

**FACTORS ASSOCIATED WITH INJURIES IN ROAD-RUNNERS AT A LOCAL
ATHLETIC CLUB**

BY

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ABSTRACT

Across the world, physical inactivity was found to be associated with cardiovascular and chronic diseases of lifestyle which often leads to an increased rate of various physical disabilities and premature death. To combat these high incidences of chronic diseases of lifestyle, WHO strongly encourages people to become physically active on a daily basis to reduce the risk of premature death. Running has thus become the preferred choice of physical activity by thousands of people to help improve their overall health and wellbeing. Apart from the health benefits that running provides, it can also predispose the runner to potential injury especially when runners follow an inappropriate training programme and have inadequate knowledge about factors causing injury. Therefore, baseline data about the prevalence, incidence of injury and the identification of the aetiological factors associated with running injuries are needed to develop and implement preventative programmes to allow runners to optimally perform in training and races without injury. In South Africa, there is limited research available on the incidence of injury in runners yet there is an annual increase in participation in races such as Two Oceans and Comrades marathon which could lead to an increase in the number of running injuries. Thus, the purpose of this study was to determine the incidence of injuries and identify the various risk factors that are associated with injuries in road runners at a local athletic club.

Methods: A prospective cohort study design over a 16 week period using quantitative research methods was used. A sample of 50 runners had consented to participate in the study. The participants had to complete a self-administered questionnaire and clinical measurements of BMI, Q-angle, leg-length, muscle strength of lower leg and ROM of hip and knee were recorded. The participants had to complete an injury report form to record any new injuries sustained over the 16 week period of the study. Statistical Package for Social Sciences (SPSS) version 18 and software SAS v9 (SAS Institute Inc., Cary, NC, USA) was used for data capturing and analysis. Descriptive and inferential statistics

were done to summarize the data and was expressed as frequencies, percentages, means and standard deviations. Injury prevalence and cumulative incidence was calculated as a proportion rate along with 95% confidence interval. The Poisson regression model was used to analyse the association between running injury and the independent variables of interest such as demographics, anthropometric measurements, training methods, running experience and previous injury. The alpha level was set as $p < 0.05$. **Results:** The study found that the majority (92%) of the participants ($n=46$) sustained running injuries in the past prior to the study. A total of 16 participants sustained a number of 50 new injuries over the 16 week study period. Thus the prevalence rate of injuries was 32%. The incidence rate of injuries for this study was 0.67 per 1000km run at a 95% confidence interval of 0.41, 1.08.

Furthermore, the most common location of new injuries reported were the calf (20%) and the second most common location was the knee (18%). PFPS was the most common type of knee injury diagnosed, followed by lumbar joint sprain. The results showed that none of the identified factors (running distance, stretching, age, Q-angle, BMI, running experience, leg-length discrepancy and previous running injuries) were directly associated with running injuries. However, a marginal significance was found for running distance ($p = 0.08$) and leg length discrepancy ($p = 0.06$).

Conclusions: The study found a high prevalence and incidence rate of injury thus the need for preventative programmes have been highlighted. There was no statistical significance found between the identified factors and risk of injury however, there was clinical relevance found between factors identified. One major limitation was the small sample of participants and the short duration of study period. Thus, future research is needed to further determine possible factors associated with running injuries over a longer period and including a larger sample. The results of the study will be made available to all the stakeholders (runners, coaches and medical team) to implement in athletic club.

KEY WORDS

Physical inactivity, Chronic diseases of lifestyle, Running injuries, Prevalence, Incidence of injury,
Risk factors (extrinsic/ intrinsic), Prevention strategies, Training programmes



DECLARATION

I hereby declare that:” **Factors associated with injuries in road-runners at a local athletic club**” is my own work and has not been submitted, or part of it, for any degree or examination at any other university, and that all the resources I have used in the thesis have been indicated and acknowledged by means of complete references.

Signature:_____

Candice Hendricks

Witness:_____

Prof. Julie Phillips

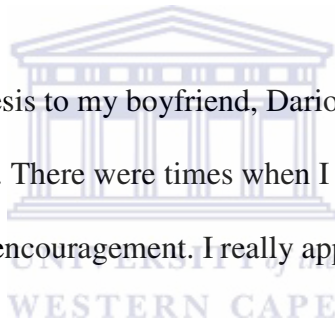


DEDICATION

Firstly, I would like to dedicate this thesis to my heavenly Father and would like to give all thanks and glory unto Him for allowing me to complete this great milestone in my life.

Secondly, I would like to dedicate this thesis to my immediate family. To my father, my mother and brothers, thank you very much for all your support and assistance throughout my study. Thank you dad and mom for driving my participants to and fro during data collection for this study and always taking care of me, especially while I was studying late at night. I really appreciate all your support.

Finally, I would like dedicate this thesis to my boyfriend, Darion. Thank you for all your support and encouragement throughout my study. There were times when I really felt discouraged and then you always motivated me with words of encouragement. I really appreciate everything that you have done.



ACKNOWLEDGEMENT

I would like to sincerely thank the Lord our God and Jesus Christ for allowing me the opportunity to have undertaken this challenge and successfully completing my thesis. It was surely not an easy road to undertake but through prayer, strength, wisdom and perseverance given by God, I was able to complete my thesis.

Furthermore, I would like to thank and acknowledge my supervisor, Prof. Julie Phillips, for all her time and hard work that she had invested in my thesis. Thank you for all your guidance and constructive criticism upon my work and encouraging me throughout the process, especially when I was demotivated, I really appreciate everything you have done for me. I would like to sincerely thank all the staff at the Physiotherapy department who supported and encouraged me throughout my study. The interest and concern shown by my friends and colleagues at the department are truly appreciated. A special thanks go to Prof. Jose Frantz for helping me achieve this goal in my life. Thankyou for the kind reminders for research progress and keeping me on my feet and encouraging me when I was down. This really helped me when I had felt demotivated to write my thesis. I would like to give a special thanks to my colleague, Michael Rowe, for editing my thesis. Thankyou for availing yourself on such short notice and sacrificing your personal time and effort to edit my thesis, I really appreciate all your assistance.

I would like to acknowledge and thank Prof. Richard Madsen from the Univeristy of Missouri who assisted with the statistics and analysis of my thesis. Thankyou for analysing my results and speeding up the process of writing my thesis.

A special thanks goes to all the management at the Biokinetics Clinic and the biokinetics students at the University of the Western Cape who assisted with the process of data collection of my study. I appreciate all the long hours you have sacrificed and patience shown while assisting in collecting the data for my study.

To all my friends at church, thank you very much for all your prayers and words of encouragement. I am certain that your prayers and thoughts helped carry me through my study. I really appreciate all your support and value your friendships. To my family and boyfriend, Darion, thank you once again for all your love, support and encouragement throughout my study.

I would like to thank and acknowledge the Research Foundation of the South African Society of Physiotherapy (SASP) for their financial contribution toward my thesis. I am truly grateful for your assistance in helping me complete my thesis.



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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

This chapter presents a description of running as a sport and the physical benefits thereof, the incidence and prevalence of running injuries, risk factors contributing to injury and an overview of injury prevention in runners. This chapter includes the motivation for the study, the problem statement, the aims and objectives and the significance of the study.

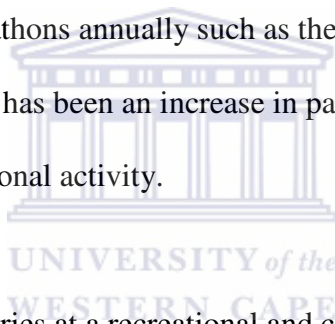
1.2 BACKGROUND

People across the world are engaging in exercise on a daily basis to improve their health. This exercise revolution is allowing individuals to attain the goal "Health for all by the year 2000" that the World Health Organisation (WHO) launched at the Alma-Ata Conference in 1978 (WHO,1978). Thus people are encouraged to improve their health status and wellbeing in order to lead a socially and economically productive life. This health awareness across the world has encouraged many individuals to get involved in physical activity like individual or team sports. Even though physical activity is a way of improving health and wellbeing, it can be expensive, time-consuming and may contribute to injury.

Running is recognised throughout the world as a form of physical activity that improves cardio-respiratory function, health and wellbeing (Van Gent et al., 2007). This popularity in running increases levels of physical activity in people of all ages. This addresses an important factor as physical inactivity is one of the contributing factors for many chronic diseases of lifestyle, decreased longevity, loss of physical function and weight control (Ryan et al., 2006). Running is an affordable and a

convenient sport and has considerable benefits to physical fitness but it can also contribute to lower limb injuries (Gerlach et al., 2008 & Butler et al., 2006).

A survey conducted in Hong Kong in 1998 found that there was an increase in participation in running from 9.6% in 1996 to 12.5% (Yeung et al., 2001). In Vancouver, Canadian events like the Sun Run 10km are motivating thousands of people to participate in the running programme and prevalence and incidence rates have been frequently reported which varies from 24%-77% (Ryan et al., 2006). The Royal Dutch Athletics Federation estimates that on average 12.5% of all Dutch people run on a regular basis and participates in running events (Buist et al., 2007). Furthermore, South Africa is one of many countries that host international marathons annually such as the Two Oceans Marathon and the Comrades Marathon. Globally, there has been an increase in participation in running events over the past 30 years, especially as a recreational activity.



The incidence of running related injuries at a recreational and competitive level internationally varies from 30% to 79% (Buist, 2007 & Schwellnus, 2006). According to Lun (2004), during a period of 6 months of training it was found that 79% of runners sustained a running-related injury. In a systematic review it was found that the predominant site of lower limb running injuries was the knee, ranging from 7.2% to 50.0%. Other common sites of injury were the lower leg (shin, Achilles tendon, calf and heel) where the incidence ranged from 9% to 32.3%; foot and toes with the incidence ranging from 5.7% to 39.3% and the upper leg (hamstring, thigh and quadriceps), with the incidence ranging from 3.4% to 38.1%. The less common sites of lower limb injuries were the ankle, hip and groin where the incidence ranged from 3.9% to 16.6% and 3.3% to 11.5% respectively (van Gent et al., 2007).

The majority of runners who have injuries often complain of overuse injuries in the lower limb, possibly caused by training errors like running too often or too soon (Johnston et al., 2003). Therefore, the aetiology of these injuries is multifactorial and diverse. Van Mechelen (1992) highlighted four factors that were significantly related to running injuries in the lower limb. These factors included (a) lack of running experience, (b) previous injury, (c) running to compete, and (d) excessive weekly running distance (Buist et al., 2007). A number of retrospective studies reviewed injured runners and concluded that most of the injuries were a result of training errors such as too much mileage, excessive speed work and inadequate rest (Johnston et al., 2003 & Fields et al., 1990).

Some extrinsic factors like terrain, hard running surfaces or incorrect shoes have also been identified as contributing factors to injury (Taunton et al., 2003). A combination of intrinsic factors such as poor flexibility, malalignment, anthropometry, previous injury and running experience could relate to running injuries (Taunton, 2002). Research in the field of running injuries is vast and backdated to the early 1970s. However, research into new intrinsic factors began in the late 1980's and has highlighted more factors that may predispose runners to injury. Thus it is important to have knowledge about possible risk factors associated to running injuries to prevent further injury and severe long-term complications (Wexler, 1995). The medical management of any sports injury can be expensive and time consuming, thus preventative strategies are needed to reduce medical expenses. Before any of these programmes can be designed and implemented, it is imperative to have baseline data including prevalence, incidence rates and the possible risk factors that predispose the athlete to injury (Van Mechelen, 1997a).

According to Logan (2006) and Noakes (1990), a suitable training programme should be tailored to the biomechanical requirements of the individual. Appropriate footwear should accommodate and compensate for structural abnormalities and a stretching and strengthening programme should be incorporated to maintain flexibility and restore muscle strength and endurance. Runners who follow an incorrect training programme that includes improper surfaces, too much mileage, frequency and duration, are more prone in sustaining injury in the lower limb than those who follow an appropriate training programme (Logan, 2006). To promote independence in injury management, it is essential to address these factors, as well as others such as poor flexibility, previous injuries, muscle weakness and incorrect running style. Thus, a holistic approach is needed to rehabilitate injuries successfully.

