.1 Introduction

This chapter is an introduction to trail running as well as the aims, objectives, and purpose of this study.

1.2 Background

Running is seen as one of the best ways to remain physically and mentally fit. It has been shown to have many positive effects on general health such as reducing the incidence of obesity and heart disease (Hespanhol, Pena Costa and Dias Lopes*,* 2013). In addition to this, running is one of the most popular sports worldwide performed with minimal equipment (Videbaek *et al.,* 2015). An alternative to road running is trail running, which is defined as running on any surface or terrain other than the road such as sand, grass or rock (Schmidt Easthope *et al.,* 2010). Due to the inconsistent running surface experienced by trail runners, there is an increased risk of injury associated with running (Milliaropoulos, Mertyri and Tsaklis, 2015). The trail runner is exposed to high-intensity forces with altered terrain and unstable running surfaces (Giandolini *et al.,* 2015a). There are other multifactorial contributors which differentiate trail running from road running such as different footwear (Kong, Candelaria and Smith*,* 2009) and increased training time due to the surface terrain being more of a challenge to navigate than the general flat surfaces associated with road running (Milliaropoulos, Mertyri and Tsaklis*,* 2015). The popularity of this sport has increased over the last decade; however, there is paucity in the literature with respect to an injury profile analysis associated with trail runners (Vernillo *et al,* 2015).

1.3 Aim of the study

The aim of this study was to determine the point and period prevalence of musculoskeletal injuries, the injury profile, associated risk factors and the impact of musculoskeletal injuries on trail runners who participated in selected trail races in the eThekwini municipality.

1.4 Objectives

1. To determine the point and period prevalence of musculoskeletal injuries in trail runners.

2. To investigate the injury profile (such as the location of the injury, cause) of trail runners.
3. To determine selected risk factors (such as previous injury, distance run per week, shoes) associated with musculoskeletal injuries in trail runners.
4. To determine the impact of the musculoskeletal injuries on trail runners and running performance.

1.5 Rationale behind the study

Due to its convenience, health benefits and economic nature, running has and continues to be the sport of choice for many; however, the potential for injuries related to running are as high as 18.2% to 94.2% as was documented by Hespanhol, Pena Costa and Dias Lopes (2013). Running is known to have a positive effect on an individual's physical fitness as well as reducing the incidence of obesity and chronic health issues such as heart disease and diabetes (Van Gent *et al.,* 2007). These are some of the factors which have led to the increased participation in running, which has, in turn, led to the increase of running-related injuries (Hespanhol, Pena Costa and Dias Lopes, 2013). An alternative to road running is known as trail running, which takes place on various natural terrains with minimised running on paved surfaces (Milliaropoulos, Mertyri and Tsaklis, 2015).

Trail running can be performed on terrains such as mountains, deserts and forests which consist of rock or sand trails and may include extensive vertical displacement uphill and downhill (Schmidt Easthope *et al.,* 2010). These long uphill (positive elevations) and downhill (negative elevations) of trail routes, such as those found in the South African terrain may cause substantial physiological and mechanical stress to the individual predisposing to injury (Giandolini *et al.*, 2015a). The different terrains associated with trail running are suspected to influence trail runners such that they would have a different injury profile in comparison to road runners (Denissen *et al*., 2012). Previous studies done by Milliaropoulos, Mertyri and Tsaklis (2015) and Hespanhol, Pena Costa and Dias Lopes (2013) surveyed injuries in trail runners who were running on a different terrain to that which is found in South African, suggesting that the South African trail runner will be exposed to a different profile of trail running related injuries (Ellapen *et al*., 2013).

Predicting factors associated with trail running related injuries need to be investigated in order to aid in the prevention and management of these injuries (Milliaropoulos, Mertyri and Tsaklis, 2015). Chiropractic management is more likely to be successful when the focus is on restoring the dysfunction of the kinetic chain (Sandell, Palmgren and Bjorndahl, 2008). Therefore, an injury profile analysis will indicate the most common areas of dysfunction which are likely to occur in a trail runner thereby, enabling specific, tailored treatment guidelines to be established. There is extensive research focusing on injuries associated with road running as those done by Van Gent *et al.* (2007), Hespanhol, Pena Costa and Dias Lopes (2013) and Kluitenberg *et al.* (2015); however, there is a paucity of literature in relation to trail running overuse injuries (Milliaropoulos, Mertyri and Tsaklis, 2015). There is a further need for epidemiological investigation to determine intrinsic factors predisposing trail runners to injury within the South African terrain (Ellapen e*t al*., 2013). Knowledge of the physiological and biomechanical changes associated with trail running is fundamental to understanding the control of human locomotion (Vernillo *et al.*, 2016). This study will be of benefit as understanding these changes will allow for more specific and correct identification of common injuries and the management of these injuries to prevent reoccurrence thus improving the health, training, and competition of the athlete (Vernillo *et al.,* 2016).

1.6 Conclusion

The introduction to the study and the aims and objectives were explained in this chapter. The background, context and research problem of the study was described above. The research questions and the scope of the study were also presented in this chapter. The following chapter provides an overview of the literature which was obtained from google scholar in order to facilitate a better understanding of trail running and trail running related injuries.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter is a review of the literature pertaining to this study. It looks at; the normal mechanics of running, the gait cycle, biomechanics of the gait cycle during running, biomechanics of the gait cycle during trail running, incidence and prevalence of trail running related injuries, risk factors associated with the development of injuries associated with trail running, intrinsic and extrinsic risk factors, training errors and environmental factors associated with trail running, and concludes with the role of the health care provider.

2.2 Introduction to trail running

Physical activities, such as running, are important for the maintenance of general health by preventing the development of chronic illnesses such as diabetes, hypercholesterolemia and heart disease (Hespanhol, Pena Costa and Dias Lopes, 2013). Due to its convenience, easy accessibility, health benefits, and economic nature, running has and continues to be the sport of choice for many (Van Gent *et al.*, 2007). Regular physical activity improves an individual's quality of life and reduces morbidity and mortality (Hespanhol *et al*., 2015). In the last decade, running long distances has become increasingly popular (Vernillo *et al.,* 2015) and this has resulted in an increase in the number of injuries related to running (Giandolini *et al.*, 2016).

Running can be defined as an act with a period where no limbs are touching the ground and it is performed on tarred or paved surfaces over various distances (Tongen & Wunderlich, 2010). Running has different variances based on surface, terrain, distance, and speed. Once such variant of running is trail running (Milliaropoulos, Mertyri and Tsaklis, 2015).

Trail running, which was introduced in South Africa in 1981, is a popular alternative to road running and is considered to be one of the most popular sporting activities in the country (Heyns, 2013). Trail running consists of running on various natural terrains with less than 20% of the total distance being run on a paved surface (Milliaropoulos, Mertyri and Tsaklis, 2015). Trail running can be defined as an outdoor activity consisting of running distances anywhere from five kilometres (km) to over 300km on surfaces such as sand, grass, rock and sometimes even through water, with positive and negative elevations ranging from 500 metres (m) to over 20000m (Giandolini *et al.*, 2016). In a

South African context, it has been defined as a run on varied terrain such as hiking trails, minor gravel roads and may include beaches, dunes and mountains with no distinct path, with less than 10% consisting of tar and more than 20% trail hiking or single track (Heyns, 2013).

The terrain that the runner is exposed to is one of the largest contributing risk factors for sustaining an injury (Giandolini *et al.*, 2015a). South Africa has a wide variety of rugged terrains and is geographically different to other countries, exposing the trail runner to a higher risk of developing an injury (Nunn & Puga, 2012). Due to the multifactorial components such as footwear, running with a load, terrain and other environmental factors; trail running may be more strenuous and result in a different injury profile to other running related activities (Denissen *et al*., 2012). Understanding these different injury profiles will be of benefit to the health, training, treatment, management, and competition of the trail runner (Vernillo *et al.,* 2016).

2.3 Normal mechanics of running

2.3.1 Gait cycle

According to Tongen & Wunderlich (2010), there are two basic requisites for the act of walking; periodic movement of each foot from one position of support to the next and sufficient ground reaction forces applied through the feet to support the body. The basic unit of measurement in the gait analysis is the gait cycle which starts when one foot comes in contact with the ground and ends when the same foot contacts the ground again (Nassif, Hughey and So, 2016). The gait cycle can be divided into two separate phases i.e. the stance phase (60%) and the swing phase (40%) (Ren, Jones and Howard, 2008; Tongen & Wunderlich, 2010).

During walking, there is never a period where both feet are off the ground at the same time thus the stance phase lasts longer than half the gait cycle and always begins with periods of double support, where both feet are on the gound (Nassif, Hughey and So, 2016).

The stance phase is comprised of heel strike (initial contact where the foot comes into contact with the ground and the bodies centre of gravity is at its lowest), loading response (when the plantar surface of the foot touches the ground) the phase continues with mid-stance (where the contra-lateral foot passes the stance foot and the bodies centre of gravity is at its highest) this is followed by terminal stance or heel off (the point at which the heel loses contact with the ground and is initiated via the triceps surae muscle which plantar flexes the ankle) (Ren, Jones and Howard, 2008; Levine, Richards and Whittle, 2012).

The swing phase is then initiated with toe-off (which is the point at which the foot leaves the ground). This is followed by initial swing, whereby the hip flexors are activated to accelerate the leg forward and the foot leaves the ground; mid-swing whereby the foot passes directly beneath the body and terminal swing whereby the hip extensors prepare for the next heel strike by slowing the leg and stabilising the foot, thus ending the swing phase (Ren, Jones and Howard, 2008).

Distance is measured by stride length and step length. Step length is defined as the distance travelled by a person during one stride (or cycle) and can be measured as the length between the heels from one heel strike to the next heel strike on the same side. Step length is measured as the length between the heels from one heel strike on one side to heel strike on the opposite side. Two step lengths will make up one stride length. (Levine, Richards and Whittle, 2012).

2.3.2 Biomechanics of the gait cycle during running

The transition from walking to running begins when velocity or distance travelled per unit of time is increased (Schubert, Kemp and Heiderscheit, 2013). High magnitude forces are applied over short periods of contact thereby decreacing the stace phase of the gait cycle (Nassif, Hughey and So, 2016). The existence of the “double support” phase (where both feet are in contact with the ground) during the stance phase of walking gives way to periods of the “flight” or “double float” phase (where neither limb is in contact with the ground) and as the speed increases, initial contact changes from being hindfoot to forefoot (Nassif, Jugher and So, 2016). It is also the stance phase which is altered in order to increase speed during running (Tongen & Wunderlich, 2010). There is also increased hip and knee flexion as well as increased ankle dorsiflexion, thereby, causing greater forces to be placed on the joints of the kinetic chain (Schubert, Kemp and Heiderscheit, 2013).

Wille *et al.* (2014) noted that the two most important concepts in dealing with the biomechanics of running are the kinetic chain and ground reaction forces. The kinetic chain can be described as a system of linked body segments (Naito, Fukui and Maruyama, 2012) which means that when muscles across a joint are activated, a movement is produced resulting in movement of the next joint in the kinetic chain (Vernillo *et al.,* 2016). During the swing phase of the gait cycle no external forces are applied on the foot side from gravity. On the contrary, during the stance phase, the ground constantly exerts a force on the foot, and this is known as the ground reaction force (Nassif, Hughey and So, 2016). Ground reaction forces are defined as the forces which are equal in magnitude but opposite in direction to the force experienced by the limb bearing weight and these ground reaction forces can be generated in either the horizontal, vertical or rotatory planes of movement (Schubert, Kemp and Heiderscheit, 2013). During running, peak vertical loads of 2.5 times body weight have been measured, thereby impacting and adding to the ground reactive forces produced (Silder, Bosier and Delp, 2015). There is an increased risk of overuse injuries (such as tibial stress fractures and achilles/patella tendonitis) associated with an increased vertical impact peak and rate of vertical impact loading (Grabowski & Kram, 2008).

The shape of the ground reaction force patterns is also affected by variations in running biomechanics (Schubert, Kemp and Heiderscheit, 2013). When the feet contact the ground in running, the lower extremities transfer this force into the pelvis and spine via the closed-kinetic chain. The energy is then transmitted to the upper extremities and shoulders and then back down along the spine into the pelvis and lower extremities through the thoraco-lumbar fascia thus, generating increased speed and efficiency of performance (Lewis & Garlbay, 2015).

2.3.3 Biomechanics of the gait cycle during trail running

The steep gradients, variable surfaces and uneven terrain which occur during trail running expose the runner to unpredictable and varied terrains; thereby causing altered gait patterns relative to road running (Bean *et al.*, 2017). Trail running imposes strenuous physical loads on the kinetic chain resulting in decreased locomotive efficiency and structural muscle damage, which may predispose the runner to injury (Easthope Schmidt *et al.*, 2014).

The gradient of the trail's induces a change in initial foot contact kinetics (Vernillo *et al.*, 2016). Compared to level road running, trail running induces higher peak accelerations at the ankle, tibia and sacrum which increases the shock absorption in these areas (Giandolini *et al*., 2016). Since knee flexion at initial contact is increased in forefoot striking, the more anterior the foot strike pattern is, the greater the axial and resultant impact vibrations will be between the tibia and the sacrum (Shih, Lin and Shiang, 2013). The uneven terrain experienced during trail running will result in initial foot strike altering from an even controlled position of the ankle, knee and hip, to one of increased hip flexion in order to assist stabilisation of the ankle and the knee joints (Giandolini *et al*., 2016).

Compared to road running, variable joint angles and even joint stiffness distribution are facilitated by increased pre-activation and co-activation of the surrounding musculature in trail running (Bean *et al.*, 2017). The large proportion of eccentric contractions during downhill segments of trail running involve force generation in a lengthening muscle and result in severe structural damage in muscles, this may cause the development of compensation by other muscles which may alter the runner's biomechanics and predispose to injury (Schmidt Easthope *et al.*, 2010).

2.4 Incidence and prevalence of trail running related injuries

The yearly incidence rate for injury in runner's has been reported to be as high as 90% in those training for longer distances (Lopes *et al*., 2012). According to Giandolini *et al.* (2016), trail runners completing downhill forest trails, 50% to 75% of all running injuries associated with trail running are overuse injuries which resulted in the runner taking a break from running for a period of time. An overuse injury is typically acquired due to the constant repetition of the same movement over a prolonged period of time (Hoffman & Krishnan, 2014). During a trail run, the typical runner is exposed to foot-ground contacts which are likely to subject the trail runner's joints, bones and cartilage to a much higher stress than those faced by other runners (Giandolini *et al*., 2016).