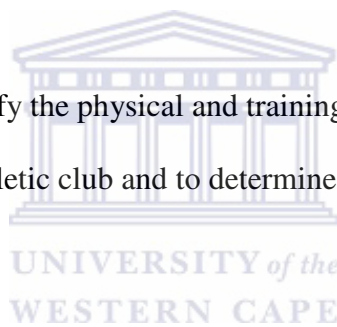
During the process of gathering literature for this study, few research articles to date were found on running injuries specifically in determining the incidence and prevalence rate of injury, the associated risk factors and preventative strategies in South Africa. There is not only limited research found on risk factors in running injuries but also on the epidemiology of running injuries. This raises a deep concern in the sporting arena of the country as it hosts internationally recognized marathons annually. In addition to this, epidemiology of injuries serves as the foundation platform for the development of prevention strategies. Thus a lack of epidemiological information of running injuries could result in the delay of development of prevention strategies for runners in South Africa. This gap in literature highlights a need for more updated research in this particular field of sport in South Africa to be able to continue the process of successful management and prevention of running injuries. Furthermore, literature also states that there is a need for prospective studies to identify underlying factors that could be responsible for running injuries which in turn will help determine easy measurable variables that could be associated to these risk factors (Hreljac et al., 2006).

1.3 PROBLEM STATEMENT

Road running is an affordable and convenient type of physical activity preferred by thousands of people across the world. Running also provides considerable benefits for both the physical and mental wellbeing of an individual which in turn could assist in the management and prevention of chronic diseases of lifestyle. However, running as a form of physical activity is also associated with an increased risk of injury. To reduce this possibility of sustaining an injury, it is essential to identify the risk factors associated with overuse running injuries in order to manage and prevent common running injuries from occurring.

1.4 AIM

The purpose of this study is to identify the physical and training related risk factors associated with injuries in road runners at a local athletic club and to determine the incidence of injury.



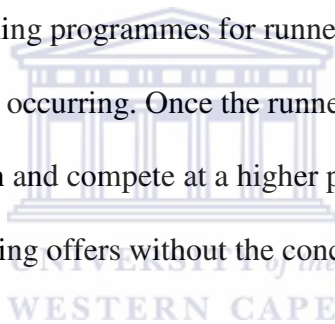
1.5 OBJECTIVES

- a. To identify risk factors associated with lower limb injuries among the runners
- b. To determine the incidence of running injuries among runners
- c. To establish the prevalence of injuries among runners at a local athletic club
- d. To establish the location and recurrence of injuries among these runners
- e. To investigate possible prevention strategies

1.6 SIGNIFICANCE OF STUDY

People are participating in sports such as road running on a daily basis at either a recreational or competitive level. As the global number of runners increase annually, so does the rate of participation

in long distance marathons increase too? This in turn could increase the risk of running injuries. The reasons for injury are multifactorial and inadequate knowledge of running as a sport could be a factor contributing to injuries. This study will be able to provide information on identifying possible risk factors causing injury, managing new and recurrent injuries, modifying training programmes and developing prevention strategies for running injuries to runners, coaches and medical management teams. The new gained knowledge will enable the runner to act proactively in the management and prevention of injuries by seeking necessary medical treatment. Medical practitioners could also utilize the information provided by the study to develop a screening process that could identify runners who are at a higher risk of developing running injuries. Furthermore, the coaches could use the information provided to develop appropriate training programmes for runners who are possibly at risk in sustaining injuries to prevent such injuries from occurring. Once the runner becomes independent and free from injury, the runner will be able to train and compete at a higher performance level and gain the benefit of the positive health effect that running offers without the concern of injury. (Hreljac et al., 2006).



1.7 ABBREVIATIONS

The following abbreviations have been used in this thesis:

WHO: World Health Organisation

ROM: Range Of Motion

Q-angle: Quadriceps angle

A/E: Athletic Exposure

BMI: Body Mass Index

PFPS: Patellafemoral pain syndrome

ITBS: Iliotibial band syndrome



1.8 DEFINITION OF TERMS

A distance runner:

It is defined as an individual who participates in middle and long distance running events. Middle distance running events are from 800 metres to 5 000 metres, while long distance running events include track or road races of 10 km and longer distances. (Oxford Advanced Learner's Dictionary of Current English, 1992).

Running Injury:

Any reported muscle, joint or bone problem /injury of the back or lower extremity (i.e. hip, thigh, knee, shin, calf, ankle, foot) resulting from running in a practice or meet and requiring the runner to be removed from the practice or meet or to miss a subsequent one. (Rauh et al, 2005)

An injury was defined as an injury that is severe enough to require medication, injection into the painful muscle, joint or tendon, surgery, physiotherapy, rehabilitative treatment, braces or orthotics. (Schwellnus et al, 2006)

A running related injury is defined as musculoskeletal pain in the lower extremity or back causing a restriction of running for at least 1 week, that is, three scheduled consecutive training sessions.

(Buist et al., 2009)

Initial injury:

The runner's first injury during the running season either during training or competition. (Rauh, 2005).

Subsequent injury:

Any injury to the same or different body part, which occurred after the runner's initial injury (Rauh, 2005).

Athletic Exposure:

An athletic exposure is any practice or competitive event where a runner was at risk of sustaining an injury. (Rauh et al., 2000)

Total Injury Rate:

It is the total number of injuries divided by the total number of athletic exposures. (Rauh et al, 2005).

Incidence:

Incidence is a measure of the risk of developing some new condition within a specified period of time.

Although sometimes loosely expressed simply as the number of new cases during some time period, it is better expressed as a proportion or a rate with a denominator

([http://en.wikipedia.org/wiki/Incidence_\(epidemiology\)](http://en.wikipedia.org/wiki/Incidence_(epidemiology))).

Incidence Proportion:

In epidemiology, incidence proportion (also known as cumulative incidence) is the number of new cases within a specified time period divided by the size of the population initially at risk. For example, if a population initially contains 1,000 non-diseased persons and 28 develop a condition over two years of observation, the incidence proportion is 28 cases per 1,000 persons, i.e. 2.8%.

([http://en.wikipedia.org/wiki/Incidence_\(epidemiology\)](http://en.wikipedia.org/wiki/Incidence_(epidemiology)))

Prevalence:

In epidemiology, it is defined as the ratio (for a given time period) of the number of occurrences of a disease or event to the number of units at risk in the population

(<http://www.thefreedictionary.com/prevalence>)

Q- angle:

It is measured as the angle between the line connecting the centre of the patella to the anterior superior iliac spine and the line connecting the tibial tuberosity to the centre of the patella. (Taunton et al, 2002).

Leg length:

It is the distance from the anterior superior iliac spine to the medial malleolus. (Johnston et al, 2003).

Risk Factor:

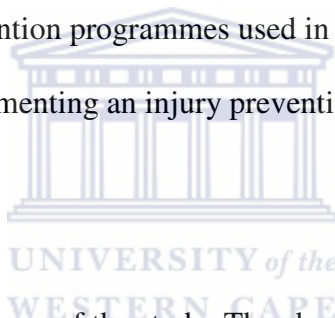
A risk factor is defined as a variable that, while not necessarily proven to be causative, is considered to be associated with the onset of injury. (Ryan et al, 2006).



1.9 OUTLINE OF THESIS

Chapter one describes briefly the importance of physical activity across the world, how running as a sport can provide health benefits to the individual, the prevalence and incidence of running injuries, common risk factors contributing to injury and the importance of an injury prevention strategy.

Chapter two provides more background information on the history of running as a sports activity. It also elaborates more on the incidence and prevalence of running injuries internationally and on a national level. A summary of previous studies done on factors causing running injury is included as part of the background information to identify possible factors contributing to injury. The chapter concludes with information on prevention programmes used in other studies which could serve as a foundation for developing and implementing an injury prevention strategy tailored to the factors associated with the injury.



Chapter three describes the methodology of the study. The chapter clearly describes the research setting, research design, population and sample, research instruments, procedure, the reliability and validity of the instruments and the data analysis. The research setting was at a local athletic club in the Western Cape. A prospective cohort study design using quantitative research methods with both retrospective and prospective components. A self-administered questionnaire was used to obtain demographic information, running history and anthropometric measurements. The anthropometric measurements included height, weight, BMI, Range of Movement (ROM) of the hip and knee, muscle strength of the lower limb, leg-length and Quadriceps angle (Q-angle). An injury report form was used to record new and recurrent injuries that occurred during the study period. The chapter ends with a description of the ethical considerations.

Chapter four presents and describes the results of the data that were collected in the form of frequencies, means, percentages and standard deviations. The data is illustrated using tables, pie charts and bar graphs. The results could establish the prevalence of injuries, the location and re-currence of injuries, the cumulative incidence of running injuries over a period of 16 weeks and the possible factors associated with lower limb injuries among the participants. From the findings, an injury prevention programme was developed and implemented among the participants and coaches of the athletic club.

Chapter five discusses the results of the collected data of the study and suggests possible reasons for the problems identified. It also compares the similarities and differences found in previous studies that are similar to the current study.

Chapter six provides a summary of the results of the research study, the conclusion, discusses the limitations of the study and gives recommendations for future research in the field.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provides background information on the history of running as a sports activity, the incidence and prevalence of running injuries internationally and on a national level. A summary of previous studies on the factors associated with running injuries are included to identify the possible factors that contribute to injury. The chapter concludes with information on prevention programmes used in other studies which could serve as the foundation for the development and implementation of an injury prevention programme for local runners.

2.2 RUNNING AS A SPORTS ACTIVITY

2.2.1 Running as a form of physical activity

Physical inactivity was found to be a contributing factor to cardiovascular diseases and other chronic diseases of lifestyle resulting in premature death (Taylor et al., 2004 & Warburton, 2001). Middle-aged women who were physically inactive and who engaged in exercise for less than one hour per week had a 52% increase in all cause mortality and a 29% increase in cancer related mortality than women who were physically active (Hu et al., 2004). In America, a public health recommendation was issued and endorsed by the Centers for Disease and Prevention and the American College of Sports, stating that an active lifestyle incorporating daily physical activity will provide individuals with a reduced risk of chronic diseases and an overall enhancement in quality of life (Pate et al., 1995). Apart from the health benefit of an active lifestyle, physical activity may also contribute to improved balance, co-ordination and agility which in turn assist in the prevention of falls in the elderly (Parsons

et al., 1992). The background information regarding the importance of physical activity as mentioned before encourages regular exercise, which could be the reason why running has become such a popular form of exercise. Regular physical activity (e.g. running) contributes to the primary and secondary prevention of common chronic diseases of lifestyle (diabetes mellitus, obesity, hypertension, bone and joint disease and cancer) thereby reducing the risk of premature death. As the risk of chronic disease starts developing in childhood and gradually increases with age, it is important that health promotion programmes (regular exercise in the form of sport) should be implemented and suitable for all ages (Warburton, 2006).

These findings encouraged the exercise revolution whereby individuals strive to attain the goal "Health for all by the year 2000" that the World Health Organisation (WHO) launched at the Alma-Ata Conference in 1978 (WHO,1978). Primary Health Care has become the focus point of attaining "Health for all by the year 2000", thus people are encouraged to improve their health status and wellbeing in order to lead a socially and economically productive life. This health awareness led people across the world to engage in daily physical activity such as running, as a form of individual sport.