Trail running has been seen to push the extremes of human tolerance in terms of neuromuscular and physiological adaptations, thereby, putting the runner at higher risk for injury (Vernillo *et al.*, 2016). This type of running is specialised and results in neuromuscular function being altered at different levels of the motor pathway which runs from the motor cortex to the skeletal muscles (Giandolini *et al.*, 2015a) resulting in substantial fatigue of the muscles, thus leaving the trail runner predisposed to a higher risk of musculoskeletal injury (Kluitenberg *et al.*, 2015).

Trail running has been known to cause muscle damage and general fatigue due to the duration of each run, eccentric contractions during downhill trails and the constant change in slope (Milliaropoulos, Mertyri and Tsaklis, 2015). Easthope Schmidt *et al.* (2014) reported that trail runners who each completed a single-track mountain course consisting of rocky and tree root covered paths, repetitively eccentrically contract their muscles affecting their locomotive efficiency resulting in a decrease of 3.2% in running efficiency. Following long distance trail runs, muscle fatigue and damage resulted in a decrease of maximal voluntary muscle contraction by 20% to 40%, thus putting the runner at risk for acquiring a sudden injury such as an ankle sprain (Easthope Schmidt *et al.,* 2014). Van Middelkoop e*t al*. (2008), Buist *et al*. (2010) and Hespanhol, Van Mechelen and Verhagen (2017) reported that the prevalence of road running related injuries varied from 26% to

92.4%; however, according to Milliaropoulos, Mertyri and Tsaklis (2015) reported an outlier of 90% of ultra-trail runners reported at least one running-related injury.

The incidence rate of running-related injuries can range anywhere from 18.2% to 92.4%, depending on the age of the runner and their previous running experience (Cheung & Davis, 2011; Lopes *et al*., 2012; Hespanhol, Pena Costa and Dias Lopes, 2013). Hoffman & Krishnan (2014) reported an annual incidence rate of 5.5% relating to stress fractures in ultra-marathon runners in the United States, who ran greater distances during the year. According to Giandolini *et al.* (2016), the high number of foot-ground contacts experienced during a trail run may be directly related to the large incidence of osteo-articular injuries.

Despite its excellent health benefits, concerns have been raised about the high incidence rates of musculoskeletal injuries, primarily of the lower limbs, which are associated with trail running (Milliaropoulos, Mertyri and Tsaklis, 2015).

2.5 Risk factors associated with the development of injuries associated with trail running

The aetiology of running-related injuries is multi-factorial, with both intrinsic factors (personal) and extrinsic factors (environmental) playing a role in causing injuries (Buist *et al.*, 2010). Risk factors that have been identified for developing running-related injuries include but are not limited to; previous injuries sustained, more than 60km run per week and less than three years of running experience (Hespanhol, Pena Costa and Dias Lopes, 2013). Another contributing factor to the risk of injury is whether the runner includes stretching into their training programme (Milliaropoulos, Mertyri and Tsaklis, 2015).

One of the highest risk factors for developing a running-related injury is a history of previous running injuries (Hespanhol, Pena Costa and Dias Lopes, 2013). Previous injury has been shown to be a significant predictor of injury reoccurrence in runners as there is a tendency toward re-injury of the same area (Van Gent *et al.*, 2007). Most injuries sustained in runners are overuse injuries (Hespanhol, Pena Costa and Dias Lopes, 2013). The majority of overuse injuries are biomechanically linked to kinetics and different terrains such as those experienced in trail running which puts trail runners at a much higher risk of sustaining an injury (Benca *et al.*, 2013). As a consequence of previous injury, runners tend to alter their running mechanics in order the better cushion impacts during running. These include, but are not limited to; increased knee flexion, increased hip flexion and increased plantarflexion at heel strike, which may all contribute to the development of an overuse injury to these areas (Giandolini *et al*., 2016).

Increased training distances per week is another contributing factor (Buist *et al.*, 2010). It has been suggested that the number of days run per week (frequency), how long each run is (duration) as well as the intensity of each run may affect the risk of developing an injury (Denissen *et al.*, 2012). Milliaropoulos, Mertyri and Tsaklis (2015) stated that limiting the number of kilometres run per week and shortening the duration of training would minimise the development of a running-related injury, as the majority of subjects were found to be over training.

Fredericson & Misra (2007) stated that road runners with less experience were more prone to injury than those who had been running for many years with the number of years running being inversely related to the incidence of injuries. This may be due to the runners having decreased muscle strength and joint stability compared to runners who have been running for a longer period of time (Fredericson & Misra, 2007).

The above risk factors for endurance running are well documented; however, risk factors associated with trail running as well as predicting factors and the most affected anatomical areas have very little information available (Milliaropoulos, Mertyri and Tsaklis, 2015).

2.6 Intrinsic risk factors

2.6.1 Age and body mass index

Participation of athletes has increased in long distance running events with the average age in runners being 40 years and older (Fields, 2011). Buist *et al.* (2010) conducted a prospective cohort study on roadrunners and found that women below the age of 31 years were less likely to sustain a new running-related injury; however, after the age of 50 the risk for developing a running-related injury was increased. A significant trend for acquiring injury exists with increasing age (Buist e*t al*., 2010). A systematic review conducted by Van Gent e*t al.* (2007) found that greater age was a significant risk factor for injury in runners. This correlates with the findings of Faulkner *et al.* (2007) who noted that after 50 years of age, there is a gradual loss of 50% of muscle fibres from all skeletal muscles.

According to Fields (2011), injuries in older runners are becoming more common than in younger runners. This may be due to the greater number of structural and functional transformations which lead to an overall physical decline induced by the aging process or it may be due to the fact that normal muscle strain which occurs with training takes a greater time to repair with aging (Easthope Schmidt *et al.*, 2014; Fields 2011). Older runners have also been seen to continue running at a similar frequency to that of younger runners despite age-related changes such as decreased strength and increased stiffness, which put them at a higher risk of developing a running-related injury (Fields, 2011).

Performance endurance in runners will peak until the ages of about 30 to 35 years, after which there will be a moderate decrease until the ages of 50 to 60 years; thereafter, a progressively steeper decline is noted after the ages of 70 to 75 years (Beat *et al.*, 2011). In a study conducted in Switzerland on elite men and women running half- and full marathons, it was found that a runner's performance peaked between 25 to 35 years of age (Aschmann *et al*., 2013). Beat *et al.* (2011) found that an individual's running pace and strength will peak in both genders between the ages of 25 to 30 years, as indicated by world record performances. A runner's performance will then decline after the age of 40 years, with up to 50% of peak level performance being decreased by the age of 80 years (Faulkner *et al.*, 2007). According to Beat e*t al*. (2011), a runner's performance is notably decreased after the age of 55 years in both genders and females have a tendency to decline faster than males.

The age of the runner has also been shown to have an effect on differing patterns of injury between younger and older runners (Fields, 2011). Younger runners were more prone to knee and shin problems, whereas the older runners experienced a higher incidence of calf, achilles and hamstring injuries (Fields, 2011).

Male runners with a height of 1.70m or more have been shown to be at a significantly increased risk of suffering new injuries (Van Gent *et al.,* 2007). This may be due to greater forces acting on the bones, muscles and connective tissue (Buist *et al.,* 2010). Buist *et al*. (2010) found that a higher body mass index (BMI) put the runner at an increased risk for sustaining an injury possibly due to the added physical stress. However, in a study done by Milliaropoulos, Mertyri and Tsaklis (2015), there was no association found between BMI and the risk of sustaining an injury.

2.6.2 Gender

Males and females have different risk profiles for developing a running-related injury (Buist *et al.*, 2010). Females are twice as likely to sustain a running-related injury when compared to their male counterparts (Chumanov, Wall-Scheffler and Heiderscheit*,* 2008). Women demonstrate increased hip width to femoral length ratio causing increased hip adduction and internal rotation, thus resulting in increased genu valgus and abduction. These structural differences displayed in females predispose them to different movement patterns such as increased non-saggital plane motion which could possibly contribute to the development of various running-related injuries (Ferber, McClay Davis and Williams, 2003; Chumanov, Wall-Scheffler and Heiderscheit , 2008).

According to Van Gent *et al.* (2007), women are more at risk of developing running-related injuries compared to men due to differences in structures predisposing men to different running mechanics, which lead to specific injuries. Women were more likely to sustain injuries such as patellofemoral pain syndrome, iliotibial band (ITB) syndrome or injury to the gluteus medius (Chumanov, Wall-Scheffler and Heiderscheit, 2008). Buist *et al*. (2010) reported that male participants were at a higher risk for acquiring a running-related injury than female participants, this contradicts the findings of Chumanov, Wall-Scheffler and Heiderscheit (2008) and Van Gent *et al*. (2007) who found that women were more likely to sustain an injury.

Ellapen *et al*., (2013) found that the presence of deviant Q-angles among male runners predisposes them to the development of musculoskeletal knee injury. The Q-angle is an indicator of the muscle symmetry of the quadriceps femoris muscle surrounding the knee, therefore larger Q-angles increase the compressive forces applied to the knee joint (Ellapen *et al*., 2013).

Gender differences relating to lower extremity kinematics have been identified as possible contributory factors to running-related injuries (Chumanov, Wall-Scheffler and Heiderscheit, 2008). It is likely that underlying gender-related muscle activity is also present due to the identified gender differences in joint kinematics (Chumanov, Wall-Scheffler and Heiderscheit, 2008). Contradicting previous statements; Kohne, Ormsbee and McKune (2016) hypothesised that the female sex hormone, estrogen, possesses the ability to provide a protective effect by enhancing skeletal muscle growth and maintaining muscle mass. In contrast to this, Cheung & Davis (2011) found that the risk of developing an injury was much higher in active female runners.

Female runners are more likely to incur hip injuries whereas male runners are more prone to hamstring or calf injuries (Van Gent e*t al.*, 2007). This may be due to gender discrepancies in muscle activity during locomotion such as greater gluteus medius and vastus lateralis muscle activity displayed in females. In addition to this, gender-specific morphology of the pelvis and thigh such as the greater hip internal rotation observed in females may contribute to the gender-related differences in injuries sustained (Chumanov, Wall-Scheffler and Heiderscheit, 2008). Ellapen *et al*., (2013) found that females with tight hip flexors produced an anterior pelvic tilt altering the normal length tension relationsip between the hip posterior rotators/extensors and anterior hip rotators/flexors. This induced a decreased hip flexion angle and predisposed the runner to be more likely to sustain a lower back/hip musculoskeletal injury.

2.6.3 Ethnicity

Running has been shown to be a social phenomenon, with various ethnic groups participating in the sport (Aschmann e*t al*., 2013). However, with regard to trail running, dominance in ethnic groups has not yet been clearly established. In a study conducted on recreational half-marathon road runners in KwaZulu-Natal, it was found that the participants consisted of 50% White, 33% Indian, 12% African and 6% Coloured, thus showing the wide racial diversity portrayed in the South African running community (Ellapen *et al*., 2013).

African runners have dominated in long-distance road running events and have been shown to have certain advantageous factors such as physiological characteristics, social factors, nutritional differences in diets and genetic predisposition contributing towards their success (Eksterowicz, Naplerala and Zukow*,* 2016; Aschmann *et al.,* 2013). According to Onywera *et al*. (2006), studies comparing physiological characteristics between White and African runners, found that African runners had lower blood and muscle lactate concentrations at a given exercise intensity, better running economy and an increased ability to tolerate higher utilisation of maximal oxygen uptake (VO_{2max}). African runners consume more oxygen than White runners who are running at the same speed and this leads to increased utilisation of fats while saving glycogen during physical activity (Eksterowicz, Naplerala and Zukow, 2016).

Another factor which may be contributing to African dominance in running is that African runners have lower plasma lactate concentrations (Harley *et al*., 2009). Lower plasma lactate concentrations provide an increased resistance to fatigue and superior performance ability becomes enhanced (Harley *et al*., 2009). As the African race is seen to dominate these events, there may be an overall increase in the number of African runners who sustain running-related injuries (Aschmann *et al*., 2013).

2.6.4 History of previous injury

One of the highest risk factors for developing a running-related injury especially in the lower extremities is a history of previous running injuries (Buist *et al.*, 2010; Joseph & Molloy, 2016). Previous injury has been seen to be a significant predictor of the reoccurrence of injury in runners as there is a tendency toward re-injury of the same area (Milliaropoulos, Mertyri and Tsaklis, 2015). This may be due to residual biomechanical and structural deficits, the repaired tissue offering less protection, the development of compensatory gait patterns or incomplete healing of the original injury (Joseph & Molloy, 2016).

Milliaropoulos, Mertyri and Tsaklis (2015) found that runners with a previous running-related injury may not have been completely rehabilitated before resuming training. Health education should focus primarily on the importance of complete rehabilitation of injuries and early recognition of symptoms of overuse as this will greatly decrease the risk of recurrence (Knobloch, Yoon and Vogt, 2008). Treatment choice may also increase or decrease the risk of re-injury to the same region. Conservative treatment will alleviate most overuse injury symptoms, while no treatment and continuation of training may exacerbate and worsen a sometimes minor injury (Knobloch, Yoon and Vogt, 2008).

2.7 Extrinsic risk factors

2.7.1 Running with a load

An additional risk factor to consider is running with a load (which is common in trail runners as most trail runners carry a fluid and other items) as it has been shown to increase leg stiffness, as well as increased peak vertical ground reaction forces (Silder, Boser and Delp, 2015). Increased leg stiffness has been associated with an increased risk of bone-related injuries (Lussiana, Hebert-Losier and Mourot, 2015). Trail runners are also exposed to a high number of shock forces including high-intensity shocks on negative elevations during running which predispose the runner to a higher risk of injury (Giandolini *et al.*, 2016).

Running with a load combined with high-intensity shock forces will put a higher strain on the lower limbs, thus causing muscle fatigue and increased risk of injury (Abe *et al*., 2011). High loads (also known as impact peaks) which are applied at high frequency (such as over long distances) will potentially increase the risk of developing an overuse injury (Schmitz *et al.*, 2014). Overuse injuries such as shin splints and heel pain are common due to the increased rate of vertical ground reaction forces (Zadpoor & Nikooyan, 2011).

2.7.2 Terrain

Trail running presents a unique challenge as courses often transverse varied terrain making races last longer; thereby resulting in the runner being exposed to factors such as widely fluctuating temperatures, dehydration, and fatigue (Parise & Hoffman, 2011). Trail running encompasses long uphill and downhill sections resulting in substantial physiological and mechanical stress to the body (Giandolini *et al.*, 2015a). Runners adjust limb stiffness in order to maintain constant support mechanics on surfaces of different terrain (Muller *et al.,* 2010). Changes in the slope or ground elevation combined with an increased running duration are known to cause muscle damage and general fatigue in trail runners (Milliaropoulos, Mertyri and Tsaklis, 2015).