Many people across the world have begun running in order to improve their overall health status because of its convenience and affordability. This popularity in running has increased over the years on a global level as people are becoming more health conscious (Paluska, 2005). However, as running is becoming an ever increasing sport of choice, the risk of lower limb injuries is possible as the incidence of injury increases at both a recreational and competitive level. (Van Gent et al., 2007). Runners often sustain overuse injuries (injuries to the musculoskeletal system) especially to the lower

limb and often have a relapse in training or competitions as some injuries are not managed successfully (Van Gent et al., 2007 & Hreljac et al., 2006). This popularity in running has resulted in an increase in the incidence of injuries which can affect the athlete negatively as doctors often forget to identify and treat the actual cause of the injury thus resulting in unsuccessful treatment and recovery (Noakes, 2003). Running injuries can furthermore result in reduced activity within running programmes or even dropping out of a running programme completely. This in turn could possibly lead to a poor self-image and the start of a sedentary lifestyle if untreated or managed incorrectly (Chorley et al., 2002; Sallis et al., 1992 & Smith et al., 1990).

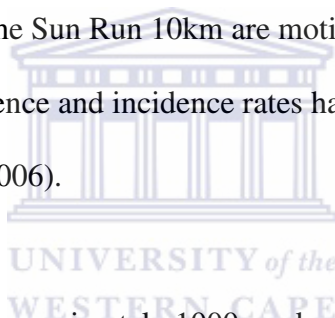
Van Mechelen (1997a) developed a theoretical framework on how to successfully manage and prevent sports injuries. The following processes need to occur to ensure that a prevention programme is effective: (a) acquiring data about the prevalence, nature, extent and severity of the injury; (b) aetiological factors involved in sports injuries; (c) implementation of prevention programmes and evaluation of the intervention to compare incidence and severity of injury before and after intervention. This framework highlights that the runner should be made aware of the nature of running injuries and the possible risk factors associated with the injuries in order to seek appropriate management to prevent injury, thereby reducing their incidence of injury (Buist et al., 2007). However, data about the prevalence or incidence of injury and the contributing factors need to be obtained before any development and implementation of prevention programmes can occur.

Research in the field of running injuries is vast and dates back to the early 1970's. A number of studies have investigated the aetiology of running injuries and found many factors positively associated to injuries. However, literature highlights the difficulty in distinguishing the exact cause of running

injuries and to specify which factor produced which injury as the aetiology of these injuries are multifactoral and diverse (Van Mechelen, 1995).

2.2.2 Participation in running events

Various studies illustrate statistics on the prevalence of running as a sport. A survey conducted in Hong Kong found an increase in participation in running from 9.6% in 1996 to 12.5% in 1998 (Yeung et al., 2001). The Royal Dutch Athletics Federation reported that on average 12.5% of all Dutch people run on a regular basis and participates in running events (Buist et al., 2007). There has been an increase participation in running events during the past 30 years, especially for recreational athletes. In Vancouver, Canada, events such as the Sun Run 10km are motivating thousands of people to participate in the event where prevalence and incidence rates have frequently been reported, and which varies from 24%-77% (Ryan et al., 2006).



In South Africa, it is estimated that approximately 1000 road races are held throughout the country annually, attracting approximately 4000 participants for some of these events (Tom Cottrell's Old Mutual Runners guide, 2004). Recent statistics shows that in 2011 the number of entrants for the Two Oceans Marathon was just over 14 000 for 21 km marathon and under 9000 entrants for the 56 km ultra marathon (Runner's world, 2011). The total number of participants entered for the Comrades Marathon in 2011 was 19 617 with 4882 beginner runners who will experience the Comrades marathon for the first time (Look local, 2011).

With the increased participation in running both at a recreational and competitive level, a marked increase in the number of injuries associated has also been documented (Van Gent et al., 2007).

Various definitions for running injuries are provided by many researchers; however, these definitions were too vague as it did not include training or competition days missed due to injury.

2.3 PREVALENCE AND INCIDENCE OF RUNNING INJURIES

In this study, a running injury was defined as any reported muscle, joint or bone problem /injury of the back or lower limb (ie. buttock, hip, thigh, knee, shin, calf, ankle, foot) resulting from running in a practice or meet and requiring the runner to be removed from the practice or meet or to miss a subsequent one (Rauh et al, 2005).

The incidence of running injuries of the lower limb at a recreational and competitive level varies from 29% - 79% (Buist et al., 2007; Lun et al., 2004; Taunton et al., 2003). Taunton et al.(2003) found a 29.5 % injury rate during an investigation of the effects of a specific training programme over 13 weeks in preparation for the 10km Vancouver Sun Run Race in Canada. Another researcher, Lun (2004), found an incidence rate of 79% and a total of 81 running injuries sustained from 69 of 87 runners during a study period of 6 months. The injury incidence was 59 % per 1000 hours of running of training. This wide range in the incidence could possibly be due to the difference in definitions of injury, the population at risk, the methods used to assess running injuries and exposure to running (Rauh et al., 2005).

Van Middelkoop et al. (2007), found a lower incidence of injury (18.2%) from 647 runners during the Rotterdam marathon and a higher prevalence rate of injury of 54.8% during the 12 months preceding the marathon. The injury incidence was 3.2 injuries per 1000 running hours in exposure time. This incidence rate is by far the lowest reported by an international country and the difference in incidence

rates in other studies could be due to differing definitions of injury, sample size and variations in methodology. A more recent study by Buist et al. (2010) observed 629 novice and recreational runners over a period of 8 weeks for the incidence of injury. It was found that the overall incidence of running injuries was 30% (95% Confidence Interval 25.4 to 34.7) per 1000 hours of running exposure with a total of 163 new injuries. The male participants (31%) were more prone to injury than females (23%).

Ethiopia had their first Great Ethiopian 10 km Run in November 2001, during which the incidence of injuries were studied by Davey and Tilahun (2002), who found an overall incidence of minor injury of 2.4 % (227 of 9380 runners) with diagnoses of only soft tissue injury (0.09%) and heat stroke (0.14%). This study showed a considerably lower incidence of injury compared to other international studies mentioned in this literature review. To further reduce this already low incidence of injury, the researchers recommended that the race should start earlier the next year. Unfortunately, very little literature on the incidence of running injuries in other African countries is available. This raises a need for future studies in African countries to determine the prevalence and incidence of injury as baseline information for prevention strategies to be implemented.

In South Africa, Fourie (1994) determined the incidence and characteristics of running injuries in 373 long distance runners, of which 329 were men and 44 were women. There was no overall incidence of injury reported but the study gave reference to another study by Brunet et al. (1990) who found similar results with an incidence of 72% of running injuries. A more recent study by Schwellnus et al. (2006) found an overall incidence of 6.04 (Experimental group) and 6.71 (Control group) injuries per 1000 running sessions. The total number of injuries reported was 93 in 94 runners (Experimental group) and 115 injuries in 83 runners (Control group).

Another local researcher, Puckree et al. (2007) found that the incidence of knee injuries accounted for 51% (45 of 88 runners). It was also found that 58% of the 88 runners had abnormal Q-angles and 67% of these runners reported knee injuries. In this study, abnormal Q-angles were significantly associated with the incidence of knee injuries. This study only included Indian male runners, therefore a need arises to do research in this area using participants from all races and cultures to be able to have a more generalized opinion.

To date there are few researchers undertaking prospective studies to determine the prevalence and incidence of injury in runners on a national level. Future prospective research is needed to fill this gap in the prevalence and incidence of injury among runners.

2.4 COMMON TYPES OF INJURIES IN RUNNERS

There are different types of overuse injuries that are prevalent in runners. It was found by the American Academy of Orthopaedic Surgeons (AAOS, 2003) that the most serious injuries found in 853 runners were tendonitis (22%), stress fractures (13%), muscle strains (9%), joint sprains (8%) and ligament stretches or tears (7%). This is similar to Anderson et al. (2001) who found that muscle strains and tendonitis were the most common type of injury reported by runners.

Furthermore, Taunton et al. (2002) found the following common injuries during a retrospective study of 2002 participants during 1998-2000. It was found that patellafemoral pain syndrome (PFPS) was the most common injury reported, followed by iliotibial band syndrome (ITBS), plantar fasciitis, meniscal injuries, tibial stress syndrome, achilles tendinopathy, patellar tendinopathy, gluteus medius injuries, tibial stress fractures and spinal injuries. The results of a regression model in this study

showed that younger age (<34 years) was a risk factor in men and women for PFPS and in men for ITBS, patellar tendinopathy and tibial stress syndrome. Other factors such as a BMI lower than 21 kg/m² in women and running experience fewer than 8 years were significant factors contributing to tibial stress syndrome injuries. Schwellenus (2006) found PFPS to be the most frequent reported injury in 94 runners (experimental group) and ITBS as the most frequent reported injury in 83 runners (control group). There were no significant differences found between the two groups in the study though.

The three most common injuries (PFPS, ITBS and plantar fasciitis) according to Taunton et al. (2002), will be further discussed to identify the possible risk factors associated with these injuries.

Patellofemoral pain syndrome is by far the most commonly reported running injury and is often referred to as “the runner’s knee” (Wexler, 1995 & Naokes et al., 1990). There are no single predictors or cause for PFPS, however an increased Q-angle (>20°) in females and (15°-20°) in males are said to be a contributing factor to PFPS (Rauh et al., 2007). A strong predictor for PFPS in females is possible weakness of hip muscles, especially the external rotators, which leads to internal rotation and results in injury and weakness in the trunk and pelvic muscles (Souza, 2009 & Mascal, 2003).

Specific conditions such as ITBS have been reported as the most common cause of lateral knee pain in runners, which occasionally results in lateral hip pain (Paluska, 2005). There is no distinct cause for ITBS, it is multifactorial and factors such as excessive running distance, leg length discrepancy, genu varum and muscle weakness of the hip and hip inflexibility were found to be associated with injury (Fredericsson, 2000 & Wexler, 1995).

Plantar fasciitis often results from repetitive strain to the plantar fascia, a tough band of tissue connecting the calcaneus or heel to the end of the foot at the toes (Wexler, 1995). Factors such as excessive pronation (as it increases the tension placed on the fascia, especially if toe-off occurs with the ankle in full pronation during running) and body weight of more than 60 kg in women was found to contribute to the injury (Taunton et al., 2002 & Noakes et al., 1990).

2.5 LOCATION OF INJURIES

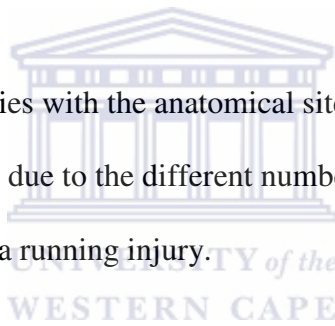
Taunton et al. (2003) conducted a prospective study involving 17 training clinics and a total of 844 runners. It was found across all the clinics that the knee was the most common site of injury, accounting for 33.7% of 249 injuries in total with 36% for men and 32% for women. The following sites of injury were also reported; the shin (15.2%), foot (13.2%), calf and Achilles tendon (10%), ankle (10.4%), hip and pelvis (9.2%), lower back (5.6%), hamstring (2.4%) and thigh (0.8%). Half of the injured runners reported that they had sustained the same injuries previously, indicating that previous history of injury is a predictor for injuries. A survey by AAOS (2003) of 853 runners confirms that the knee is the most common site of injury, as it was reported by 28% of the runners. The foot, ankle, hip and lower back were reported in this order as other common sites of injury. A national study in South Africa by Puckree et al. (2007) also found that knee injuries accounted for 51% (45 of 88 runners).

A study by Rauh et al. (2007) found a different outcome, whereby 148 injured runners (out of 393) reported that the shin was the most common site of injury (42%), followed by the knee (23%), hip (12%) and ankle (10%) for females. The knee was the most common site of injury (30%) in males followed by the shin (22%) and ankle (13%). Van Middelkoop et al. (2007) however, found the calf to

be the most frequently reported site of injury during the Rotterdam marathon(33.9%), the second most common site was the knee (27%) followed by the thigh (17.8%). Buist et al. (2010) also found the lower leg (calf and shin) to be the most common site of injury in women (35.7%) and the knee in men (38.4%).