The type of running surface has been known to influence load absorption or absorption mechanics (Tessutti *et al.*, 2008). Adjustments in running kinematics compensate for changes in the impacting surface and are necessary to maintain the impact forces the body experiences in these conditions (Giandolini *et al*., 2016), thus possibly putting the runner at greater risk for injury.

A major characteristic of trail running involves a large proportion of eccentric work during downhill segments which have been shown to result in severe structural damage to muscles by altering their contractile and recuperative properties (Easthope Schmidt *et al.,* 2010). It has been assumed that peak impact forces which are associated with overuse injuries are reduced when running on surfaces which have an increased cushioning property such as a trail route. Bean *et al.* (2017) suggested that road runners carry a different biomechanical consequence compared to trail runners (trail runners display variable joint angles and increased joint stiffness), thereby, indicating that trail runners would have a different injury profile compared to road runners.

2.7.3 Footwear

Selection of the correct footwear for trail running, especially for longer distances, is essential and can be either a contributing or preventative factor towards the development of an injury (Fuller *et al*., 2015). Incorrect footwear or lack of footwear (i.e. barefoot) has been found to be a significant contributing or preventative factor to injuries sustained while running (Kong, Candelaria and Smith, 2009). Changing the type of running footwear may be one of the preventative measures one can take to avoid the risk of injury (Joseph & Molloy, 2016). Running economy is also affected by footwear which in turn affects the overall performance of the runner (Fuller *et al.,* 2015).

External shock due to ground impact forces are absorbed by the footwear of the runner and this could play an important role in preventing or causing injuries (Kong, Candelaria and Smith, 2009). With increased wear of the shoe, its ability to attenuate shock decreases which then results in an increased force applied to the lower extremity (Joseph & Molloy, 2016). Several footwear characteristics have been identified that influence running performance such as shoe mass, cushioning, motion control, longitudinal bending stiffness, grip and comfort (Fuller *et al*., 2015).

According to Kong, Candelaria and Smith (2009), there are generally three classifications of the running shoe i.e. motion control (for control at the subtalar joint and compensatory pronation), the support shoe (for the runner not requiring much control) and the cushion shoe (for a rigid-type foot requiring flexibility and cushioning for shock absorption).

Motion control, being the most popular type of shoe, aims at preventing excessive foot pronation (where the arches of the foot roll inwards), which results in decreased incidence of pronation-related injuries such as shin splints, plantar fasciitis, Achilles tendonitis and patella femoral pain syndrome (Cheung & Ng, 2008).

Shoe mass has shown to determine running economy with increased shoe mass resulting in an increased metabolic workload (Fuller *et al.,* 2015). Footwear with good grip may prevent falls, slipping and injury and may actually increase the runner's speed in negative elevations (Heyns, 2013). Trail runners require a running shoe which has adequate grip, shock absorption, and flexibility in order to decrease the potential risk of developing an injury (Vercruyssen *et al.*, 2016).

The distance, which the runner will run also plays a vital role in determining footwear as longer distances and multi-stage events require shoes with much more stability, protection and comfort; while shorter distances and sprint races require a minimalistic, quick dry shoe (Heyns, 2013). Some trail runners prefer a shoe which provides stability to protect the runner, while others prefer a more flexible shoe for increased speed; thereby giving the trail runner a different injury pattern (Milliaropoulos, Mertyri and Tsaklis, 2015).

2.8 Training errors and environmental factors associated with trail running

2.8.1 Running experience

Running inexperience has been found to be a major risk factor for sustaining a running-related injury (Buist *et al.*, 2010). This statement has been supported by Nielsen *et al.* (2012) who stated that high running experience has been shown to diminish the risk of injury. However, Milliaropoulos, Mertyri and Tsaklis (2015) found that having more than six years running experience was a significant risk factor for developing injury especially in the low back region, the tibia and plantar areas. This may be due to these areas experiencing repetitive shock and ground reaction forces over an extended period of time (Giandolini *et al*., 2016).

These contradicting statements may be due to experienced runners knowing their own injury threshold, therefore being less likely to sustain an injury. It could also be that novice runners may be more likely to report new injuries than experienced runners, who in some cases, may have sustained multiple injuries and no longer consider some conditions severe enough to classify as an injury (Nielsen *et al.*, 2012).

2.8.2 Training schedule

Nielsen *et al.* (2012) reported that 60% to 70% of all running injuries are due to training errors such as a change in training routine or excessive distances run. It has been suggested that the number of days run per week (frequency), how long each run is (duration) as well as the distance of each run may affect the risk of developing an injury (Saragiotto *et al.*, 2014). Nielsen *et al.* (2012) found that those who trained a minimum of five days per week were more likely to sustain an injury compared to those who trained a minimum of three days per week.

According to Cheung & Ng (2008), running patterns change when mileage is increased as well as an increase in foot pronation on landing. A sudden increase in mileage is one of the biggest risk factors for developing a running-related injury (Milliaropoulos, Mertyri and Tsaklis, 2015). Yeung & Yeung (2011) found that a decreased running distance significantly reduced the development of overuse injuries. Saragiotto *et al*. (2014) correlated with the above by stating that if mileage rises above a given threshold level, biomechanical abnormalities will have sufficient time to interact and cause injury.

Saragiotto *et al.* (2014) found that an individual who fails to establish a sufficient training base during training sessions will be more likely to sustain an injury during a race where the distance run is steadily increased. Milliaropoulos, Mertyri and Tsaklis (2015) found that episodes of double training sessions were more likely to result in the development of a hip joint injury.

An additional contributory factor to the risk of injury is whether a runner includes stretching into their training programme as Yeung & Yeung (2011) found that stretching the gastrocnemius muscle was associated with a significant decrease in the risk of lower limb injuries in running. Wilson *et al.,* (2010) found that static stretching before running improved performance of the athlete and reduced the risk of injuries. Baxter *et al.* (2017) correlated with these findings stating that stretching would significantly reduce the incidence of overuse injuries. This may be due to the result of muscle lengthening and relaxation which occurs with stretching, resulting in the athlete having increased mobility while navigating a trail run (Wilson *et al*., 2010). The duration of each training session is important as training for 15 to 30 minutes per day significantly reduces the incidence of injury development compared to training for a minimum of 45 minutes per day (Yeung & Yeung, 2011).

2.8.3 Nutrition

Adequate nutrition plays a vital role in sustaining performance and limiting fatigue during long distance running (Stellingwerff, 2012). Elite distance runners should follow optimised nutrition programmes in order to maintain their training schedules (Schroder *et al.*, 2008). Carbohydrate metabolism which primarily provides muscle glycogen is the dominant fuel for exercise activities where more than 75% VO_{2max} intensity is reached (Stellingwerff, 2012). The more carbohydrates that are consumed prior to a training session or race, the better the potential for endurance performance enhancement (Stellingwerff, 2012). However, if these needs are not met, early onset of fatigue and resultant injury may occur (Schroder *et al.*, 2008).

Schroder *et al.* (2008) determined that the optimal diet for runners consisted of 55% to 60% of energy in the form of carbohydrates, 30% energy in the form of fat and 10% to 15% of energy in the form of protein.

Fluid intake in the form of water and energy drinks prove essential electrolytes during training and are essential in preventing dehydration and ensuring successful completion of races (Williamson, 2016). Jeukendrup (2011) found that when runners consumed carbohydrate drinks compared with water, their endurance performance was enhanced. This suggests that the more carbohydrates which are feasibly consumed the better the runner's potential endurance performance will be (Stellingwerff, 2012).

Therefore, it is important to consider nutrition as a possible factor contributing towards a trail running related injury due to the increased bodily fuel consumption during increased durations of exercise which are associated with trail running (Easthope Schmidt *et al.*, 2010).

2.9 The role of the health care provider

The above factors having been extensively researched in road runners have led to the development of an injury profile related to road running as stated by Kluitenberg *et al.* (2015); however, there is a paucity in the literature with respect to injuries related to trail running (Milliaropoulos, Mertyri and Tsaklis, 2015).

Running epidemiological surveillance studies conducted on road runners enabled professionals to establish injury profiles and associated risk factors as well as programmes which have enabled better treatment and management of these conditions. This is important for inter-referrals between health care providers such as doctors, surgeons, physiotherapists, biokineticists and chiropractors (Konczak & Ames, 2005;

Sandell, Palmgren and Bjorndahl*,* 2008); however, there is a paucity in the trail running epidemiology literature in South Africa.

With high incidence rates of running-related injuries as stated by Kong, Candelaria and Smith (2009), it is paramount to have knowledge of the types of injuries incurred during trail running, the risks associated with sustaining these injuries and what methods have been proven to be successful in treating them in order to be able to improve the runners rehabilitation, training and performance (Giandolini *et al*., 2015b). The ability to appropriately regulate locomotive behaviour in response to changes in gradient, such as those experienced by trail runners, is fundamental to increasing our understanding of the control of human locomotion and injury patterns (Vernillo *et al.*, 2016).

2.10 Conclusion

The relevant literature review pertaining to the topic was extensively described in this chapter. The literature presented in this chapter outlined the incidence and prevalence of trail running injuries as well as those associated with road running in order to make a comparison. Intrinsic and extrinsic risk factors were discussed in order to determine the most significant factors associated with sustaining an injury while trail running. Training errors and environmental factors were included in the discussion as these may also influence the risk of acquiring an injury while trail running. The following chapter will describe the methodology used in this study.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter will present the research methods and data collection tool used in this study.

3.2 Study design

The study used a quantitative cross-sectional observational survey design. A quantitative study is a formal, objective, systematic process in which numerical data is used to obtain information (Muijs, 2010). This research method describes variables, examines relationships among variables and determines cause-and-effect interactions between variables.

3.3 Study population

The study sample was trail runners in the eThekwini municipality of KwaZulu-Natal. Participants from various trail running races volunteered to participate in the study after completion of a trail race.

3.4 Participant recruitment

The participants were made aware of the research study by means of advertisements (Appendix A) which were placed at trail running races in the eThekwini municipality. Only participants who had completed a minimum distance of 10km were selected to participate as Giandolini *et al.* (2015a) suggested that this minimum distance would more likely define a consistently active trail runner.

3.5 Sampling

3.5.1 Sample size

Subjects who met the requirements for the study according to the inclusion and exclusion criteria were allowed to participate in the study. Based on the average number of trail runners in the eThekwini municipality, the minimum sample size for this study was 215 participants, which was calculated using a 95% confidence interval and a 5% margin of error with a minimal response rate of 90% (Esterhuizen, 2018). The average number of trail runners was determined by averaging the total number of entries of the three largest trail races during 2016 and 2017, which was a total of 250, as there were no official trail running clubs to extract this data from.

3.5.2 Sample characteristics

3.5.2.1 Inclusion criteria:

- Participants completed a minimum distance of a 10km trail race (Giandolini *et al.*, 2015).
- Participants who were active trail runners with an average of 30km run per week (Schmidt Easthope *et al.*, 2010).
- Participants who were over the age of 18 years.
- Participants who read the letter of information (Appendix B) and signed an informed consent (Appendix C).

3.5.2.2 Exclusion criteria:

- Patients who wished to no longer participate in the study were automatically excluded and their data was not was used.
- Participants who participated in the focus group and pilot study were excluded.
- Questionnaires which were not at least 70% completed were excluded.

3.5.3 Measurement tools

The questionnaire used in this study was developed by reviewing the work of Clarsen *et al.* (2015) for questions which related to injury profile analysis as well as incorporating questions used in the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire. Questions relating to the treatment of injuries were adapted from the work of by Bahr *et al.* (2004) and Fritz & Irrgang (2001). The work of Taunton *et al.* (2003) was adapted to formulate questions relating to demographics and risk factors associated with acquiring an injury. In addition to this, the work of Morgan *et al.* (2001) was taken into account with respect to questionnaire design and structure. This resulted in the development of the pre-focus questionnaire (Appendix D).

Table 3.1 Questionnaire reference list

Demographics (age, gender, ethnicity, occupation)	Taunton *et al.* (2003) - Section A
Running training history (average monthly mileage and other sporting activities)	Clarsen *et al.* (2015), and Taunton *et al.* (2003) - Section A
Running competition (average monthly trail races)	Clarsen *et al.* (2015), and Taunton *et al.* (2003) - Section A
Running shoe (type of shoe)	Taunton *et al.* (2003), Bahr *et al*. (2004) and Fritz & Irrgang (2001) - Section A
Running equipment (carrying of fluid and how it is carried)	Taunton *et al.* (2003) - Section A
Musculoskeletal injury (how the injury was sustained and the region of injury)	Taunton *et al.* (2003), Bahr *et al.* (2004), and Fritz & Irrgang (2001) - Section B
Injury consequence (past/current injury affect)	Bahr *et al.* (2004), Fritz & Irrgang (2001), and Taunton *et al.*(2003) - Section B

3.6 Research procedure

3.6.1 Focus group

A focus group involves an organised discussion with a selected group of individuals to gain information about their views and experience on a topic, thereby, ensuring the validity of a questionnaire (Morgan *et al.*, 2001).

3.6.1.1 Inclusion criteria:

- Participants who were over the age of 18 years.
- Participants who read the letter of information (Appendix E) and signed the confidentiality agreement (Appendix F) and informed consent (Appendix G) were allowed to participate.

3.6.1.2 Exclusion criteria:

- Potential participants for the pilot study and the main study were excluded.

The focus group was run according to the structure that was presented in the work of Morgan *et al.* (2001), Silverman (2016) and Streiner (2009). The focus group for this study was conducted as follows:

- A date and time was set for the focus group.
- A venue was secured.
- Participants included a quantitative researcher, the researcher, an epidemiological expert, the two research supervisors, and two active trail runners.
- The participants were contacted and asked if they would like to be part of the focus group.
- The participants were welcomed upon arrival.
- Thereafter, the participants were asked to read the letter of information (Appendix E), the confidentiality agreement (Appendix F) and informed consent form (Appendix G).
- The participants were then given an opportunity to ask any questions relating to the procedure of the focus group and were given time to sign the informed consent (Appendix G) and the confidentiality agreement (Appendix F) which stated that the participant would keep confidential any discussion within and regarding the focus group.
- The focus group then proceeded with the discussion of the pre-focus questionnaire (Appendix D).

- The researcher, as the chair of the meeting, sequentially read the questions out aloud before the group was asked to discuss the relevance of the question to the aims and objectives of the study as well as then deciding whether the questions were understandable by the general trail running population.
- The focus group participants were allowed to agree to, disagree with or be undecided about the inclusion of questions in the questionnaire. In order for the questions to be included or excluded, the group was required to be unanimous in their agreement to include or exclude questions. For those questions where there was indecision about the relevance or inclusion of the question, it resided to a simple vote with a majority or the question could be deferred for purposes of being reviewed by the researcher in the context of the literature available in the domain of running.
- Once the focus group completed reviewing the questionnaire, the participants were thanked for their participation.
- The focus group participants were then offered refreshments.
- The researcher ensured that the focus group discussion was recorded in both written and audio recorded form such that the researcher had sufficient reference points to update the pre-focus group questionnaire (Appendix D).
- The post-focus group questionnaire (Appendix H) was then developed.

3.6.2 Pilot study

The fundamental purpose of conducting a pilot study is to examine the feasibility of an approach that is intended to ultimately be used in a larger scale study (Leon, Davis and Kraemer, 2012).

3.6.2.1 Inclusion criteria:

- Participants who were over the age of 18 years.
- Participants who were active trail runners who ran less than 10km so as to not diminish the size of the population for the main study unnecessarily.
- Participants who read the letter of information (Appendix I) and signed the informed consent (Appendix J).

3.6.2.2 Exclusion criteria:

- Participants who no longer wished to participate in the pilot study were excluded and replaced.
- Participants of the focus group and potential participants for the main study were excluded.

The pilot study was conducted as follows:

- This utilised participants that who were similar to the main study; however, they were not athletes that complied with the inclusion criteria of having participated in the minimum 10kms races so to ensure that the population for the main study was not diminished unnecessarily.
- Permission was requested from the event organisers for an identified event at which the pilot was completed (Appendix K).
- The three pilot study participants were approached as per the procedure for the main study in order to determine any logistical problems with the proposed main study procedure (Hicks *et al.*, 2001).
- The pilot study participants were required to read and complete the letter of information (Appendix I) and informed consent (Appendix J).
- Thereafter, the participant was required to complete the post-focus group questionnaire (Appendix H).
- The participant was then required to complete a questionnaire evaluation form (Appendix L) in order to identify any problems with the questionnaire.
- The comments from the pilot study participants were then incorporated into the post-focus group questionnaire (Appendix G) thereby resulting in the final questionnaire (Appendix M), which was utilised in the main study.

3.6.3 Main study procedure

- Permission was sought from the trail race organisers to collect data at the various trail race events (Appendix N).
- Once permission was obtained, the researcher travelled to the various venues.
- Contact was made with the runners through advertisement (Appendix A) at trail running races.
- The runners were then approached individually after completion of the race and asked to read and complete a letter of information (Appendix B) and informed consent form (Appendix C) prior to completing the questionnaire (Appendix M).
- If a participant did not understand a question, they were able to ask the researcher for clarification.
- Due to trail race venues varying, the questionnaire (Appendix M) was completed in allocated areas at selected trail races in the eThekwini municipality.
- The completed informed consent forms (Appendix C) were stored in a sealed “ballot box with a slit on the lid”- which was marked A. This was to ensure that all the forms were confidentially until the research was completed.

- The completed questionnaires (Appendix M) were placed in a sealed "ballot box with a slit on the lid"- which was marked B to ensure that they were retained in a sealed container for the duration of the study and were kept anonymous.
- Both ballot boxes were kept sealed until all letters of information (Appendix B), informed consent (Appendix C) and the questionnaires (Appendix M) were completed. This was tracked by a tracking sheet stuck to the outside of the ballot boxes.
- Once the ballot boxes were unsealed the documents were kept in safe storage during the process of data capturing, recording, analysis and reporting. All data was coded to ensure anonymity.

3.7 Data analysis

IBM SPSS version 25 was used to analyse the data. A p value <0.05 was considered as statistically significant. Categorical variables and outcomes were described using proportions and 95% confidence intervals ($p<0.05$). Continuous variables were summarised using mean and standard deviation. Non-normal distributed variables were summarised using the median and inter-quartile range. Associations between categorical predictors and presence of injury (period prevalence) were tested using Pearson's chi-square test. Associations between continuous variables and injury were tested using t-tests. A p value <0.1 was considered for inclusion in a multiple logistic regression model. Backwards selection based on likelihood ratio tests was used to arrive at a final predictive model. Odds ratios and 95% confidence intervals were reported (Esterhuizen, 2018).

3.8 Ethical considerations

The ethical issues that applied to the study included:

- IREC approval (Appendix O) was sought before data collection commenced for this study.
- All participants were given a letter of information (Appendix B) and were required to sign an informed consent form (Appendix C) in line with autonomy.
- Questionnaires (Appendix M) were coded and letters of information (Appendix B) and informed consent (Appendix C) were kept separate to ensure anonymity.
- Participants were chosen at random in line with justice and no bias was given to gender, ethnicity, religion or socio-economic standing.
- Beneficence was accounted for as the results of this study indicated common trail running related injuries, how these injuries had affected running performance and treatment which was utilised; thereby providing information to guide treatment and

management plans specific for trail runners and in that way, benefit the profession and patients.

- Non-maleficence was accounted for by ensuring no harm was done to any of the participants.

3.9 Conclusion

This chapter outlined the research methodology used in this study. It described the sampling and statistical methods, the development of the trail running questionnaire used to capture the data as well as the methods used to statistically analyse the data. The chapter concluded with the ethical principles that were accounted for in this study. Chapter Four and Five will present the results and discussion to this study.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter will present the results obtained from the statistical analysis of the data collected.

4.2 Sample size and response rate

The data that was collected from participants who satisfied the inclusion and exclusion criteria of the study were analysed. Out of a sample size of N=215, 197 participants responded by giving this study a response rate of 91%. The reason why a 100% response rate was not achieved was due to a repetition of the same runners at the various race events. The data of 145 of the total collected number of 197 participants were analysed in this study as 52 (24%) of questionnaires were excluded due to failure to meet the inclusion criteria for the study.

4.3 Results

4.3.1 Age and BMI

The results of this study show that the average age of female trail runners was 39 years and the average age of male trail runners was 40 years (**Table 4.1**). The average height for females was shown to be 1.64m and males 1.78m. The average body mass was determined to be 63kg for females and 78kg for males with the average BMI for females being 23.5 and males being 24.4.

Table 4.1 Demographics (age, weight, height, and BMI)

	Female		Male	
	Mean	Standard Deviation	Mean	Standard Deviation
Age	39	12	40	13
Height	1.64	.07	1.78	.08
Body mass	63	9	78	12
BMI	23.5	3.1	24.4	3.2

4.3.2 Gender

The number of female participants was 78 (53.8%) and the number of male participants was 67 (46.2%) (**Table 4.2**).

Table 4.2 Gender

		Count	Column %
Gender	Female	78	53.8%
	Male	67	46.2%

4.3.3 Ethnicity

Table 4.3 demonstrates the various ethnic groups which participated in the study. The results showed that 114 (78.6%) were White, 18 (12.4%) African, nine (6.2%) were Indian and four (2.8%) were Coloured.

Table 4.3 Ethnicity

		Count	Column %
Ethnicity	White	114	78.6%
	African	18	12.4%
	Indian	9	6.2%
	Coloured	4	2.8%

4.3.4 Period prevalence

This study showed that more than half the participants i.e. 53.8% (n=78), had acquired an injury at some point in time due to trail running (**Table 4.4**).

Table 4.4 Period prevalence

Have you acquired an injury due to trail running?				
		Frequency	%	95% confidence interval
Valid	Yes	78	53.8	45.35 % to 62.04%
	No	67	46.2	
	Total	145	100.0	

4.3.5 Point prevalence

The point prevalence of this study was 25.52% indicating that this percentage of trail runners had sustained a recent (within the past seven days) trail running related injury.

4.3.6 Past Injury

The majority of past injuries (n=78) sustained were due to trauma (44.6%) and overuse (n=27) (36.5%) (**Table 4.5**). It was found that 18.9% of past injuries sustained were of unknown origin. Of the participants who had sustained a past injury, 82.7% reported that their training had been affected ($p<0.05$) with 74% resulting in cessation of training ($p<0.05$). The average length of time off training was determined to be two months.

Table 4.5 Past Injury – Injury acquired within the past 12 months

		Count	Column N %
How did you sustain your injury? (Past Injury)	Trauma	33	44.6%
	Overuse	27	36.5%
	Unknown	14	18.9%
Has your injury affected your training? (Past Injury)	Yes	62	82.7%
	No	13	17.3%
Has your injury resulted in cessation of training? (Past Injury)	Yes	54	74.0%
	No	19	26.0%
If "Yes" please state the length of time you were unable to train (Past Injury)- months		Median = two months	

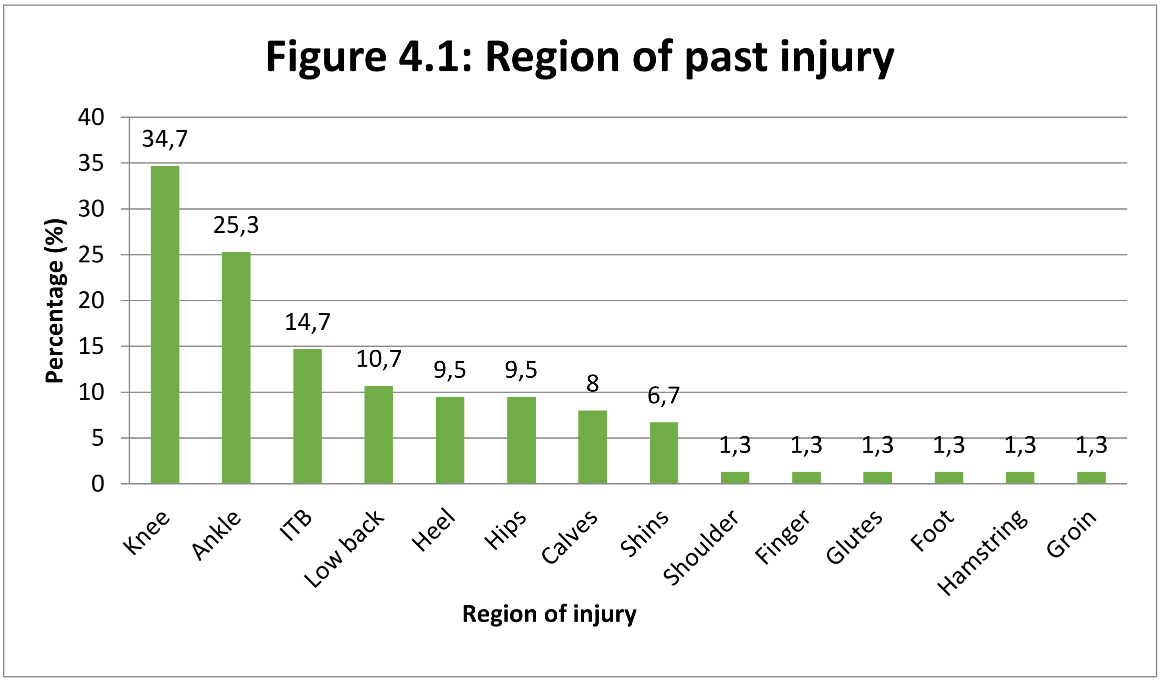

Figure 4.1Region of past injury

Figure 4.1 demonstrates the regions most injured in trail runners within the past 12 months. The most common injury sustained in trail runners was shown to be the knee region with 26 (34.7%) participants reporting pain in the area. Following the knee, the ankles also had a high injury rate of 19 (25.3%) as well as the ITB with 11 (14.7%). Other significant regions of injury included the low back with eight (10.7%) participants, heels with seven (9.5%) participants, hips with seven (9.5%) participants, calves with six (8%) participants and shins with five (6.7%) participants (p<0.05).

4.3.7 Current injury

The most common current injuries sustained were equally due to trauma and overuse (43.2%) with five (13.5%) being of unknown origin (**Table 4.6**). Of the current injuries sustained, 75.7% affected the runners training (p<0.01) with 62.2% resulting in cessation of training (p<0.01). The time of training was shown to be an average of three days.

Table 4.6 Current injury – Injury acquired within the past seven days

		Count	Column N %
How did you sustain your injury? (Current Injury)	Trauma	16	43.2%
	Overuse	16	43.2%
	Unknown	5	13.5%
Has your injury affected your training? (Current Injury)	Yes	28	75.7%
	No	9	24.3%
Has your injury resulted in cessation of training? (Current Injury)	Yes	23	62.2%
	No	14	37.8%
If "Yes" please state the length of time you were unable to train (Current Injury)- days		Median = three days	

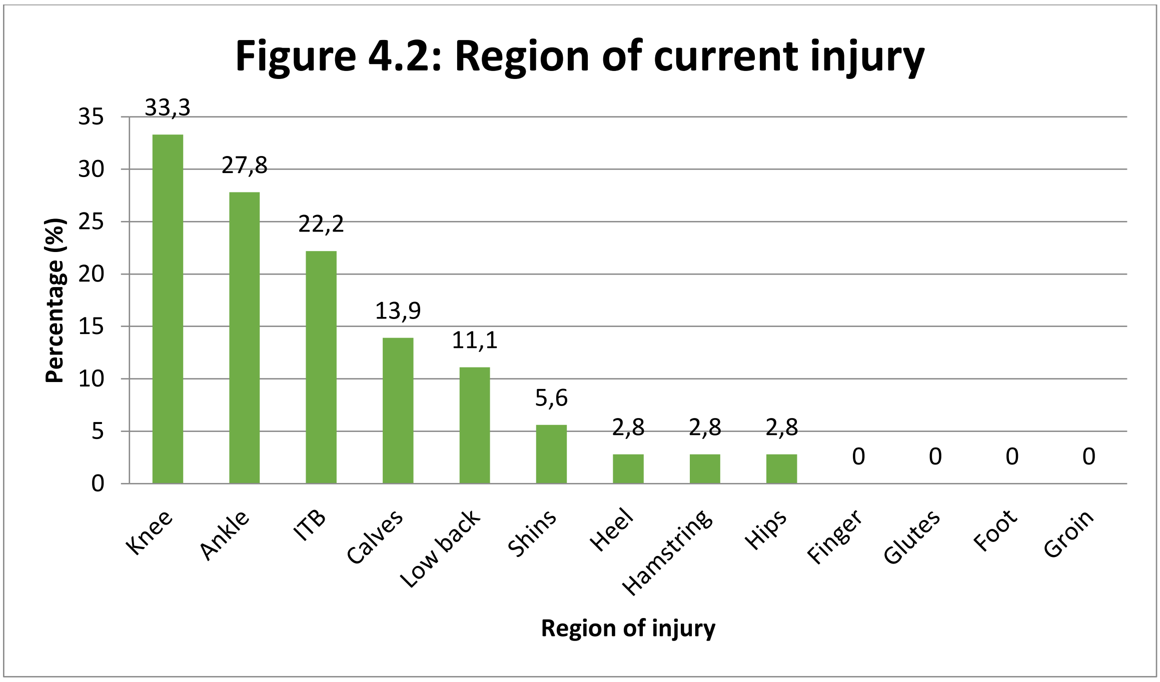

Figure 4.2Region of current injury

As demonstrated in **Figure 4.2**, the most common region of injury in a current injury was shown to be the knee region (33.3%), this was followed by the ankles (27.8%) and ITB (22.2%) (p<0.05). Other regions of significance were the calves (13.9%), low back (11.1%), shins (5.6%), heels (2.8%) and hamstring (2.8%). The fingers, glutes, foot, and groin were not shown to be significant areas of injury.