South Africa has limited research in determining the incidence and location of injury. Fourie (1994) found that the most common reported site of injury was the lower back (51,4%) and the knee (50.4%), followed by the feet (43.4%), achilles tendon (32%), the shin (27,6%), the hip and buttocks (25%) and the ankle (18%). There were no injuries reported for the calf, hamstring, thigh and heel in this study.

There seems to be some inconsistencies with the anatomical sites of injury in the various studies mentioned and this could possibly be due to the different number of participants used in the studies and the various definitions given for a running injury.



2.6. RISK FACTORS ASSOCIATED TO RUNNING INJURIES

A number of studies over the past 40 years have concluded that most running injuries were overuse injuries of the lower limb, possibly caused by training errors, excessive speed work and not getting enough rest (Johnston et al., 2003 & Fields et al., 1990). Runners are in control of training methods and can easily be guided on modification of their current training methods by sports professionals. However, some of these professionals lack knowledge of the mechanisms associated with overuse injuries. These mechanisms are commonly identified as underlying anatomical or biomechanical variables which are not within the runner's control, thereby making diagnoses, treatment and prevention of running injuries difficult (Hreljac, 2005).

Running injuries usually occur through extrinsic factors (an external force impacting on the body) or intrinsic factors (internal factors that impact the body) (Noakes, 2003). Some extrinsic factors such as training methods, training surfaces or incorrect shoes have also been identified as risk factors.

However, new intrinsic factors such as muscle strength, flexibility and mal-alignment of the leg have been researched from the late 1980's to date which could further explain the aetiology of running injuries (Taunton et al., 2003). Thus, acquiring knowledge about the intrinsic and extrinsic risk factors relating to common running injuries are important as it could assist in the treatment of underlying problems and prevention of long-term injuries.

This section will highlight the possible risk factors that are associated with running injuries, and which could be considered in the management and prevention of running injuries.

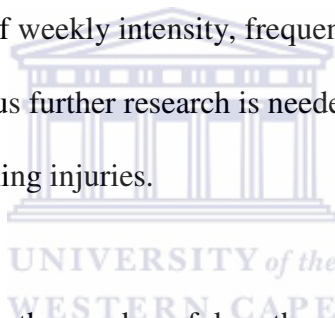
2.6.1 Extrinsic factors

The common extrinsic factors associated with lower limb injuries in runners include training methods, training surfaces and running shoes (Ryan et al., 2006; Johnston et al., 2003; Taunton et al., 2002; Yeung et al., 2001). These common factors that have been highlighted, as well as others will be discussed in this section.

Training methods

The factors that are relevant to training methods include training intensity (running speed or pace), volume of training (frequency and duration) and running distance.

The training intensity is associated to running speed or pace in a running program. Derrick (2000) and Mercer (2002) reported that an increase in running pace often generates larger forces and moments (a measure of the tendency of the force that rotates an object about some point.) on the musculoskeletal structures involved in running which could increase the likelihood of injury. According to Johnston et al. (2003), applying the 10% rule by not increasing training intensity more than 10% weekly, could decrease the risk of sustaining running injuries. However, Buist et al. (2008) found no significance in the incidence of running injuries between a modified training program applying the 10% rule and a normal training program after a randomized control trial over a 13 week period. This study had many limitations though and recommended that the intervention of the graded running program should be lengthened concerning the increase of weekly intensity, frequency and duration to have significance in the incidence of running injuries. Thus further research is needed for conclusive results regarding training intensity and the risk of running injuries.



The frequency of training is related to the number of days the runner will train per week (Taunton et al., 2003). Yeung and Yeung (2001) suggest that runners who had trained for more than 3 days per week were more likely to be injured. Van Gent (2007) also determined that running for more than 2 days per week could increase the risk of injury. However, in a study by Taunton et al. (2003) women who had a fixed training program who participated in a group session once a week, were at an increased risk of injury. On the basis of these results, the recommended frequency of running to decrease the risk of injury should be 2-3 days per week.

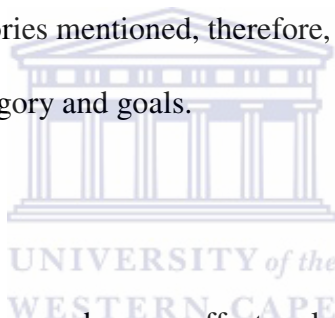
The duration of training relates to the running time in minutes per week required by the runner (Buist et al., 2008). Yeung and Yeung (2001) found that modifying a training schedule as an intervention to

prevent lower limb running injuries suggested that runners who trained for more than 30 minutes a day had a higher injury incidence than runners who trained for 15-30 minutes a day. Thus, it is recommended to run for 15-30 minutes a day to reduce the incidence rate of injury.

Running distance or mileage is considered as the measurement in kilometres (or miles) that the runner runs on a daily basis. A randomized control trial by Pollock et al (1976) found that an increase in weekly running distance was related to running injuries. Brill (1995) agreed with this as running distance is a consistent factor in population based research among recreational runners and is closely associated with an increase risk of injury. Other researchers (Macera, 1989; Walter, 1989) reported that an increase in injury rate for males is resultant from an increase in weekly distance beyond 64km. Johnston (2003) agreed with this finding as runners need to follow an appropriate training programme because 60% of all running injuries are due to increasing running distance too quickly and training too much too soon. An increase in running distance of more than 60 km per week could contribute to running injuries predominantly in males. Similarly, Hreljac (2006) agrees with this finding as an increase in running distance would increase the number of running steps taken and in turn increases the number of repetitions and of applied stress. Thus a greater running distance places the musculoskeletal structures more to the right on the stress-frequency curve, entering the injury zone on the stress-frequency graph.

Therefore, it is evident that the effects of incorrect running distance have been found in the literature. It can be concluded that an increase in weekly running distance of more than 60 km may be associated with running injuries and should be considered in the prevention of injuries.

Many authors compare the results of their studies to an “appropriate training programme”, but few researchers explain what they mean by this. There are various training programmes available which are specifically developed for different runners in the beginner, intermediate or advanced category. The runner is categorized as a beginner, intermediate or advanced runner depending on the years of running experience e.g. beginner (0-1 year), intermediate (1-3), advanced (3-10 years and older). Thus, an appropriate training programme is developed and modified according to the runner’s category and goal in completing a particular race such as a 5km, 10km, half-marathon or marathon (Runners-world, 2010). This information highlights the need to firstly identify the type of runner and to develop a specific training programme for the runner’s goal. Unfortunately, the runners in this study are not categorized into these categories mentioned, therefore, do not have specific training programmes developed for their category and goals.



Training surfaces

The different types of training surfaces can have an effect on load absorption mechanisms within the runner. The training surfaces that runners often use include hard (road, asphalt and artificial track), soft (sand), grass and gravel. The training terrain that runners usually use includes flat, hilly and sloped terrain. Incorrect training surfaces and terrain can alter a runner’s biomechanics and running performance, thus can be associated with running injuries.

Many running coaches recommend running on natural grass surfaces as it decreases the risk of sustaining musculoskeletal injuries (Bloom, 1997). This finding is similar to Tesutti et al. (2008), as running on asphalt (hard) surfaces provokes a bigger absorption load on the lateral rearfoot, increasing

the risk of injury. Contrast this with running on natural grass that leads to smaller load absorption on the rearfoot, thus decreasing the risk of injury.

Furthermore, a few researchers have highlighted that hard surfaces (road, asphalt and artificial track) can be associated with common injuries to the knee e.g. Patellofemoral pain Syndrome (PFPS) and Tibial Stress Syndrome and can possibly be due to the increased absorption load on the knee and foot (Tesutti et al., 2008). Running uphill and downhill is commonly reported as a factor contributing to Patellar Tendinopathy and Iliotibial Band Syndrome (ITBS) respectively (Johnston et al., 2003). These sloped surfaces can cause irritation of the iliotibial band as it insert onto the lateral aspect of the tibia (knee) (Paluska, 2005). Running on loose surfaces like gravel roads and trail paths can be highly associated with meniscus injuries of the knee due to the unstable surfaces causing further strain on the biomechanics of the knee (Johnston et al., 2003). Thus, a variation in training surfaces (hard, soft, grass, gravel, hilly and flat) should be considered when working to prevent running injuries. Ideally, an optimal running surface should be smooth, resilient, flat, even and fairly soft like grass to avoid undue stress on the knee, ankle and foot (Academy of Orthopaedic Surgeons, 2003).

Runners that follow an incorrect training programme, which includes improper surfaces, uneven sloped surfaces, too much mileage, frequency and duration, are more prone to sustain injury to the lower limb than those who follow an appropriate training programme (Logan, 2006).

Running shoes

Running injuries can occur during training or while competing in a race wearing incorrect shoes that has insufficient height, rigid soles, and twists easily or is worn out (Kvist, 1994). Shoes that have been

used to run more than 700km lose the ability to absorb shock optimally and could be associated with injury (Fredericson, 1996). Thus, running shoes are often selected on the runner's foot type to correct their biomechanics (Moore, 2002). Butler et al. (2006) agrees with this finding as the recommendations in running shoes should be focused on the runner's mechanics. However, if an evaluation of the mechanics is not available, the recommendations could be based on the runner's arch type. This results in many shoe companies developing new models of running shoes promoting the effectiveness in shock absorption assisting in the prevention of running injuries. During a systematic search by Yeung et al. (2001) from 1966 to 2000, limited randomized trials were done to investigate the effectiveness of different models of running shoes in the prevention of injury. During this search, 6 other trials were found, in which 4 of the trials were about shock absorbing insoles and 2 of the trials investigated the role of modified footwear in army recruits. The results showed no significance with the use of insoles in the reduction of overuse soft tissue injuries. However, a Cochrane review found that shock absorbing insoles were effective in reducing the incidence of stress fractures (Gillespie, 1999).

Schwellnus (2006) investigated whether runners who were advised on running shoes following a clinical lower limb biomechanical assessment prior to purchasing running shoes, had a reduced risk of developing a running injury when compared to runners who did not receive any advice. The results showed that there was no difference in the incidence of common injuries between the runners who had advice on shoe purchase and the runners who did not have an assessment and advice. However, the study had some limitations, including recall bias of the runners who completed the questionnaire and a potential selection bias.

Thus, the advice on the selection of running shoes according to foot type does not influence the incidence of running injuries compared to the general advice on running shoe purchase. In conclusion, it is recommended that running shoes have good shock absorption and are replaced immediately when worn out.

Stretching

Stretching is often incorporated in exercise programmes and sporting codes as a part of a warm up and cool down strategy to prevent injuries. This commonly given advice is practiced by many runners in the hope of reducing or preventing running injuries.

Van Mechelen (1992) reported that regular stretching is considered a preventative strategy for running injuries, but the efficacy of stretching has not yet been proven. However, a lack of stretching as part of a warm up and cool down is suggested to be a possible risk factor to injury (as cited in Ryan, 2006). Furthermore, Van Mechelen (1992) found no associations between stretching before running and injuries and no studies have reported that regular stretching reduces the number of running injuries.

According to Pope et al. (1998), it was found that stretching five times before or after training and holding it for 30 seconds reduced the risk of injury. However, Yeung et al. (2001) identified studies wherein runners had stretched before and after a training session and found that inadequate stretching for short periods of time can be associated to injury as mild stretching cause damage at a cellular level in muscles. According to Thacker et al., (2004), stretching increases flexibility and might benefit performance or decrease the risk of injury. However, it has been suggested that when stretching is done, it should be complementary to adequate strength training conditioning and an appropriate warm-up.

In overall, the results of the reviewed studies showed inconclusive evidence on the relationship of stretching and injury. However, Hreljac (2006), has reported that data of studies relating to stretching habits were often obtained from surveys or self-reported questionnaires and should be taken into consideration as recall bias could have taken place.