4.3.8 Risk factors

Demographic, training, and equipment were considered as potential risk factors with respect to the period prevalence of musculoskeletal injuries. Ethnicity was shown to be statistically significant as White's were five times more likely to be injured than African's (p=0.005) (**Table 4.7**). Females were more likely to sustain a trail running related injury as 53.8% of the sample population had sustained an injury, while only 46.2% were males. The combined injury rate for males and females was not significant (p=0.989) (**Table 4.7**).

4.3.8.1 Running with a load

Trail running with a load (equipment) was also shown to be a statistically significant risk factor for sustaining an injury as 42 (53.8%) of participants who carried a load while trail running reported an injury (p=0.047) (**Table 4.7**).

4.3.8.2 Footwear

A high percentage of participants (88.5%) who wore shoes specifically designed for trail running reported an injury (p=0.050) and 30.8% of trail runners who used the same running shoes for both road and trail running had acquired an injury (p=0.055) making these significant risk factors as demonstrated (**Table 4.7**).

4.3.8.3 Training schedule

The number of trail runs per month was determined to be statistically significant for developing a trail running related injury as those who ran more than ten times per month were 4.65 times more likely to sustain an injury than those who ran less than five times per month (p=0.012) (**Table 4.7**). The distance run on a tarred/paved surface per week, in addition to trail running, was also shown to be a protective factor (p=0.038). Those who had sustained a trail running related injury had a low average mileage of 17km per week, whereas those who had not sustained an injury spent more time training on a tarred/paved surface with an average of 27km per week (**Table 4.8**).

Table 4.7 shows the crude univariate associations between each categorical factor and injury. The five factors which achieved a p<0.1 were taken forward as predictors into a multiple logistic model and statistically predicted the outcome variables.

Table 4.7 Risk factors associated with acquiring an injury due to trail running

		Have you acquired an injury due to trail running?				*p* value
		No		Yes		
		Count	Column %	Count	Column %	
Gender	Female	36	53.7%	42	53.8%	0.989
	Male	31	46.3%	36	46.2%	
	Other	0	0.0%	0	0.0%	
Ethnicity	African	14	20.9%	4	5.1%	0.005
	Coloured	3	4.5%	1	1.3%	
	Indian	6	9.0%	3	3.8%	

	White	44	65.7%	70	89.7%	
	Other	0	0.0%	0	0.0%	
Do you stretch before you run?	Yes	34	50.7%	32	41.0%	0.241
	No	33	49.3%	46	59.0%	
Do you stretch after you run?	Yes	36	53.7%	40	51.3%	0.768
	No	31	46.3%	38	48.7%	
How often do you trail run?	< 5 times per month	44	65.7%	36	46.2%	0.012
	Between 5-10 times per month	18	26.9%	23	29.5%	
	More than 10 times per month	5	7.5%	19	24.4%	
Do you run on the road/tarred surface in addition to trail running?	Yes	58	86.6%	67	85.9%	0.907
	No	9	13.4%	11	14.1%	
Do you participate in any other sporting or exercise activities?	Yes	49	73.1%	57	73.1%	0.994
	No	18	26.9%	21	26.9%	
Do you participate in any other sporting events or races competitively?	Yes	20	29.9%	19	24.4%	0.457
	No	47	70.1%	59	75.6%	
Do you wear running shoes which are specifically designed for trail running?	Yes	51	76.1%	69	88.5%	0.050
	No	16	23.9%	9	11.5%	
Have you had your	Yes	18	26.9%	26	33.3%	0.398

feet professionally analysed for the correct trail running shoes?	No	49	73.1%	52	66.7%	
Do you use the same running shoes for both road and trail running?	Yes	31	46.3%	24	30.8%	0.055
	No	36	53.7%	54	69.2%	
How often do you replace your trail running shoes	Once per year	53	79.1%	59	75.6%	0.670
	Twice per year	13	19.4%	16	20.5%	
	Three times per year	1	1.5%	3	3.8%	
Do you carry fluid while trail running?	Yes	42	62.7%	56	71.8%	0.243
	No	25	37.3%	22	28.2%	
Do you carry any other equipment while running?	Yes	25	37.3%	42	53.8%	0.047
	No	42	62.7%	36	46.2%	

Table 4.8 depicts the crude univariate associations between each continuous variable and injury. The one variable which achieved a $p<0.1$ was taken forward together with the five above as predictors for acquiring a trail running related injury into a multiple logistic model. The average age of trail runners who acquired an injury was 40.5 years. The average BMI in participants who acquired a trail running injury was 23.7, which was lower than those who did not, as their average BMI was determined to be 24.1 (**Table 4.8**).

Table 4.8 Associations between continuous variables and injury

	Have you ever acquired an injury due to trail running?	N	Mean	Std. Deviation	*P* value
BMI	No	67	24.130	3.5732	0.517
	Yes	78	23.789	2.7462	
Age	No	67	38.34	12.921	0.278
	Yes	78	40.56	11.650	
How long have you been a runner?	No	67	9.343	10.3097	0.474
	Yes	78	10.635	11.2116	
On average, how many kilometres do you run on trail per week?	No	67	38.84	8.092	0.772
	Yes	78	38.44	8.392	
What is your average pace for a 10km trail run during training?	No	67	72.61	20.628	0.479
	Yes	78	75.22	23.143	
On average, how many kilometres per week do you run on the road/tarred surface?	No	61	27.02	37.238	0.038
	Yes	72	17.07	14.201	
How many hours per week do you spend participating in this sporting or exercise activity?	No	49	5.63	4.081	0.364
	Yes	57	4.91	4.041	
On average, how many trail races do you compete in per month?	No	67	1.60	1.001	0.899
	Yes	78	1.58	.905	
On average, how many road races do you compete	No	67	.88	1.080	0.400
	Yes	78	.73	1.053	

in per month?					
What is your average competitive pace during a 10km trail race?	No	65	68.75	23.171	0.881
	Yes	77	69.31	20.979	

Table 4.9 displays the regression models of the selected variables which were tested to determine the most significant predictors for acquiring a trail running related injury.

Table 4.9 Selected variables

Variables in the Equation

	B	S.E.	Wald	df	Sig.	OR	95% C.I.for OR	
							Lower	Upper
Ethnicity			9.361	3	.025			
Coloured vs African	-1.190	1.431	.692	1	.406	.304	.018	5.025
Indian vs African	-.185	.987	.035	1	.852	.831	.120	5.754
White vs African	1.258	.665	3.579	1	.059	3.520	.956	12.966
How often do you trail run?			6.464	2	.039			
5-10 times/month vs < 5 times/month	.469	.456	1.057	1	.304	1.598	.654	3.908
More than 10 times/months vs < 5 times /month	1.830	.730	6.285	1	.012	6.237	1.491	26.089
Do you wear running shoes which are specifically designed for trail running? Yes vs	.223	.618	.130	1	.718	1.250	.372	4.197

no								
Do you use the same running shoes for both road and trail running? No vs yes	.301	.480	.392	1	.531	1.351	.527	3.465
Do you carry any other equipment while running?(1)	.531	.410	1.678	1	.195	1.700	.762	3.794
On average, how many kilometres per week do you run on the road/tarred surface?	-.017	.012	1.988	1	.159	.983	.959	1.007
Constant	-1.384	.771	3.223	1	.073	.251		

After eliminating the non-significant predictors, the final model which shows the significant predictors for acquiring an injury associated with trail running is depicted in **Table 4.10**. Only ethnicity and how often they trail ran per month were shown to be significant predictors for developing an injury. Being of White ethnicity put the trail runner at a risk of five times more likely to develop an injury than being African and those who ran more than ten times a month were 4.65 times more likely to be injured than those who ran less than five times a month. The other predictors (wearing running shoes specifically designed for trail running, using the same running shoes for both road and trail running, carrying equipment while running and the average mileage run on the road/tarred surfaces) were dropped from the model due to not being statistically significant after adjustment for confounding.

Table 4.10 Final model

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Race			10.898	3	.012			
Coloured vs African	-.424	1.329	.102	1	.750	.654	.048	8.856
Indian vs African	.453	.931	.237	1	.626	1.574	.254	9.750
White vs African	1.620	.612	7.005	1	.008	5.052	1.522	16.763
How often do you trail run?			7.703	2	.021			
5-10 times/month vs < 5 times/month	.600	.414	2.094	1	.148	1.822	.808	4.105
More than 10 times/months vs < 5 times /month	1.537	.579	7.044	1	.008	4.651	1.495	14.474
Constant	-1.547	.599	6.664	1	.010	.213		

4.5 Conclusion

The results of the data analyses are presented in this chapter in the manner relevant to quantitative research. Ethnicity and training schedule was shown to be significant predictors for acquiring a trail running related injury. Other risk factors included running with a load and footwear. Protective factors were shown to be a higher BMI and increased mileage on a tarred/paved surface in addition to trail running. The discussion of the results presented in this chapter will be seen in chapter Five.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

This chapter discusses the results presented in Chapter Four and compares them to similar studies. The discussion includes sample size and response rate, demographics, the point and period prevalence of musculoskeletal injuries in trail runners, risk factors associated with the incidence of sustaining a trail running related injury and the impact of musculoskeletal injuries on trail runners.

5.2 Sample size and response rate

The total sample size needed for the study was 215 trail runners (Esterhuizen, 2018). In total, 197 participants responded by giving this study a 91% response rate. The reason why a 100% response rate could not have been achieved was due to a repeat of the same runners at the various trail race events. Out of the total response rate, 52 questionnaires (24%) were discarded as they failed to meet the inclusion criteria of the study.

The population size for his study was larger than previous studies conducted on trail runners. Muller *et al.* (2010) looked at leg adjustments when running on uneven terrain using a sample size of nine healthy physically active male participants. Schmidt Easthope *et al.* (2010) compared trail runners' muscular performance between 11 young and 15 master athletes. Giandolini *et al*. (2015a) using 23 male participants looked at neuromuscular alterations induced by downhill trail running, and how these affected the gait and kinetic chain of the trail runner. A total of 40 ultra-trail runners (36 men and four women) participated in a study by Milliaropoulos, Mertyri and Tsaklis (2015) which looked at certain risk factors associated with acquiring an injury. Vercruyssen *et al*. (2016) conducted a surveillance on 13 well-trained, competitive male athletes focusing on the effects of footwear and how different running shoes affected the biomechanics of the trail runner. Giandolini *et al.* (2016) examined how different foot strike patterns affected shock acceleration and attenuation in downhill trail running on 23 experienced male trail runners. Bean *et al.* (2017) conducted a preliminary study on 29 male and female participants who had at least two years running experience, could run a 10km trail race in under 60 minutes and had been injury free for six months prior to the study. The study focused on the risk factors for acquiring an injury in trail running.

Hespanhol, Pena Costa and Dias Lopes (2013) had a larger population sample size, although the study was conducted on road runners and not on trail runners, unlike this study which focused specifically on the trail running population.

Most of the previous studies were done on a specified group and gender of trail runners focusing on different aspects of trail running, muscular performance, footwear, and related injuries. This study included a larger sample size as well as having no bias towards gender, ethnicity or age, giving a broader profile relating to injuries sustained in the trail running population.

This study attained a sufficient response rate for it to be statistically acceptable when compared to the target areas and the total number of trail runners in the eThekwini municipality of KwaZulu-Natal.

5.3 Demographics

5.3.1 Age and BMI

Trail runners who had acquired a trail running related injury were found to have an average age of 40.5 years old (**Table 4.1**). This correlates with the findings of Buist *et al*. (2010), who stated that the risk for developing a running-related injury was increased after the age of 40 years.

Milliaropoulos, Mertyri and Tsaklis (2015) noted no relationship between BMI and the risk of acquiring an injury in trail runners. This may be due to the fact that all the participants of that study displayed a normal BMI, as well as the different terrain in which the study was conducted. Buist *et al*. (2010) found that a higher BMI in road runners was seen as a risk factor to acquiring an injury, possibly due to a participant having increased physical stress from the extra weight, coupled with the high impact forces on the body experienced while running on the road/paved surfaces. Contradictory to these findings, it was determined in this study that those who had a lower BMI were more likely to sustain an injury. This may be because this study was conducted on trail runners and not road runner's, indicating that trail running has a different biomechanical response on a runner's body and that having a higher BMI could possibly protect against injury during trail running, as it would give the runner more stability while navigating the terrain experienced during trail running.

5.3.2 Gender

The results of this study showed that women were more likely to sustain a trail running related injury than men (**Table 4.7**). These results confirm the findings of Van Gent *et al*.

(2007) and Chumanov, Wall-Scheffler and Heiderscheit (2008) who both found that women were more likely to sustain a running-related injury than men due to structural differences predisposing them to different running mechanics. However, both these studies were conducted on road runners and not on trail runners. It is postulated that the reason for women sustaining more injuries than men in trail running may be due to the different running mechanics of female runners, gender discrepancies in muscle activity during locomotion, or the increased hip adduction and internal rotation displayed in females.

5.3.3 Ethnicity

Various ethnic groups participated in this study; however, there was a dominance of the White ethnic group (78.6%) (**Table 4.3**). Ethnicity was shown to be a strong predictive factor for acquiring an injury while trail running in this study. It was shown that Whites were five times more likely to be injured than African's (**Table 4.7**). This contradicts the findings of Aschmann *et al*. (2013) who found that Africans were more likely to be injured as this ethnic group dominates road running events. Eksterowicz, Naplerala and Zukow (2016) correlated with the findings of Aschmann *et al.* (2013) and also found that Africans dominated road running events putting this ethnic group at a much higher risk of developing a running-related injury due to the high volume participating in these events.

The findings of this study may be due to the high percentage of White participants in trail running events and the much lower percentage of African runners. The reason for this may be due to the difficult to reach locations of some trail races, as well as the cost involved in getting to these races and entry fees. Another reason for the dominance of White participants may be due to trail running being less popular than road running as it is still considered a relatively new sport.