Age

Age was another factor identified in many studies as having a significant association to the risk of running injuries. Taunton et al.(2002) found that younger runners (i.e. younger than 34 years) showed a significant association with the risk of running injuries, especially patellofemoral pain syndrome (PFPS), both in men and women. Furthermore, Taunton et al.(2003) found women younger than 31 years were significantly associated with fewer injuries. This highlights some inconsistencies with the association of younger age (<34 years) and the risk of injury in runners. Possible reasons could be the difference in sample size with the two studies; the different study design used (one being retrospective case control and the other a prospective cohort design); the difference in study period and the difference in ratio in gender (male vs. female).

Although some studies have reported on the association on younger age and risk of injuries, others have reported an association between higher age and risk of injury in runners. Wen et al (1998) found that increasing age is significantly associated with the risk of injury during a 32 week study period. This finding is in agreement with Taunton et al.(2003) who found that women older than 50 years had a higher odds ratio of sustaining an injury in conjunction with wearing shoes 4-6 months and running only once a week. A more recent study by Van Middelkoop (2007) found negating evidence on increasing age as the number of injuries in runners were not directly proportional to older age, thus

older age was not a predictor for running injuries. As these results are inconsistent, there are no clear guidelines on whether age is a predicting factor for running injuries. Possible reasons for the inconsistencies could be that Taunton (2003) had used multiple variables in the regression model compared to Van Middelkoop (2007). Other reasons could be due to differences in methodology used in the studies and the differences in definition of running injury. Literature highlights inconsistencies found with association to age and the risk of running injuries, thus more consistent studies are needed to identify the relationships between these factors.

2.6.2 Intrinsic factors

A combination of intrinsic factors is commonly found among athletes with running injuries. It varies from anthropometry such as increased quadriceps angle, leg length inequality, age, gender, body mass index, poor flexibility and muscle strength, mal-alignment, arch type, rear-foot varus, tibia varum etc. (Hreljac et al., 2006 & Johnston et al., 2003). Biomechanical variables such as kinetic or mediolateral control variables are common factors involved in injury. These variables are the magnitude of impact forces, the rate of impact loading the magnitude of active forces, increased forces of the medial side of the foot and the magnitude of knee joint forces and moments. Other factors that contribute to running injuries are previous injury and running experience (Hreljac et al., 2006).

Anthropometry

Some common anthropometric factors such as leg-length discrepancy, muscle strength, Q-angle, BMI, ROM of hip and knee will be discussed to identify their possible associations to injury. The association between biomechanical variables, history of previous injury and running experience and injury will also be discussed.

The standard values for leg length are $<0.5\text{cm}$, $>0.5\text{-}1.0\text{cm}$, $>1.0\text{-}1.5\text{cm}$ and $>1.5\text{cm}$. If the leg length difference is found to be less or more than $0.5\text{-}1.0\text{cm}$, there is a leg length inequality or discrepancy. Leg length discrepancy could result in muscle imbalance and possibly predispose athletes to lower limb injuries that are associated with running (Noakes, 2003). If the leg length inequality is not correctly managed by appropriate heel lifts on the shorter leg, it can result in pelvic tilt, scoliosis, hip and knee joint mal-alignment and excessive unilateral pronation (McCaw, 1992). Common injuries such as ITBS, piriformis syndrome, hip pain and lower back pain are always associated with acquired shortage (leg length discrepancy). The leg length discrepancy or shortage is due to pronation, which causes the muscles of the hip to work ineffectively and unequally, leading to pain (Kiper, 2006). However, according to Noakes (2003), there is insufficient evidence or contradictory evidence on the association between leg length discrepancy and the risk of lower limb injuries.

Powers (2003) and Novacheck (1998) found that weakness of the hip abductors can be associated with excessive pronation. This could be due to compensatory internal femoral and tibial rotation and subtalar joint eversion, which is a risk factor for Iliotibial band Syndrome (as cited in Ryan et al., 2006). According to Fredricson et al.(2000), runners with ITBS showed significant weakness in the hip abductor muscles in the affected leg. Thus, weak hip abductor muscles may lead to increased hip adduction during the stance phase in running and possibly cause ITBS. Noehren et al.(2007) agreed with this finding as an increased hip adduction and knee internal rotation angles were revealed in runners who had ITBS. Ferber et al. (2010) agreed with Noehren, in that recreational runners with a previous history of ITBS showed a significant increase in hip adduction, knee internal rotation angles and rearfoot invertor moment in the stance phase of running. Thus, there is conclusive evidence that ITBS is related to weak hip abductor muscles leading to abnormal running mechanics.

Runners with Patellofemoral pain syndrome (PFPS) often showed weakness of the quadriceps muscle of the involved limb, thus quadriceps strengthening has been advised in order to reduce symptoms (Kannus et al., 1999). Mascal et al.(2003) suggests that an assessment of the hip, pelvis and trunk should be considered in patients presenting with PFPS, who should focus on strengthening the involved musculature as part of a rehabilitation programme. Similarly, Souza (2009) found that females with PFPS presented with an increased hip internal rotation accompanied by decreased hip muscle strength and increased gluteal maximus EMG activity. There is therefore evidence that PFPS is related to weak hip and quadriceps muscles.

The Q-angle is the angle between the line connecting the anterior superior iliac spine (ASIS) and the midpoint of the patella. The Q-angle provides an approximation of the angle of the quadriceps muscle on the patella in the frontal plane. The normal Q-angle values are between $11^{\circ} \pm 3^{\circ}$ (men) and $15^{\circ} \pm 5^{\circ}$ (women) (Horton et al., 1989). An increased Q-angle causes a larger lateral pull on the patella against the lateral femoral condyle possibly contributing to patella subluxation and patellofemoral pain disorders (Powers, 2003). Rauh et al. (2005) found that runners with an increased Q-angle ($>15-20^{\circ}$) had a higher risk of lower limb injuries. However, Heiderscheit et al.(2000) found no relationship between the Q-angle and rearfoot eversion or tibial and femoral rotation. The idea that an increased Q-angle changes rearfoot eversion or tibial and femoral rotation in running is unsupported. Thus, the association between Q-angle and tibial rotation and knee injuries is vague. This study only used 32 participants, which is a limitation, especially considering that Rauh (2005) used 421 participants. Another limitation is the discrepancy between the various standard values for Q-angle, in which some researchers assume that a Q- angle $>15^{\circ}$ is increased and others assume it is the standard value. According to Rauh et al.(2007), a large Q-angle ($\geq 20^{\circ}$) was related to running injuries, especially to

the knee. In conclusion, it would seem that an increased Q-angle ($\geq 20^\circ$) is an important risk factor for knee injury.

The normal body mass index (BMI) is categorized between 18.50kg/m^2 - 24.99kg/m^2 , where anything more is considered to be high (Rauh et al., 2005). A systematic review was conducted on 12 studies from 1974-1998 by Yeung & Yeung (2001) who found that a lower than average BMI ($<21\text{kg/m}^2$) was significantly related to an increased risk in running injuries. This is in agreement with Noakes (2003), who found a low body mass index ($<18.50\text{kg/m}^2$) to be significantly related to the risk of running injuries. Furthermore, literature has demonstrated the significance of a greater BMI and the likelihood of injuries in runners. It was found by Buist et al. (2008) that a greater BMI (24.99kg/m^2) was associated with sustaining a running injury in females. This was possibly due to the added physical strain of the extra weight placed on the anatomical structures involved in running. However, Taunton et al. (2003) found that an increased BMI (greater than 26kg/m^2) was a protective factor against injury in men and could be due to the fact that these individuals do not train often. There is however, inconclusive evidence that a higher or low BMI is associated with running injuries.

Normal biomechanics of the lower limb is necessary for optimal running. During a running stride, the leg rotates inward (internal rotation) during the swing phase of running. It remains in this position during the support phase and by midsupport, the leg rotates outward (external rotation) until it reaches the toe-off phase. Thus, according to Noakes (2003), normal biomechanics such as ROM of hip internal and external rotation and the ankle joint is paramount to allow this normal sequence of running. According to Hreljac (2004), a lack of ROM could possibly result in overuse injuries caused by undue stresses placed on the adjacent joints. However, Buist (2010) found that there was no

significant association between internal and external rotation of the hip and running related injuries in novice runners. An interesting finding by Souza and Powers (2009) revealed that an increased ROM in internal rotation of the hip during running was accompanied by reduced hip muscle strength and an increase in gluteus maximus EMS signal intensity, possibly resulting in injury.

Biomechanical Variables

Many of the biomechanical variables associated with overuse running injuries could be categorised as kinetic or mediolateral control variables. The kinetic variables consist of the magnitude of impact forces, the rate of impact loading, the magnitude of active forces, the increased forces of the medial side of the foot and the magnitude of knee joint forces and moments (Willems et al., 2006; Scott et al., 1990; Winter, 1983; Nigg et al., 1981; Cavanagh et al., 1980). The mediolateral control variables that are commonly associated with injury is the magnitude and rate of foot pronation.

A significant association has been found between a group of injured runners and larger vertical impact forces and loading rates (Hreljac et al., 2000). Similar results were reported by Ferber et al.(2002), who found that a history of stress fractures were associated with greater vertical impact ground forces, loading rates and peak tibial acceleration among female runners. Related to this, Derrick (2004) found that an increase in knee flexion during running cause a lowered impact of force, decreasing the risk of injury. According to Hreljac et al. (2006), many researchers have studied the correlation of kinetic variables to overuse injuries but have not reported on the impact forces.

Rolf (1995) found that the rate of pronation positively contributes to overuse running injuries.

Similarly, Willems et al. (2006) found a strong association between runners with overuse injuries and

an increased amount of pressure under the medial side of the foot during midstance. At the same time, it was reported that these injured runners had a greater range of pronation, which could possibly be related to one of the mediolateral control factors.

It is evident that biomechanical variables have direct associations with running injuries but too little research has been conducted regarding these variables. Thus, future research is needed to examine and report the associations between biomechanical variables and injury.

History of previous injury

A history of previous injuries related to running is found to be an associated risk factor as runners tend to continue training whilst experiencing pain and this delays healing of the injured structures. This involves competitiveness as the runner will run excessive mileage and possibly sustain an injury but will ignore the signs and symptoms and continue to run through pain (Wexler, 1995). Furthermore, once the athlete returns to running after the presumed recovery of injuries, the athlete tends to be more competitive and subjects the already compromised structure to an increase in training, thereby increasing the risk of re-injury (Ryan et al., 2006). Macera (1989) found that a 74% increased risk was found in runners who had a history of previous injury (as cited in Buist et al., 2007). Similarly, Wen et al. (1998) agreed that a history of previous injury was significantly associated with running injuries.

Running experience

A lack of running experience has been identified by some researchers (Taunton (2002), Yeung (2001), Van Mechelen (1992) as a contributing factor to overuse injuries in runners. According to Satterthwaite (1999), there is a significant association between hamstring or knee injuries and a first

time participation in a marathon. Furthermore, he found that runners with a lack of experience, especially those who participated in a marathon for the first time, had more than a 50% chance of sustaining an injury. Thus, a negative association was found between running experience and risk of injury. Taunton et al.(2003) agrees with this finding as inadequate running experience was found to be a risk factor as both men and women who had a history of running that was below average (less than 8.5 years) were relatively at risk for tibial stress syndrome. A more recent study by Buist et al. (2008) agreed that a lack of running experience is one of the most important factors predicting injury in both male and female runners. Thus a lack of running experience was significantly associated with the risk of injury in runners.