5.3.4 Past injury

It was shown that more than half the participants of this study 53.8% (n=78), had acquired an injury at some point in time as a result of trail running (**Table 4.4**). This figure is lower than a previous study conducted on trail runners by Milliaropoulos, Mertyri and Tsaklis (2015) who found that 90% of trail runners reported at least one trail running related injury. Previous studies by Van Middelkoop *et al*. (2008), Buist *et al*. (2010) and Hespanhol, Van Mechelen and Verhagen (2017) found incidence rates varying from 26% to 92.4%; however, these studies were conducted on the road running population and not specifically on trail runners. This shows that the trail runners in this study had a lower period prevalence when compared to road runners as well as when compared to studies done on other trail runners. This may be due to trail running having less of an impact force applied to the body when compared to road running. Another reason for this study having a lower percentage of injuries may be due to the South African terrain being different from other countries, such as the USA and Greece, where previous studies have been conducted.

The majority of past injuries sustained were due to trauma (44.6%) (**Table 4.5**). These findings contradict previous studies done by Giandolini *et al*. (2016) who stated that 50% to 75% of all trail running injuries were overuse injuries. This may be due to the different terrain in the areas where this study was conducted. In this study, 82.7% of participants who had sustained an injury reported that their training had been affected by the injury and 74% of these reported a cessation in training for an average of two months. Giandolini *et al*. (2016) found that most injuries resulted in the runner taking a break from running for a period of time, confirming the findings of this study.

The most common area for injury in this study was shown to be the knee (34.7%). Following the knee was the ankles (25.3%) and the ITB (14.7%). These findings are similar to those of Ellapen *et al*. (2013) who found that the knee was the most common region of injury followed closely by the ankles; however, their study was conducted on South African road runners as opposed to trail runners. Fredericson & Misra (2007) whose study was also conducted on road runners found the knee to be the most common region of injury in both males and females followed by the ITB. Milliaropoulos, Mertyri and Tsaklis (2015) conducted an injury profile analysis on trail runners and found the most reported injury to be to the lower back region, followed by the knee with equally high prevalence. Possible reasons for this study having slightly different results to previous studies conducted is that others were done on roadrunners and not trail runners, as well as the South African terrain varying from trail running terrain compared to other parts of the world.

5.3.5 Current Injury

In this study, 25.52% of participants reported a current injury (within the past seven days). As shown in **Table 4.6**, the most common cause of current injury was equally due to trauma and overuse (43.2%). Of these, 75.7% reported that their training had been affected with 62.2% stopping training for an average period of three days. The most common area of injury reported was shown to be the knee (33.3%), followed by the ankles (27.8%) and ITB (22.2%). These findings are consistent with studies done by Van Gent *et al*. (2007) and Buist *et al*. (2010) who found that previous injury was shown to be a significant predictor of re-injury to the same area. The findings of this study show that the majority of areas of injury in terms of current injury were consistent with those in past injury. An explanation for this may be due to early return to training before complete healing of the injury which may result in a reoccurrence of a previous injury as was suggested by Milliaropoulos, Mertyri and Tsaklis (2015) and Hespanhol, Pena Costa and Dias Lopes. (2013).

5.3.6 Running with a load

Running with a load was shown to be a statistically significant risk factor for acquiring an injury, as 53.8% (n=42) of participants who carried a load while trail running reported an injury (*p*=0.047) (**Table 4.7**). These findings are in keeping with those of Silder, Boser and Delp (2015) and Lussiana, Hebert-Losier and Mourot (2015) who found that running with a load would increase leg stiffness which has been shown to be associated with an increased risk of sustaining an injury. It has thus been shown in this study that trail running with a load puts the runner at an increased risk for sustaining an injury. This may be due to the load causing the runner to alter their running mechanics, therefore, predisposing them to acquiring an injury.

5.3.7 Footwear

An additional risk factor for acquiring an injury was determined to be footwear. Those who wore shoes specifically designed for trail running (88.5%) reported an injury (*p*=0.050) (**Table 4.7**). These findings are contradictory to a previous study done by Vercruyssen *et al*. (2016) who found that footwear specific for trail running had no significant correlation with the development of an injury. An explanation for this may be due to different footwear tested in previous studies done, as well as a difference in terrain experienced by the South African runner. Fuller *et al.* (2015) found that certain footwear could improve running economy, thereby decreasing the risk of fatigue and resultant injury that follows; however, their study was a systematic review study conducted on roadrunners and not on the trail running population. The results of this study indicate that footwear specifically designed for trail running actually increases the risk of acquiring an injury.

It was found that 30.8% of trail runners who used the same shoes for both road and trail running reported an injury. This finding was only marginally significant (*p*=0.055). Joseph & Molloy (2016) stated that changing the type of running shoe may be a preventative measure in avoiding an injury which reinforces the findings of this study.

5.3.8 Training Schedule

The training schedule of the trail runner was shown to be one of the most significant predictors for acquiring a trail running related injury. Those who ran more than ten times per month were 4.65 times more likely to sustain a trail running related injury than those who ran less than five times per month (**Table 4.7**). This study correlated with a previous study done by Nielsen *et al*. (2012) who found that those who trained more than ten times per month were more likely to sustain an injury compared to those who trained less. Hoffman & Krishnan (2014) who conducted a study on long distance road runners found that those who ran greater distances per month were at a higher risk of sustaining an injury confirming the findings of this study. Fredericson & Misra (2007) correlated with the above findings by stating that a decrease in running distance per week would significantly reduce the development of overuse injuries in the runner.

The distance spent per week running on a tarred/paved surface was shown to be a protective factor in sustaining an injury while trail running. The findings of Fredericson & Misra (2007) support the findings of this study as they found that experienced runners were at a decreased risk of acquiring an injury as they were able to develop musculoskeletal adaptations to running conditions. Therefore, it has been shown in this study that training less than ten times per month on a trail as well as including training on a tarred/paved surface will decrease the risk of acquiring a trail running related injury.

5.4 Conclusion

The results of the study were discussed and compared to previous relevant studies in this chapter. The most significant predictors for acquiring a trail running related injury in this study was shown to be those of White ethnicity and training more than ten times per month. Other significant factors included being female, having sustained a previous trail running related injury, running with a load and footwear. Protective factors against acquiring a trail running related injury were shown to be a higher BMI, and the total distance spent running on tarred/paved surfaces in addition to trail running. The conclusion, limitations, and recommendations of this study will be discussed in the following chapter.

CHAPTER SIX: LIMITATIONS, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This chapter discusses the limitations as well as recommendations of this study and it concludes the study.

6.2 Limitations

A limitation of this study was that there is a dominance of the White ethnic group participating in trail running events, so a true reflection of injuries amongst ethnic groups was not attained.

Whether the participant's current injury was due to past injury could not be properly determined in this study.

This study excluded novice runners so their injury data was not analysed. Perhaps another study could look at novice runners and compare them with experienced runners.

6.3 Recommendations

A study done on the trail running population in other cities of KwaZulu-Natal as well as in other provinces of South Africa, would be recommended to see whether there are differences or correlations to the findings of this study.

A recommendation would be to conduct a gender specific study to determine a different injury profile for each gender.

Correlating past and current injury in the same participants may give a clearer injury profile in trail runners.

Another recommendation would be to conduct a study incorporating treatment and management of trail running related injuries.

A study comparing trail and road running related injuries is recommended, to determine whether there is a correlation between them.

Determining injury profiles of professional trail runners and comparing it to amateur trail runners is another recommendation.

6.4 Conclusion

With regards to the aims and objectives of this study, the results showed that there was a high period prevalence (53.8%) for sustaining a trail running related injury. The point prevalence (25.52%) was found to be much lower than that of period prevalence; however, the regions of injury in both categories were shown to be very similar. The most common area of injury in trail runners was shown to be the knee, followed by the ankles and ITB. The most common cause of injury in past injuries sustained was shown to be trauma whereas in current injuries the cause was equally due to trauma and overuse.

The common risk factors associated with sustaining a trail running related injury were shown to be an average age of 40 years old females were more likely to be injured than males, being of White ethnicity (p=0.005), running with a load (equipment) (p=0.047), footwear (p=0.050) and running more than ten times per month (p =0.012). Protective factors against acquiring a trail running related injury were shown to be a higher BMI and the distance spent running on tarred/paved surfaces (p=0.038) in addition to trail running.

The impact of musculoskeletal injuries was shown by determining the average time the runner had to stop training for. In past injuries, the median was shown to be two months and in current injuries, it was determined to be three days. The most prominent predictors for the development of a trail running related injury in this study was shown to be ethnicity; as White's were five times more likely to be injured than African's and training schedule as running more than ten times per month put the runner at an increased risk of 4.65 times more likely to sustain an injury than those who ran less than five times per month.

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APPENDICES

Appendix A

ARE YOU A TRAIL RUNNER? WHO HAS SUFFERED AN INJURY RELATED TO TRAIL RUNNING?

Become a part of a research study

Contact:

Maxine Millar - 0313732205

Appendix B

LETTER OF INFORMATION

Title of study: An epidemiological investigation into musculoskeletal injuries in trail runners in the eThekwini Municipality, Kwa-Zulu Natal

Research student: Maxine – Lee Millar

Supervisor:Dr D Varatharajullu (MTech: Chiropractic)

Co-Supervisor: Dr A Abdul-Rasheed (MTech: Chiropractic)

Purpose of the study

The aim of the study is to determine the demographics, injury profile and impact of musculoskeletal injuries and risk factors on trail runners who participate in selected trail races in the eThekwini municipality.

Procedures

You will receive the questionnaire to be filled out, following the completion of a trail race with a minimum distance of 10km run. The expected time to complete each questionnaire is approximately 10 minutes. You will be expected to complete and sign Informed Consent (Appendix B) prior to receiving the questionnaire (Appendix A).

Inclusion criteria:

- Only forms completed at various trail running race events will be included in this study, these are geographically dispersed across a large range of running terrain to most accurately represent the general population of trail runners
- You must have completed a minimum 10km trail race (Giandolini*et al*, 2015)
- You must be an active trail runner with an average of 30km run per week (Easthope *et al*, 2010)
- You must be over the age of 18 years old
- You will only be accepted into the study if they give their informed consent (Appendix B) in writing

Exclusion criteria:

- If you no longer wish to participate in the study, you will be automatically excluded and your data will not be used
- Participants included in the focus group and pilot group will be excluded
- Questionnaires will be excluded which are not at least 70% completed
- If you are only a road runner and do not run trail races

Risks or discomfort to the participant

There are no risks or risk of discomfort to you during this study.

Benefits

Your contribution to this study by volunteering to partake will help us Chiropractors to build on our knowledge. This will benefit you as a patient, as we will be able to provide you with more effective health care in the future as a trail runner. This study will give you a better understanding on how certain injuries are more common in trail runners and which management plans are the most successful in treating these injuries, therefore benefiting the entire trail running community as a whole and enabling each trail runner to perform at an optimal level.

Reason why you may be withdrawn from the study

If you are non compliant and have not completed at least 70% of the questionnaire, you will be withdrawn from the study

AS A VOLUNTARY PARTICIPANT IN THIS RESEARCH STUDY, YOU ARE FREE TO WITHDRAW FROM THE STUDY AT ANY GIVEN TIME, WITHOUT GIVING A REASON FOR WITHDRAWING AND WITHOUT CONSEQUENCE

Remuneration

You will not be receiving any monetary or other type of remuneration for participation in this study

Cost of the study

You will not be expected to cover any costs towards the study

Confidentiality

All patient information is confidential. The results of this study will be used for research purposes only. Only individuals that are directly involved in this study (Dr D Varatharajullu (MTech: Chiropractic), Dr A Abdul-Rasheed (MTech: Chiropractic) and myself) will be allowed to access these records.

Persons to contact should you have any problems or questions

Should you have any questions that you would prefer being answered by an independent individual, feel free to contact my supervisors on the following numbers Dr D. Varatharajullu (Tel: 0782220942) or Dr A. Abdul-Rasheed (Tel: (031) 3732102). If you are not satisfied with a particular area of this study, please feel free to forward any concerns to the Durban University of Technology Research and Ethics Administrator on (031) 3732375. Complaints can be reported to the Director: Research and Postgraduate Support, Prof S. Moyoon on (031) 3732577 or moyos@dut.ac.za.

Thank you for participating in my research study.

Maxine – Lee Millar
(Research student)

Appendix C

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Maxine-Lee Millar, about the nature, conduct, benefits and risks of this study - Research Ethics ClearanceNumber: REC 162/17
- 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 personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Full Name of Participant **Date** **Time** **Signature /**

I, Maxine-Lee Millar, herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Full Name of Researcher **Date** **Signature**

Full Name of Witness (If applicable) **Date** **Signature**

Full Name of Legal Guardian (If applicable) Date **Signature**

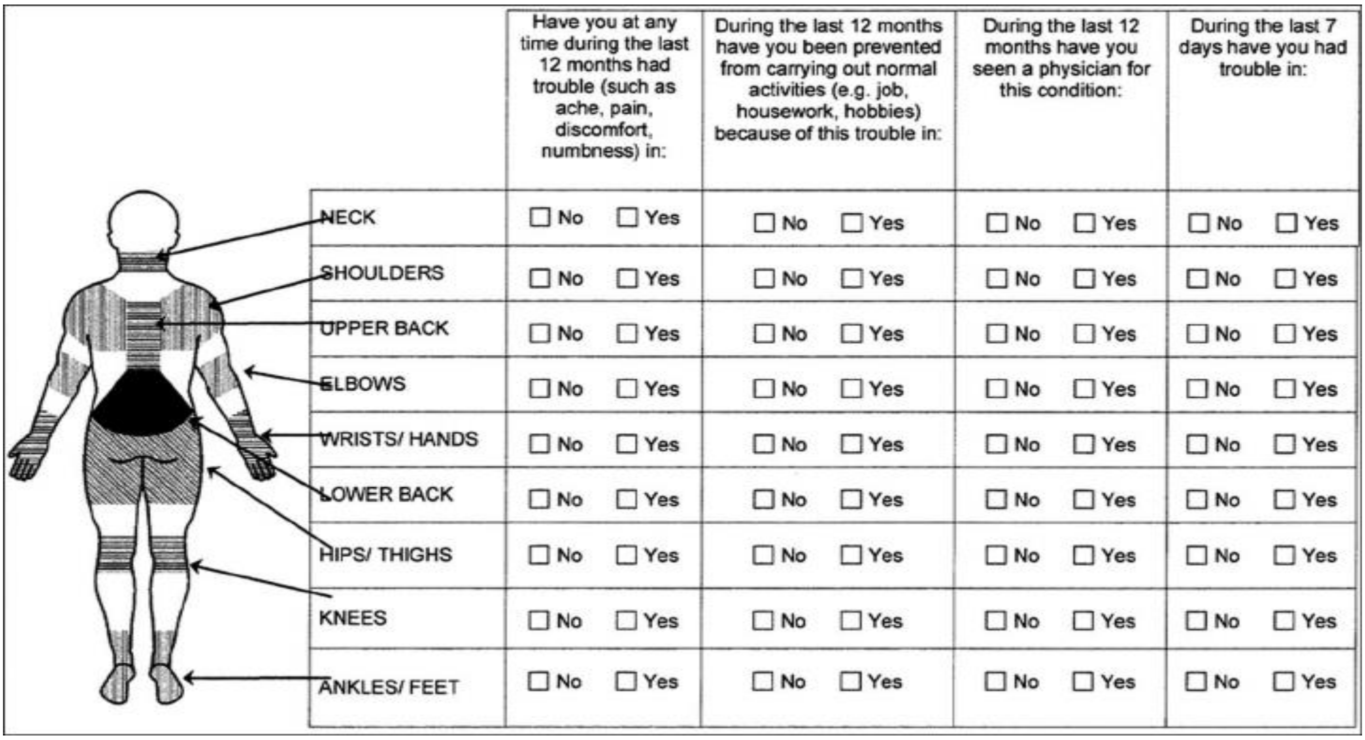
Appendix D

SECTION A					
Demographics: *(Participant: Please fill in or tick where relevant)*					
Age					
Gender	Female			Male	
Race	Black	Coloured	Indian	White	Other_______
Occupation					

Running			
2. Training History			
How long have you been a trail runner?	_________________months or ____________years		
Do you stretch before you run?	Yes		No
Do you stretch after you run?	Yes		No
How often do you trail run?	Less than 5 times per month	Between 5-10 times per month	More than 10 times per month
On average how many kilometres do you run on trail?	________________________ km per week		
Do you run on the road in addition to trail running?	Yes		No
On average how many kilometres do you run on the road?	________________________ km per week		
Do you participate in any other sporting or exercise activities?	Yes		No
If "Yes" please state what sporting or exercise activities you participate in			
How many hours per week do you spend doing this sporting or exercise activity?	_______________________ hours per week		
3. Competition			
What type of runner do you consider yourself?	Beginner	Intermediate	Advanced
On average, how many trail races do you compete in per month?	_________________ races per month		
Do you compete in road running races?	Yes		No
On average, how many road running races do you compete in per month?	_________________ races per month		
Do you participate in any other sporting events or races competitively?	Yes		No
4. Running shoe			
Do you wear running shoes which are specifically designed for trail running?	Yes		No
Do you use the same running shoes for road running as you do for trail running?	Yes		No
How often do you replace your trail running shoes?	____________ times per year		
5. Equipment			
Do you carry fluid while trail running?	Yes		No
How do you carry your fluid while trail running?	Camelback/ Backpack	Water Bottles	Other________

SECTION B

6. Musculoskeletal Injury (Injury – discomfort, pain, or damage to a part which may or may not cause cessation of training)						
	Previous Injury (in the last 12 months)			**Current Injury (in the last 7 days)**		
How did you sustain your injury?	Trauma (e.g. a fall resulting in a sprain)	Overuse (e.g. a stress fracture)	Unknown	Trauma (e.g. a fall resulting in a sprain)	Overuse (e.g. a stress fracture)	Unknown



	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	During the last 12 months have you been prevented from carrying out normal activities (e.g. job, housework, hobbies) because of this trouble in:	During the last 12 months have you seen a physician for this condition:	During the last 7 days have you had trouble in:
NECK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
SHOULDERS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
UPPER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ELBOWS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
WRISTS/ HANDS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
LOWER BACK	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
HIPS/ THIGHS	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
KNEES	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes
ANKLES/ FEET	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

Figure 1: Strain Assessment based on the Nordic Musculoskeletal Questionnaire (Franasiak*et al*, 2015)

7. Injury consequence		
Has your injury (past/current) affected your training?	Yes	No
Has your injury (past/current) resulted in cessation of training?	Yes	No
If "Yes" please state how long you were unable to train	____________________days/months/years(*please circle appropriate response*)	
Has your injury (past/current) resulted in missing days at work?	Yes	No
If "Yes" please state how long you missed work for	____________________days/months/years(*please circle appropriate response*)	

Appendix E

LETTER OF INFORMATION – FOCUS GROUP

Title of study: An epidemiological investigation into musculoskeletal injuries in trail runners in the eThekwini Municipality, Kwa-Zulu Natal

Research student: Maxine – Lee Millar

Supervisor:Dr D Varatharajullu (MTech: Chiropractic)

Co-Supervisor: Dr A Abdul-Rasheed (MTech: Chiropractic)

Purpose of the study

The aim of the study is to determine the demographics, injury profile and impact of musculoskeletal injuries and risk factors on trail runners who participate in selected trail races in the eThekwini municipality.

Procedures

You will be asked to read the Letter of Information (Appendix F), the Confidentiality agreement (Appendix G) and Informed Consent (Appendix H). You will then be given an opportunity to ask any questions regarding the focus group procedure and have time to sign the Letter of Information (Appendix F) and Informed Consent (Appendix H) as well as (Appendix G) which states that you will keep confidential any discussion within and regarding the focus group. The focus group will then proceed with the discussion of the questionnaire. The researcher as the chair of the meeting will sequentially read the questions out aloud before the group is asked to discuss the relevance of the question to the aims and objectives of the study as well as then deciding whether the questions are understandable by the general trail running population. Therefore the focus group may agree to, disagree with or be undecided about the inclusion of questions in the questionnaire. In order for the questions to be included or excluded, the group is required to be unanimous in their agreement to include or exclude questions. For those questions were there is indecision about the relevance or inclusion of the question, it may either need to reside to a simple vote with a majority or the question can be deferred for purposes of being reviewed by the researcher in the context of the literature available in the domain of running.

Inclusion criteria

- You must be over the age of 18 years old
- You must have an understanding of what trail running is
- You must sign the Letter of Information (Appendix F), Confidentiality agreement (Appendix G) and Informed Consent (Appendix H) to be allowed to participate

Exclusion criteria:

- If you no longer wish to be a part of the focus group you will be excluded and replaced
- Potential participants for the pilot study and main study will be excluded

Risks or discomfort to the participant

There are no risks or risk of discomfort to you in this study

Benefits

Your contribution to this study by volunteering to partake will help us Chiropractors to build on our knowledge. This will benefit you as a patient, as we will be able to provide you with more effective health care in the future. This study will give you a better understanding on how certain injuries are more common in trail runners and which management plans are the most successful in treating these injuries.

Reason why the participant may be withdrawn from the study

If you are non compliant and have not completed at least 80% of the questionnaire, you will be withdrawn from the study

AS A VOLUNTARY PARTICIPANT IN THIS RESEARCH STUDY, YOU ARE FREE TO WITHDRAW FROM THE STUDY AT ANY GIVEN TIME, WITHOUT GIVING A REASON FOR WITHDRAWING AND WITHOUT CONSEQUENCE

Remuneration

You will not be receiving any monetary or other type of remuneration for participation in this study

Cost of the study

You will not be expected to cover any costs towards the study

Confidentiality

All patient information is confidential. The results of this study will be used for research purposes only. Only individuals that are directly involved in this study (Dr D Varatharajullu (MTech: Chiropractic), Dr A Abdul-Rasheed (MTech: Chiropractic) and myself) will be allowed to access these records.

<u>Persons to contact should you have any problems or questions</u>

Should you have any questions that you would prefer being answered by an independent individual, feel free to contact my supervisors on the following numbers; Dr D. Varatharajullu (Tel: 0782220942) or Dr A. Abdul-Rasheed (Tel: (031) 3732102). If you are not satisfied with a particular area of this study, please feel free to forward any concerns to the Durban University of Technology Research and Ethics Administrator, LavishaDeonarian (031) 3732375. Complaints can be reported to the Director: Research and Postgraduate Support, Prof S. Moyoon on (031) 3732577 or moyos@dut.ac.za.

Thank you for participating in my research study.

Maxine – Lee Millar
(Research student)

Appendix F

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

CONFIDENTIALITY STATEMENT AND CODE OF CONDUCT: Expert group

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

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

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

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

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

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

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

Please print in block letters:

Focus Group Member: ____________________________ Signature: _________________________

Witness Name: __________________________________ Signature: _________________________

Researcher's Name: ______________________________ Signature: _________________________

Supervisor's Name: _______________________________ Signature: _________________________

Appendix G

CONSENT

Statement of Agreement to Participate in the Focus Group Study:

- I hereby confirm that I have been informed by the researcher, Maxine-Lee Millar, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number:162/17
- 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 personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

________________________ ____________ _______ __________________

Full Name of Participant **Date** **Time** **Signature /**

I, Maxine-Lee Millar, herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

____________________ ____________ ______________________

Full Name of Researcher **Date** **Signature**

____________________ ____________ ______________________

Full Name of Witness (If applicable) **Date** **Signature**

__________________ ___________ ____________________

Full Name of Legal Guardian (If applicable) Date **Signature**

Appendix H

SECTION A					
1. Demographics: *(Participant: Please fill in or tick where relevant)*					
1.1 Age					
1.2 Gender	Female		Male		Other__________
1.3 Race	African	Coloured	Indian	White	Other_______
1.4 Occupation					
1.5 Height______________m	1.6 Weight________________kg				

2. Training History			
2.1 How long have you been a runner?	________________months		
2.2 Do you stretch before you run?	Yes		No
2.3 Do you stretch after you run?	Yes		No
2.4 How often do you trail run?	Less than 5 times per month	Between 5-10 times per month	More than 10 times per month
2.5 On overage, how many kilometres do you run on trail per week?	________________km per week		
2.6 What is your average pace for a 10km trail run during training?	________________minutes per 10km		
2.7 Do you run on the road/tarred surface in addition to trail running?	Yes		No *(Proceed to 2.9)*
2.8 On average, how many kilometres per week do you run on the road/tarred surface?	________________km per week		
2.9 Do you participate in any other sporting or exercise activities?	Yes		No *(Proceed to 3.1)*
2.10 If "Yes" please state what sporting or exercise activity you participate in			
2.11 How many hours per week do you spend participating in this sporting or exercise activity?	________________hours per week		

3. Competition		
3.1 On average, how many trail races do you compete in per month?	________________races per month	
3.2 On average, how many road races do you compete in per month?	________________races per month	
3.3 What is your average competitive pace during a 10km trail race?	________________minutes per 10km	
3.4 Do you participate in any other sporting events or races competitively?	Yes	No

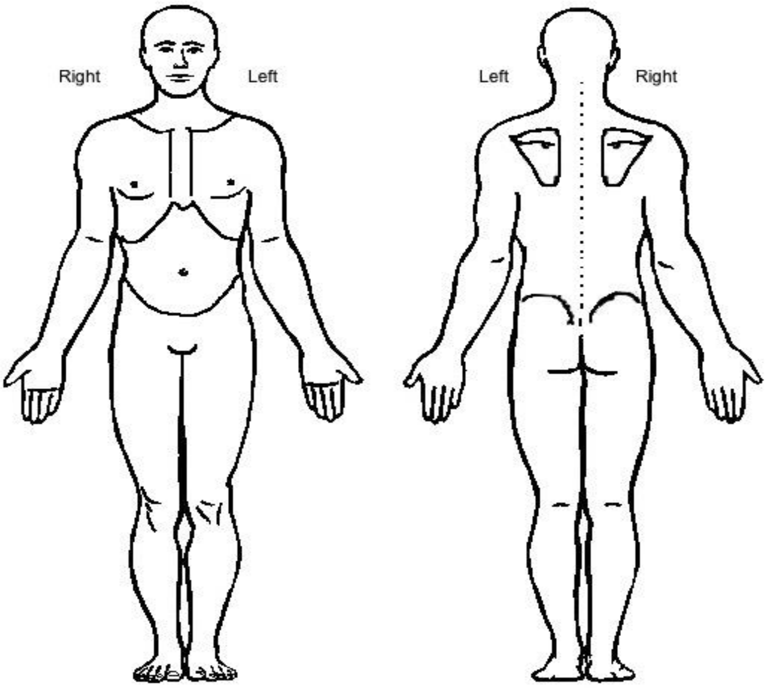
4. Running Shoe		
4.1 Do you wear running shoes which are specifically designed for trail running?	Yes	No
4.2 Have you had your feet professionally analysed for the correct trail running shoe?	Yes	No
4.3 Do you use the same running shoes for both road and trail running?	Yes	No *(Proceed to 5.1)*
4.4 How often do you replace your trail running shoes?	______________times per year	
4.5 What is the brand of your running shoe?		

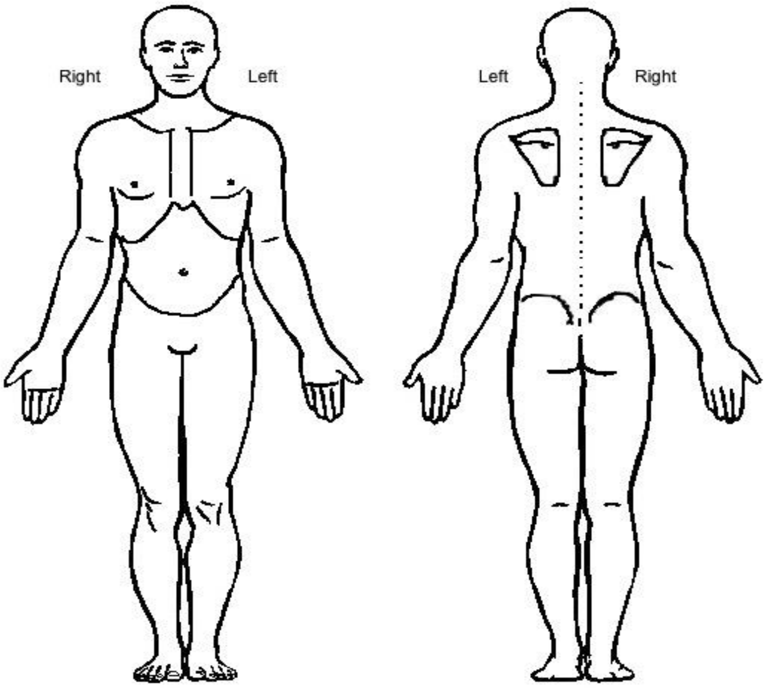
5. Equipment			
5.1 Do you carry fluid while trail running?	Yes		No *(Proceed to 5.3)*
5.2 How do you carry your fluid?	Camelback/ Backpack	Water Bottles	Other________
5.3 Do you carry any other equipment while running?	Yes		No *(Proceed to section B)*
5.4 If "Yes" please state/list object/s			

<u>SECTION B</u>						
6. Musculoskeletal Injury (Injury – discomfort, pain, or damage to a part which may or may not cause cessation of training)						
	Past Injury (in the last 12 months)			**Current Injury (in the last 7 days)**		
6.1 How did you sustain your injury? *(Please mark the most appropriate box with an "X")*	Trauma (e.g. a fall resulting in a sprain)	Overuse (e.g. a stress fracture)	Unknown	Trauma (e.g. a fall resulting in a sprain)	Overuse (e.g. a stress fracture)	Unknown
6.2 Has your injury/s been diagnosed by a medical professional?						
6.3 If "Yes" please state the diagnoses of your injury. *(In the case of multiply injuries, please state the diagnoses of the WORST injury)*						

7. Injury Consequence	**Past Injury (in the last 12 months)**		**Current Injury (in the last 7 days)**	
7.1 Has your injury affected your training?	Yes	No	Yes	No
7.2 Has your injury resulted in cessation of training?	Yes	No *(Proceed to 8.)*	Yes	No *(Proceed to 8.)*
7.3 If "Yes" please state the length of time you were unable to train	__________days/months/years(*please circle appropriate response*)		__________days/months/years(*please circle appropriate response*)	

8. Past Injury (in the last 12 months)

Please indicate with an “X” on the model where you have experienced pain or an injury in the last 12 months	

9. Current Injury (in the last 7 days)	
Please indicate with an “X” on the model where you have experienced pain or an injury in the last 7 days	

Appendix I

LETTER OF INFORMATION – PILOT STUDY

Title of study:

An epidemiological investigation into musculoskeletal injuries in trail runners in the eThekwini Municipality, Kwa-Zulu Natal

Supervisor:Dr D Varatharajullu (MTech: Chiropractic)

Co-Supervisor: Dr A Abdul-Rasheed (MTech: Chiropractic)

Research student: Maxine – Lee Millar

Institution: Durban University of Technology

Purpose of the study

The aim of the study is to determine the demographics, injury profile and impact of musculoskeletal injuries and risk factors on trail runners who participate in selected trail races in the eThekwini municipality.