2.7 IMPORTANCE OF INJURY PREVENTION PROGRAMMES

According to WHO, an important goal to reach before the year 2000 was to substantially reduce the number of sports injuries (Van Vulpen, 1989). To reach this goal, preventative measures were needed to be implemented by means of sports injury surveillance systems. According to Van Mechelen (1997a), a prevention programme can be effective if the following processes occur: (a) acquiring data about prevalence, nature, extent and severity of injury; (b) aetiological factors involved in sports injuries; (c) implementation of prevention programmes and evaluation of interventions to compare incidence and severity of injuries before and after the intervention. Furthermore, Finch (1997) identified that the primary function of injury surveillance systems is the collection of data illustrating the occurrence of injury and the factors associated with it. The sports injury data is useful in guiding activities for the prevention of injury, the development and monitoring of sports safety policies and interventions. It also forms part of baseline data which serves as a foundation for research in sports injury prevention. Similarly, Van Mechelen (1997b) found that sports injury surveillance systems

provide baseline data of the epidemiology of sports injuries thus making prevention programmes more specific to the particular sports' context. The purpose of an injury surveillance system was to identify the effectiveness of preventative measures but not all sports injury surveillance systems were useful to identify mechanisms of injury.

Information on the severity of injuries has been identified by Van Mechelen (1997b) as important data to include in a sports injury surveillance system. This type of detailed information will assist in setting objectives for prevention strategies. A criterion to describe the severity of sports injuries were developed by Van Mechelen (1997b) to assess the severity of injury as the prevention will be of highest priority regardless of injury incidence. The criteria are as follows: (a) nature of sports injury, (b) duration and nature of treatment, (c) sporting time lost, (d) working time lost, (e) permanent damage and (f) monetary cost. According to Van Mechelen (1997b), data on the epidemiology of sports injuries acquired from sports injury surveillance systems are essential in the development, monitoring and implementation of prevention strategies, thus assisting in the reduction of sports injuries.

It is evident that various extrinsic and intrinsic factors are associated with running injuries. In order to reduce the high incidence rates of running injuries and to promote independence in injury management, an appropriate rehabilitation programme including suitable recovery is necessary to prevent injury (Johnston et al., 2003). This rehabilitation programme should constitute of a training programme which gradually increases mileage, frequency and includes appropriate resting periods. It also needs to address other factors such as: appropriate running shoes for different foot types; heel lifts to adjust mal-alignments of the leg; flexibility and strengthening programmes of the lower limb and

the selection of appropriate training surfaces and terrain (Johnston et al., 2003). To promote independence in injury management it is essential to address these factors as it creates a holistic approach to the successful treatment of the injuries.

To elaborate further on prevention strategies implemented, many researchers have developed and implemented prevention programmes to reduce the likelihood of sustaining running injuries. Buist et al. (2008) developed and implemented a graded training program that consisted of a 13 week modified training week compared to a standard 8 week training programme. The difference of the two programmes was that the 13 week modified training programme was based upon the 10% training rule in which the training volume should only be increased by 10% on a weekly basis. All participants had to walk 5 minutes to warm up and cool down, and had to train 3 times a week, on any course and surface. Instructions were that they should run at a comfortable pace during which they could speak without feeling breathless. The results of the study showed no effect of a graded training programme for novice runners on the incidence of running injuries. However, some limitations were identified such as the short duration of the study and the intensity of running could be a confounding factor as the intensity was not measured. Thus, future research is needed by adapting the study to distinguish the relationship between intensity, frequency and duration of training and the risk of injury.

The ultimate goal of rehabilitation for an injured runner is to be able to return the runner to their desired level of fitness and performance (Matava, 2008). Thus a holistic approach is necessary to effectively rehabilitate an injured runner. Such a programme needs to include patient education on resting, modification of training (flat, smooth, resilient and reasonably soft surfaces) to allow optimal healing. Thereafter, once strength and endurance has regained the runner can return to running by

gradually increasing running mileage weekly (10% of volume per week). Factors such as training errors, incorrect running shoes and anatomic abnormalities should also be addressed to optimally rehabilitate the runner. Apart from these factors, fluid intake (increase fluid intake during warmer and humid conditions) and appropriate clothing should also be considered in the rehabilitation programme (Matava, 2008).

During the process of gathering literature for this literature review, it was found that there were few research articles to date about running injuries specifically in identifying risk factors, the incidence of injury and preventative strategies on a national level. This gap in literature is surprising as South Africa is one of many countries that host international marathons annually, including the Two Oceans Marathon and the Comrades Marathon. Therefore, one would assume that a vast amount of research would be available on the incidence and factors associated to running injuries. This gap in literature highlights the need for more updated research in this popular and growing sport on a national level.

A summary of the most recent findings with regards to risk factors in running injuries are illustrated below in Table 1.

Table 2.1 Characteristics of studies that identified common risk factors associated with running injuries

Author, year of publication	Study design and duration of study	Sample group	Outcome of study or Incidence of injury	Risk factors to injury	Limitations
Ferber et al., 2010	Cross sectional experimental laboratory design	35 female participants	The runners who had previous ITBS showed significant greater stance phase peak hip adduction and peak knee internal rotation angles compared to the control group.	* The study provides evidence linking atypical lower extremity kinematics and ITBS due to possible muscle weakness of hip abductor and external rotator muscles	*No measurement of hip abductor strength
Souza et al., 2009	Controlled laboratory study using a cross sectional design	21 females (intervention) with patellofemoral pain and 20 females (control) that were pain free.	Results show that females who complained of PFP had increased hip internal rotation and were accompanied by weak hip muscles. Thus the findings of this study support the link between abnormal hip function and PFP.	Possible weakness of hip muscles, especially the external rotator muscles, could lead to increase hip internal rotation, which leads to injury.	*No cause-and-effect relationships. *Hip function was assessed and not patellofemoral joint instability.
Buist et al., 2008	Randomized controlled trial	532 novice runners. Control group (236) did a standard 8 week training programme. The intervention group (250) did a graded 13 week training programme based on 10% rule.	The outcome was the absolute number of running related injuries expressed per 100 runners. The incidence of running injuries of the standard 8 week programme was 20.3%. The incidence of the graded 13 week training programme was 20.8%.	It was hypothesized that an incorrect training programme could result in increased incidence of injury, however this study found no effect of a graded 13 week training programme applying the 10% rule compared to the standard 8 week programme.	*No assessment for modifiable risk factors *Factors such as intensity, frequency and duration of training and injury risk needed to be assessed. *Short study period of 13 weeks.
Tesutti et al., 2008	Prospective study: To investigate the plantar pressure distribution during running on natural grass and asphalt surfaces.	44 adult recreational runners	Natural grass is a safe and more compliant surface which will diminish the risk of injuries commonly caused by rigid surfaces like asphalt.	*Incorrect running surfaces, like asphalt surfaces	*A small sample size *A different design of study, perhaps a RCT to determine incidence of injury.

Author, year of publication	Study design and duration of study	Sample group	Outcome of study or Incidence of injury	Risk factors to injury	Limitations
Rauh et al., 2007	Prospective cohort study	393 high school cross country runners	148 of the 393 runners were injured with cumulative incidence of 37.7%.The shin and knee was the most common site of injury	*Increased Q-angle (>20°) for females and (15°-20°) for males, predictor for knee injuries	*The use of a self reported injury data sheet by participants and coaches.
Van Gent et al., 2007	Systematic Review	Selected 17 articles (13 prospective and 4 retrospective studies)	Incidence varied from 19.4%- 92.3%	*Increased running distance per week *History of previous injury	*Inadequate discussion on factors such as downhill running, biomechanical factors such as coupling forces and the degree of rehabilitation from previous injury.
Schwellnus et al., 2006	Retrospective cohort	94 participants for Experimental group and 83 participants in the control group	EXP= 6.04 per 1000 running sessions.(93 injuries) CON= 6.71 per 1000 running sessions.(115 injuries)	*Past history of running injuries is a strong predictor, however showed no significance between the past injury group and the no past injury group	*The small number of participants in the subgroups. *Recall bias as the runners completed the questionnaire. *The runners self reported their injuries.
Rauh et al., 2005	Prospective cohort study (5-8 weeks during 1996 summer preseason	421 runners	The shin was the most common location of injury. The incidence was 17.0 per 1000 athletic exposures. The females had higher injury rate than males and were at greater risk of running injury and disability.	*Increase in number of days/ week of training *Large Q-angle (>20°) especially in females *History of previous injury.	*The coaches recorded the injuries of the runners and not a physiotherapist. *Recall bias as the participants self reported their height and weight.

Author, year of publication	Study design and duration of study	Sample group	Outcome of study or Incidence of injury	Risk factors to injury	Limitations
Johnston et al., 2003	Peer Review, focus on the prevention of injuries related to running	Results retrieved from systematic review, comparison trials and expert opinions.	None mentioned	*Malalignment of the leg *Incorrect training surfaces *Incorrect running shoes *Muscle weakness and inflexibility of lower limb	None mentioned
Mascal et al., 2003	Case Report (14 week period)	2 cases complaining of patellofemoral pain	Both patients had reported a decrease in patellofemoral pain after completing a 3 month treatment program. The program consisted of non-weight bearing strengthening of the hip muscles, then in weight bearing positions using functional activities.	*Weakness of muscles of hip, pelvis and trunk that could lead to patellofemoral pain.	None mentioned
Taunton et al., 2003	Prospective Cohort (13 week period)	844 recreational runners	29.4% (249 injuries for 844 runners)	*Increased age in females (>50 yrs) *Running frequency (1 day a week-females only) *Previous injury that has not been completely rehabilitated.	*Clinic attendance was inconsistent, resulting in possible inaccurate recordings of 3 survey trials. *Running distance could not be included in analysis as exposure time was not recorded.
American Academy of Orthopaedic Surgeons, 2003	Online survey	853 runners responded to the survey	76% of 853 runners were injured.	*Inadequate resting periods after injury *Incorrect running surfaces *Improper running shoes *Inadequate warming up, stretching and cool down *Rapid increase in running distance	None mentioned

Author, year of publication	Study design and duration of study	Sample group	Outcome of study or Incidence of injury	Risk factors to injury	Limitations
Taunton et al., 2002	Retrospective case-control study	2002 patients were included from period of 1998-2000	The knee was the most common location for injury, (PFPS- 331 patients; ITBS- 168; plantar fasciitis- 158; meniscal injuries- 100; patellar tendinopathy- 96)	*Younger age (<34 years) *Below average activity history (8.5 years) *Lower than average BMI (<21kg/m ²)	* Factors such as malalignment and weekly running volume not included in analysis. *Could not report shorter height as a risk factor as its correlated to the factors above
Yeung et al., 2001	Systematic Review to examine evidence for prevention of running injuries	Selected 12 studies (from 1974-1998) that studied 8806 participants collectively	None mentioned	*Running frequency: (>5 days per week) *Duration of training (>30 minutes per week) *Running distance (>32 km per week) *Inadequate stretching for short periods	*Insufficient evidence from studies to show significance for stretching and reduction in running injuries.
Wen et al., 1998	Prospective study (32 week period)	255 participants	32.9% (84 injuries from 255) The lower leg and the knee was the most prevalent location for injury (32.1% and 31% respectively)	*Increased age *Increased weight *Leg length malalignment *Past history of injury *Increase in training hours per week.	None mentioned

2.8 CONCLUSION

The various factors discussed in this literature review highlighted that there are numerous factors to consider before treating any running injury as the symptoms are possibly the result of training errors in conjunction with anatomical and biomechanical imbalances. It is imperative to identify all the possible factors, both extrinsic and intrinsic, that are associated with running related injuries to be able to assess and treat runners effectively and holistically and to prevent further complications to allow the runner to return to the level of performance prior to injury.



CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

In this chapter a description of the methods used in this study are provided. A description of the research setting, the research design and the population and sampling is given. Furthermore, the research instruments, the reliability and validity, the procedure, the data analysis and the ethical considerations will be given.

3.2 RESEARCH SETTING

The study sample comprised of a local athletic club in Cape Town, Western Cape, South Africa. The athletic club was established in 2006 and attained complete membership with the Western Province Athletics Association in February 2008. The athletic club is located in Mitchell's Plain, a residential area in Cape Town. Unfortunately, the running club do not have a physical building for the club thus the runners meet and train at a local sport and recreation field. For this reason, the study was conducted at the Biokinetics clinic at the University of the Western Cape. This setting was appropriate as it was a central location for all participants to meet.

Mitchell's Plain largely consists of Coloured African residents and lies about 20 km from the city of Cape Town. Looking at Mitchells Plains' growth rate, it has a population of about 1 500 000 people. It is located on the Cape Flats on the False Bay coast line between Strandfontein and Khayelitsha. Mitchells Plain was built during the 1970s to provide housing for coloured victims of forced removal due to the implementation of the Group Areas Act by the Apartheid Government. Mitchells Plain

today consists of beautiful suburbs like Portlands, Westridge, Colorado Park and Rocklands with residents from medium to high socioeconomic statuses. Over the years, Mitchells Plain has produced top class educators, politicians, sports people, artisans and highly skilled professionals in many fields of business. However, other areas like Lenteguur, Tafelsig, Beacon Valley and Eastridge are found on the outskirts of the township and poverty, unemployment, gangsters and drug use are widespread. Mitchells Plains' community advocates participation in sports as a medium to enhance the current morale of the community. Participation in sports such as club rugby, soccer, netball, athletics and recently an increasing popularity in road running is evident within all ages and class of people in the local Coloured Township (SA venues, 2010).

3.3 RESEARCH DESIGN

A prospective cohort study design using quantitative research methods was used. It was an appropriate study design to identify factors associated with running injuries and to determine the incidence of injury.

Data was collected from March 2010 to June 2010. These months were specifically chosen as this was the peak season for training and races, especially the Two Oceans and the Comrades Marathons. According to literature, an increased rate in training and races could possibly increase the rate of injury in running (Lysholm & Wiklander, 1987).

3.4 POPULATION AND SAMPLING

Most of the athletes are recreational runners and a small percentage of them compete at a high competitive level. The athletes meet regularly at a specific location on a monthly basis for meetings and the planning of future training events. Furthermore, all athletes do time trials and specific training on a particular day in the week. The club has five qualified coaches and is responsible for the training of different age groups of athletes ranging from juniors (under 19 years), seniors (20-39), veteran (40-49years), masters (50-59years) and grand masters (60-69years).

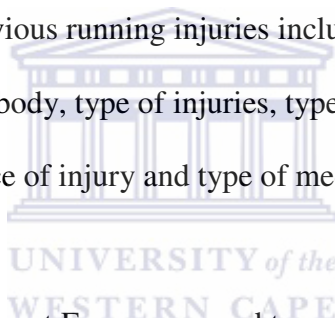
The athletic club currently has 98 registered members. Of these, 7 were in the junior group (under 19years) and 91 in the seniors group (+20 years). All road-running members who were older than 19 years old were invited to participate in the study. A sample size calculation was not possible as the participants were limited to 98. Runners who currently were injured were excluded from the study. Thus the study sample was the entire adult group (n=91) who consented to participate in the study.

3.5 RESEARCH INSTRUMENTS

Data for this study was collected by means of two research instruments. The first was a self-administered questionnaire for a retrospective analysis of personal data, history of training, running experience and previous injury of all participants. The second instrument was an Injury Report Form that recorded information regarding injuries that occurred during the 16 week time period of the study.

Information obtained from the questionnaire included demographic and medical history data, running history and experience, running environment, history of running injuries and anthropometric measurements. The medical history information included questions on chronic lifestyle diseases and

participants had to specify the type. Demographic information included items such as age and gender. Furthermore, anthropometric measurements were recorded on the data capture sheet. This data included height, weight, calculated BMI, range of motion (ROM) of the hips and knees, muscle strength of in the lower limb, leg-length and Q-angle (the position of the knee-cap on the knee). The section regarding running history and experience included items such as years of running experience, frequency of running, distance covered weekly, running time per week, rest periods during training, description of training, stretching and strengthening regimes. Information regarding the running environment included terrain, surface, type of feet, part of running shoe striking the surface first, period of running in shoes, number of pairs of shoes used annually, use of orthotics and period of orthotic use. The information on previous running injuries included items such as initial occurrence of running injury, location of injury on body, type of injuries, type of pain and symptoms experienced, recovery period of injuries, recurrence of injury and type of medical assistance received.



The second instrument, the Injury Report Form, was used to record daily participation in training and competition as well as absence from training or competitions, and limitations to participation due to injury. The Injury Report Form was divided into an initial and re-current injury category. An initial injury is the runner's first injury during participation and the re-current injury is any injury that the runner experienced before and was treated successfully before participation (Rauh et al., 2005). The injury Report form was administered by the main researcher on a weekly basis to identify and record possible injuries. The researcher gathered information regarding the type of injury sustained, the mechanism of injury reported, the location of the injury on body, and the number of training and competitive days missed due to the injury. Thus, a running injury was defined as any reported muscle, joint or bone problem /injury of the back or lower limb (ie. buttock, hip, thigh, knee, shin, calf, ankle,

foot) resulting from running in a practice or meet and requiring the runner to be removed from the practice or meet or to miss a subsequent one (Rauh et al, 2005).

3.6 RELIABILITY AND VALIDITY

The definition of reliability refers to the accuracy and adequacy of the measurements taken by an instrument where it is important to achieve consistent results should it be repeated. The validity of an instrument refers to the degree to which an instrument measures what it is supposed to measure (Polit, Beck and Hungler, 2001). The validity of an instrument can be difficult to establish as there are many aspects and assessments to consider.

To improve the reliability of the clinical measurements taken, each participant was measured three times on the same test and the calculated average of the three measurements was recorded as the mean. Leg-length was measured with a measuring tape and measured to the nearest 0.1 cm. A universal goniometer was used to assess the Joint Range of Motion (ROM) and the Quadriceps angle (Q-angle). Each test was conducted by a trained research assistant and each test was done three times to get the average measurement to ensure consistency and accuracy, thus limiting tester-related variability. The guidelines suggested by Hoppenfield (1976) for the measurement of Joint Range of Motion were used.

The questionnaire used to capture data regarding running history, running environment and history of running injuries were adapted and previously used reliably in previous studies (Fourie, 1994 & Brunet et al., 1990). A pilot study was conducted among a different group of runners (n=15) in order to determine the duration to complete the questions, as well as the clarity and level of comprehension of

the questions used. The results of the pilot study helped to obtain viewpoints about the ease of the questionnaire and improved face validity.

The injury report form used to capture information about new and recurrent injuries during the study was adopted from the instrument (Athletic Health Care System Daily Injury Report Form) used previously by Rauh et al. (2005). Unfortunately, this exact form could not be extracted for this study, thus the injury report form was adapted by using the same format and questions as the form used by Rauh (2007).

3.7 PROCEDURE

Ethical clearance was obtained from the UWC Senate Research Grants and Study Leave Committee. Thereafter, informed written consent was obtained from the Chairperson of the athletic club as well as all the participants to conduct the study. Permission was obtained from the Sport and Recreation Department at the University of the Western Cape to use the Biokinetics Clinic for testing and taking anthropometric measurements of the participants. The researcher thoroughly explained the aim and objectives of the study and the procedure to each participant. Athletes were assessed by research assistants who recorded measurements such as ROM, Q- angle, leg-length, muscle strength of the lower limb, height and weight.

A standard full circle goniometer with lengthened stationary arms was used to measure the ROM of the hip and knee. The same goniometer was used to take the measurements of the Q-angle of both legs. The participants were instructed to stand in a comfortable position with their knees extended, quadriceps relaxed, feet facing forward and shoulder- width apart, and with their body weight evenly

distributed between both legs. The borders of each patella were palpated and a small dot on the skin overlying the center of the patella was marked. The fulcrum was placed on the the center of the patella and the longer and shorter arm were directed at the superior iliac spines and the tibial tuberosities. The leg-length of each participant was measured with a measuring tape with the participant in supine lying while the measurement was taken from the superior iliac spine to the medial malleolus. The muscle strength of the lower limb was tested by doing a one repetition maximum (1-RM) leg press on a leg press machine. The muscle strength (leg press weight ratio) was calculated as the weight pushed/ body weight. The leg press weight ratio is documented as percentile rankings such as above average (>70), average (50) and below average (<30).

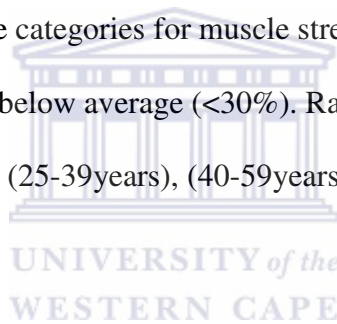
Clear and simple instructions were given during each test as each measurement was repeated three times and the calculated average was recorded by the same person who performed the test. Each participant was issued with a questionnaire to complete at the beginning of the study to record personal data, history of running, medical history, previous and current injuries and medical management. Any injuries sustained during the study period were documented on the injury report form, which was completed by the main researcher. A medical diagnosis of the injured runner was made by the same physiotherapist following an assessment and treatment.

3.8 DATA ANALYSIS

The data collected from the participants were captured and analyzed using the Statistical Package for Social Science (SPSS) version 18 and SAS v9 (SAS Institute Inc., Cary, NC, USA). Descriptive statistics were employed to summarize the demographic data of the study sample. The demographic data and anthropometric measurements were expressed as frequencies, percentages, means and

standard deviations. The data were illustrated using tables, graphs and pie charts. The anthropometric variables such as BMI, Q-angle, leg length and muscle strength of the lower limb were divided into categories for analysis of frequencies and percent. The categories for BMI were underweight ($<18.50 \text{ kg/m}^2$), normal weight ($18.50\text{kg/m}^2\text{-}24.99\text{kg/ m}^2$), overweight ($25\text{kg/ m}^2\text{-}29.99 \text{ kg/ m}^2$), and obese ($>30 \text{ kg/ m}^2$).

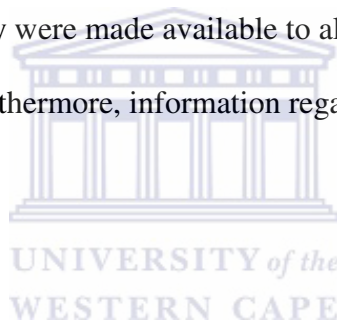
The categories for Q-angle were decreased ($<15^\circ$), normal Q-angle ($15^\circ\text{-}19^\circ$), increased ($>19^\circ$). However, the normal values according to gender are $11^\circ\text{-}14^\circ$ for males and $15^\circ\text{-}19^\circ$ for females (Horton et al., 1989). The categories for leg length were decreased ($<0.5\text{cm}$), normal leg length ($0.5\text{-}1.0\text{cm}$) and increased ($>1.01\text{cm}$). The categories for muscle strength of the lower limb were above average ($>70\%$), average (50%) and below average ($<30\%$). Range of movement of the hip and knee were divided into age groups such as (25-39years), (40-59years) and (60-70years) for analysis of mean and standard deviation.



Injury prevalence and cumulative incidence was calculated as a proportion rate with a 95% confidence interval. Poisson regression analysis was used to model random occurrences in time or space assuming that events occur one at a time (in this case it would be distance measured by km run) and it is assumed that events occur one at a time. Thus Poisson regression model was used to analyze the association between running injury and the independent variables of interest such as demographics, anthropometric measurements, running environment, running experience and previous injury.

3.9 ETHICAL CONSIDERATIONS

Ethical clearance was obtained by the Higher Degrees Committee and the Senate Research Grants and Study Leave Committee of the University of the Western Cape. Written consent was obtained through consent forms by the Chairperson and all of the participants of the athletic club. All the information regarding the purpose and procedures of the study was explained thoroughly to the participants. All information received was kept confidential and participants were free to withdraw from the study at any stage. All participant responses were anonymous to ensure that all participants were comfortable throughout the study period. If there were any participants who sustained an injury during the study, they were referred immediately to a health professional (i.e. doctor/physiotherapist) for further management. The results of the study were made available to all participants, coaches and other the stakeholders in the running club. Furthermore, information regarding injury prevention strategies was given to participants.



CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This chapter presents the results of the study and is divided into two sections. Section A describes the retrospective data and section B describes the results of the statistical analysis for cumulative incidence of injury, location of injuries, common injuries, mechanism and the severity of injuries. Statistical associations between variables and risk of injury were also reported. Data is presented in the form of frequencies, means, percentages and standard deviations and by utilizing tables, graphs and pie charts.



SECTION A: RETROSPECTIVE DATA

4.2 DESCRIPTION OF STUDY SAMPLE (N=50)

4.2.1 Response rate

A total of 91 runners belonging to a local running club were approached to participate in the study of which 50 (54.9%) consented to participate. Of the remaining 41 (45%) runners, 8 (19.5%) were ill or injured, 3 (7.3%) were track and field athletes, 2 (4.8%) were walkers, 1 runner (0.2%) had discontinued running and 27 (67%) were unavailable to contact.

4.2.2 ANTHROPOMETRIC CHARACTERISTICS OF PARTICIPANTS

The majority of the study sample was males (68%). The mean age of the study sample was 46.02 years (SD=8.503), for women 46 years (SD=7.176) and for men 45 years (SD=9.138). Table 4.1 illustrates the baseline measurements (height, weight and body mass index (BMI)) of the study sample.

Table 4.1 Anthropometric characteristics of the participants (N=50) Mean and SD

Variable	Females (n=16)	Male (n=34)	Total (n=50)
Height (cm)	1.568 (0.6)	1.712 (0.1)	1.666 (0.9)
Weight (kg)	67.79 (12.2)	74.87 (12.8)	72.61 (12.9)
BMI(kg/height ²)	27.59 (4.8)	25.48 (3.6)	26.15 (4.1)

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4.2.3 CLINICAL MEASUREMENTS OF PARTICIPANTS

Various clinical measurements such as BMI, Q-angle, leg length, muscle strength of the lower limb and ROM of the hip and knee were recorded during the study. Table 4.2 summarizes the results in the form of frequency and percentages. Table 4.3 summarizes the results of ROM of the hip and knee by means of mean and standard deviations. Categories for BMI are as follows; underweight (<18.50 kg/m²), normal weight (18.50kg/m²-24.99kg/ m²), overweight (25kg/ m²-29.99 kg/ m²), and obese (>30 kg/ m²). As illustrated in Table 4.2, most of the participants (44%) had a normal BMI and their muscle strength was above average (86%).

Table 4.2 Clinical measurements of Runners who participated in the study (N=50)

Variable	Categories	N	%
BMI (kg/height²) (mean)	Normal weight	22	44
	Overweight	18	36
	Obese	10	20
Q-angle (degrees)	Decreased (<15°)	23	46
	Normal (15°-19°)	17	34
	Increased (>19°)	10	20
Leg length difference (cm)	Minor leg length difference(<0.5)	15	30
	Normal leg length (0.5-1)	22	44
	Major leg length difference(>1.01)	13	26
Muscle strength of lower limb	Above average (>70%),	43	86
	Average (50%)	2	4
	Below average (<30%).	5	10

Table 4.3 Range of Motion (ROM) of Hip and Knee joints of participants in study (N=50)

ROM	Mean	SD	Age groups					
			25-39 (n=9)		40-59 (n=38)		60-74 (n=3)	
			Mean	SD	Mean	SD	Mean	SD
Hip flexion	108.62	14.1	113.5	12.4	108.7	13.2	92.7	23.2
Hip Extension	22.39	7.1	25.2	7.9	21.8	6.9	21.5	6.5
Hip abduction	41.95	11.2	49.89	11.35	40.31	10.67	39.05	9.97
Hip adduction	34.67	9.4	38.26	10.87	34.16	9.22	30.37	6.18
Internal rotation	34.67	11.4	42.78	14.19	36.99	11.01	42.77	1.57
External rotation	40.93	10.5	46.61	10.47	39.59	9.73	40.83	18.11
Knee flexion	115.67	8.9	114.89	9.62	115.59	9.03	119.17	5.53

4.2.4 CURRENT MEDICAL HISTORY OF PARTICIPANTS

Participants were requested to report on the presence of chronic diseases of lifestyle.

Overall, 18.75% (n=3) of the females and 14.7% (n=5) of the males reported chronic diseases of lifestyle (CDL). Of the CDL's reported, 12.5% were hypertension, 37.5% were diabetes mellitus, 50% were cholesterol, 25% were osteoarthritis and 12.5% were other.

4.2.5 RUNNING HISTORY

Running experience and training

The study sample had to report the reason or motive for starting running. It was found that 54% of the participants (n=27) started running to become healthy and of these 37% female (n=10) and 63% (n=17) males. This high percentage reported accounts to improving self-esteem in the females (62.5%) whereas it only accounts 29.4% for males.

Starting running was the preferred choice of sport by males (44.1%) compared to females (25%). Females (43.8%) were more likely to choose running as a medium to decrease stress levels whereas only a minority group of males (23.5%) chose running. A low percentage of females (37.5%) and males (29.4%) started running to lose weight.

Running experience was documented as the number of years that the participant had been running. It was reported that the majority of participants (53%) had fewer than five years of experience in running. The remaining participants had five years and more and ten years and more experience in running (8.2% and 34.7%) respectively. Only 4% had less than 1 year experience in running.

The training schedule of the runners were documented as the number of days that the study sample trained per week, the running pace, the distance covered on a weekly basis, the average running time per week and their rest periods as illustrated in Table 4.4. Categories for the number of training days was based on literature stipulating that 2-3 days a week was the norm (Van Gent, 2007). The majority of the participants (78%) had trained within these parameters. Table 4.4 illustrates a summary of the running history and training schedule of the sample

Table 4.4 Running history of experience and training programme

Variable	Categories	Frequency	Percentage
Amount of Training days	>3 times p/week (above norm)	7	14
	3 times p/week (norm)	39	78
	< 3 times p/week (below norm)	3	6
	Missing	1	2
Running pace	<3min p/km	1	2
	3-5mins p/km	15	30
	5-7mins p/km (norm)	27	54
	>7mins p/km	6	12
	Missing	1	2
Average accumulated distance covered weekly	0-32km	17	34
	32-50km	14	28
	50-80km (norm)	12	24
	80-100km	7	14
Average running time	3-5 hours p/week (norm)	20	40
	5-7 hours p/week	22	44
	7-10 hours p/week	5	10
	>10 hours p/week	3	6
No. of rest days during training	Every second day (norm)	23	46
	Every third day	6	12
	Once a week	20	40
	Missing	1	2

The bolded text and numbers represents the normal values

Type of training environment, strength training and stretching habits

The majority of the study sample (58%) reported that their preferred type of training is to alternate long and short distances on different days. The remaining participants reported alternating high and low effort training (30%), running the same distance every day (26%), hill training (18%), interval training (multiple runs of short duration with little rest between bursts) (12%) and other forms of training (4%) were their respective choices.

The majority of participants reported (60%) training on flat surfaces, 32% of the sample trained on uneven slopes and the remaining 12% preferred training on hills. The majority (84%) of participants trained on hard surfaces, whereas other surfaces such as soft, grass and artificial surfaces were rarely used.

Of the study sample, 38.8% reported that they include strengthening exercises in their training programme. Of the participants who included strengthening exercises, 14% engaged in strengthening exercises twice a week, whereas the remaining participants engaged in strengthening exercises once a week, three times per week or everyday respectively.

The study sample reported on their stretching habits during training and Figure 4.1 illustrates the percentage of participants who engaged in stretching. The majority of participants (60%) held a stretch for 10- 20 seconds, whereas a smaller group of participants (26.7%) held a stretch for 30-60 seconds and the remaining 13.5% did not stretch at all.

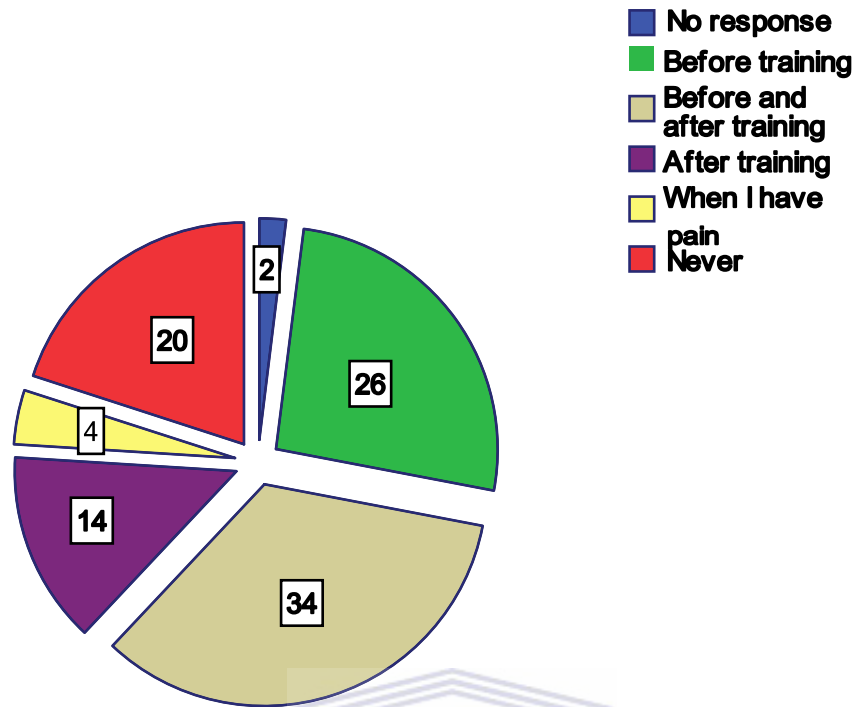


Figure 4.1 Percentage of participants engaging in stretching during training.



History of marathon participation

The study sample provided details regarding their history of participating in races and marathons. It was reported that 100% (n=50) of the study sample had participated in half marathons (21km) and 72% of the sample had completed a marathon (≥ 42 km). The mean (SD) 21km and 42km marathons completed are illustrated in Table 4.5. Furthermore, the mean (SD) duration for both 21km and 42km marathons and running pace are illustrated.

Table 4.5 Marathon participation (N=50). Mean and SD

Variable	N	Mean	SD
Number of 21km marathons	50	5.8	4.508
Number of 42km marathons	36	4.2	3.255
Average time of 21km	47	1.8	0.508
Average time of 42km	37	4.1	0.704
Running pace (min/km) during races	48	5.8	1.148



History of running shoes, arch type and orthotics

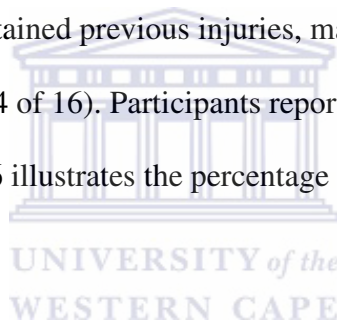
It was found that 40% of participants ran in a pair of shoes for approximately 6-12 months, whereas the other runners (45%) tended to use a pair of shoes for a period of 12-24 months and longer. Only a small percentage (15%) needed to change their shoes every 3-6 months. Similarly, it was found that 45% of the sample bought one pair of shoes per year; 40% bought two pairs of shoes per year whereas the remaining 15% bought between 3-4 pairs of shoes per year.

The majority of the sample (56%) indicated that they had normal arches or type of feet, 36% had flat shaped feet and 6% had high arches. Fifty percent of participants struck the running surface with their heel first, 26% struck with the whole foot and 22% struck the surface with the toes and ball of the foot.

The sample was questioned on the use of orthotics and they reported that 18% of them made use of orthotics. According to the sample, 8% reported that the orthotics were prescribed by an orthopaedic doctor, 6% indicated that they were prescribed by a podiatrist and 4% indicated that other disciplines had prescribed the orthotics. Of the sample, 10% had indicated that they use the orthotics for 0-6 months, whereas the other 8% uses the orthotics for more than