Procedures

The participants will be required to read and complete the Letter of Information (Appendix J) and Informed Consent (Appendix K).Thereafter the participant will be required to complete the questionnaire (post-focus group) (Appendix I). The participant will then be required to complete a questionnaire evaluation form in order to identify any problems with the questionnaire (Appendix M).
Inclusion criteria:

- Participant must be over the age of 18 years old
- Participant must be an active trail runner who runs less than 10km so as to not diminish population of the main study unnecessarily
- Participant must complete and sign the Letter of Information (Appendix J) and Informed Consent (Appendix K)

Exclusion criteria:

- Participants who no longer wish to take part in the pilot study will be excluded and replaced
- Participants of the focus group and potential participants for the main study will be excluded

Risks or discomfort to the participant

There are no risks or risk of discomfort to the participants of this study

Benefits

Your contribution to this study by volunteering to partake will help us Chiropractors to build on our knowledge. This will benefit you as a patient, as we will be able to provide you with more effective health care in the future. This study will give you a better understanding on how certain injuries are more common in trail runners and which management plans are the most successful in treating these injuries.

Reason why the participant may be withdrawn from the study

Participants who are non compliant and who have not completed at least 80% of the questionnaire, will be withdrawn from the study

AS A VOLUNTARY PARTICIPANT IN THIS RESEARCH STUDY, YOU ARE FREE TO WITHDRAW FROM THE STUDY AT ANY GIVEN TIME, WITHOUT GIVING A REASON FOR WITHDRAWING AND WITHOUT CONSEQUENCE

Remuneration

The participant will not be receiving any monetary or other type of remuneration for participation in this study

Cost of the study

The participant will not be expected to cover any costs towards the study

Confidentiality

All patient information is confidential. The results of this study will be used for research purposes only. Only individuals that are directly involved in this study (Dr D Varatharajullu (MTech: Chiropractic), Dr A Abdul-Rasheed (MTech: Chiropractic) and myself) will be allowed to access these records.

Persons to contact should you have any problems or questions

Should you have any questions that you would prefer being answered by an independent individual, feel free to contact my supervisor on the above numbers. If you are not satisfied with a particular area of this study, please feel free to forward any concerns to the Durban University of Technology Research and Ethics Committee.

Thank you for participating in my research study.

Maxine – Lee Millar
(Research student)

Appendix J

CONSENT

Statement of Agreement to Participate in the Pilot Group Study:

- I hereby confirm that I have been informed by the researcher, Maxine-Lee Millar, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number:162/17 ,
- 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 personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

________________________ ____________ ________ __________________

Full Name of Participant **Date** **Time** **Signature /**

I, Maxine-Lee Millar, herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

____________________ ____________ ______________________

Full Name of Researcher **Date** **Signature**

____________________ ____________ ______________________

Full Name of Witness (If applicable) **Date** **Signature**

__________________ ___________ ____________________

Full Name of Legal Guardian (If applicable) Date **Signature**

Appendix K

02 April 2018

Request for Permission to Conduct Research

Dear Mr K Bolton

My name is Maxine Millar, and I am a Masters student at the Durban University of Technology. The research I wish to conduct for my masters dissertation involvesThe epidemiology of musculoskeletal injuries in trail runners in the eThekwini Municipality of KwaZulu-Natal .

I am hereby seeking your consent to data collect at your trail running races at Riverside Trail.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me 0817367364. Thank you for your time and consideration in this matter.

Yours sincerely,

Maxine Millar

Durban University of Technology

Appendix L

Pre-test Evaluation

1. What is your opinion of the subject presented in this questionnaire? (Please mark the most appropriate box)

   1.1 Extremely interesting ☐
   1.2 Interesting ☐
   1.3 Average ☐
   1.4 Boring ☐
   1.5 Very boring ☐

2. Do you think the topics raised in this questionnaire were adequately covered?

   2.1 Yes ☐
   2.2 No ☐

3. What is your opinion about the covering letter? (Please mark one box only)

   3.1 Very clear ☐
   3.2 Clear ☐
   3.3 Adequate ☐
   3.4 Unclear ☐
   3.5 Needs revising ☐

4. How would you describe the instructions accompanying each of the questions? (Please mark one box only)

   4.1 Very clear ☐
   4.2 Clear ☐
   4.3 Adequate ☐
   4.4 Unclear ☐
   4.5 Needs revising ☐

5. Do you think the questionnaire is too long?

   5.1 Yes ☐
   5.2 No ☐

6. What is your opinion of the wording of the questionnaire? (Please mark the appropriate box/es)

   6.1 The meaning of all questions is absolutely clear ☐
   6.2 The meaning of most questions is clear ☐
   6.3 There is too much chiropractic/medical jargon ☐
   6.4 The questions will not be understood by lay persons ☐
   6.5 The questionnaire needs to be revised because it is unclear ☐

If you had any difficulty answering any question/s, please write the number/s of the question/s in the space below with a suggestion on how the question/s can be improved?

____

Thank you for your most valuable time in helping me with my research project.

Appendix M

SECTION A					
1. Demographics: *(Participant: Please fill in or tick where relevant)*					
1.1 Age					
1.2 Gender	Female	Male	Other__________		
1.3 Race	African	Coloured	Indian	White	Other_______
1.4 Occupation					
1.5 Height______________m	1.6 Weight________________kg				

2. Training History			
2.1 How long have you been a runner?	________________Years		
2.2 Do you stretch before you run?	Yes	No	
2.3 Do you stretch after you run?	Yes	No	
2.4 How often do you trail run?	Less than 5 times per month	Between 5-10 times per month	More than 10 times per month
2.5 On overage, how many kilometres do you run on trail per week?	________________km per week		
2.6 What is your average pace for a 10km trail run during training?	________________minutes per 10km		
2.7 Do you run on the road/tarred surface in addition to trail running?	Yes	No *(Proceed to 2.9)*	
2.8 On average, how many kilometres per week do you run on the road/tarred surface?	________________km per week		
2.9 Do you participate in any other sporting or exercise activities?	Yes	No *(Proceed to 3.1)*	
2.10 If "Yes" please state what sporting or exercise activity you participate in			
2.11 How many hours per week do you spend participating in this sporting or exercise activity?	________________hours per week		

3. Competition		
3.1 On average, how many trail races do you compete in per month?	________________races per month	
3.2 On average, how many road races do you compete in per month?	________________races per month	
3.3 What is your average competitive pace during a 10km trail race?	________________minutes per 10km	
3.4 Do you participate in any other sporting events or races competitively?	Yes	No

4. Running Shoe		
4.1 Do you wear running shoes which are specifically designed for trail running?	Yes	No
4.2 Have you had your feet professionally analysed for the correct trail running shoe?	Yes	No
4.3 Do you use the same running shoes for both road and trail running?	Yes	No *(Proceed to 4.5)*
4.4 How often do you replace your trail running shoes?	______________times per year	
4.5 What is the brand of your running shoe?		

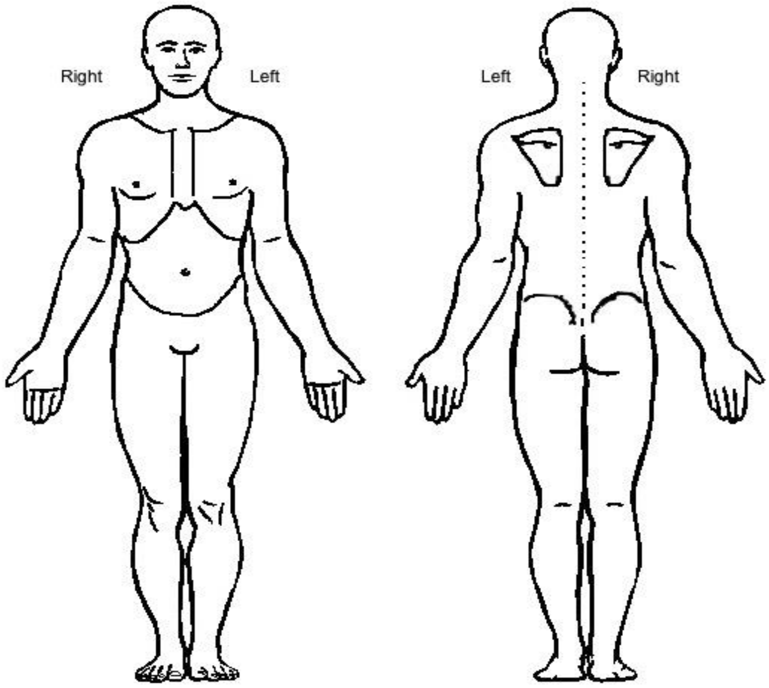
5. Equipment			
5.1 Do you carry fluid while trail running?	Yes		No *(Proceed to 5.3)*
5.2 How do you carry your fluid?	Camelback/ Backpack	Water Bottles	Other________
5.3 Do you carry any other equipment while running?	Yes		No *(Proceed to section B)*
5.4 If "Yes" please state/list object/s			

SECTION B						
6. Musculoskeletal Injury (Injury – discomfort, pain, or damage to a part which may or may not cause cessation of training)						
6.1 Have you acquired an injury due to trail running?	Yes			No (*You have now completed the questionnaire)*		
6.2 Has your injury/s been diagnosed by a medical professional?						
6.3 If "Yes" please state the diagnoses of your injury. *(In the case of multiply injuries, please state the diagnoses of the WORST injury)*						
	Past Injury (in the last 12 months)			**Current Injury (in the last 7 days)**		
6.4 How did you sustain your injury? *(Please mark the most appropriate box with an "X")*	Trauma (e.g. a fall resulting in a sprain)	Overuse (e.g. a stress fracture)	Unknown	Trauma (e.g. a fall resulting in a sprain)	Overuse (e.g. a stress fracture)	Unknown

7. Injury Consequence	**Past Injury (in the last 12 months)**		**Current Injury (in the last 7 days)**	
7.1 Has your injury affected your training?	Yes	No	Yes	No
7.2 Has your injury resulted in cessation of training?	Yes	No *(Proceed to 8.)*	Yes	No *(Proceed to 8.)*
7.3 If "Yes" please state the length of time you were unable to train	__________days/months/years(*please circle appropriate response*)		__________days/months/years(*please circle appropriate response*)	

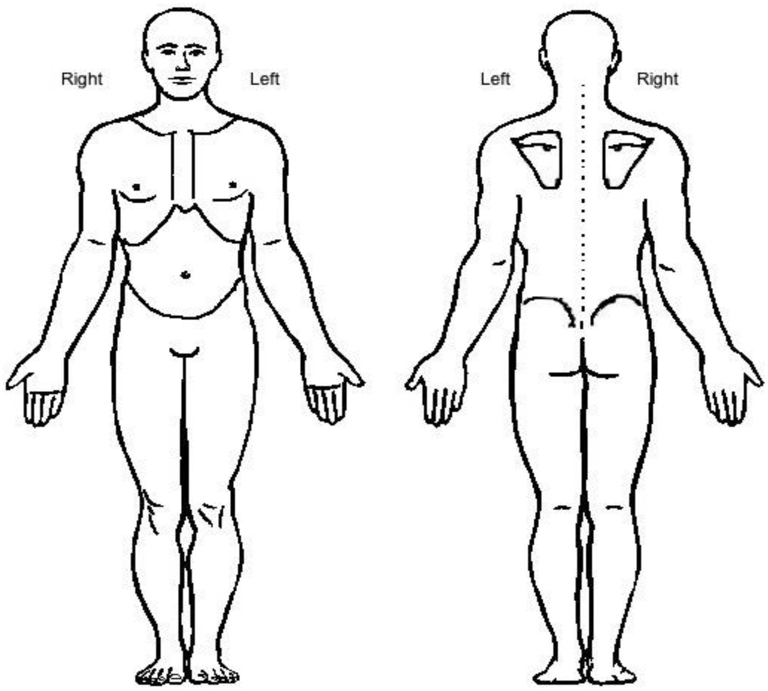
8. Past Injury (in the last 12 months)

Please indicate with an “X” on the model where you have experienced pain or an injury in the last 12 months



9. Current Injury (in the last 7 days)

Please indicate with an “X” on the model where you have experienced pain or an injury in the last 7 days



Appendix N

Gatekeeper permission to conduct research

To whom it may concern

I ____________________________________, hereby give consent for Maxine Millar, who is a masters student at Durban University of Technology, to conduct research data collection at my Trail running race events.

If you require further information please contact me on ________________

____

Signature

____

Date

09 April 2018

Gatekeeper permission to conduct research

To whom it may concern

I K.R. BOLTON, hereby give consent for Maxine Millar, who is a masters student at Durban University of Technology, to conduct research data collection at my Trai running race events.

If you require further information please contact me on [redacted]

[redacted]

Signature

11/04/18

Date

Appendix O

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: [illegible]@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

21 May 2018

IREC Reference Number: **REC 162/17**

Ms M-L Millar
35 Clarendon Street
Mount Pleasant
Port Elizabeth
6011

Dear Ms Millar

The epidemiology of musculoskeletal injuries in trail runners in the eThekwini Municipality of Kwa-Zulu Natal

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.

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

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

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 Standard Operating Procedures (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
2018 -05- 21
INSTITUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA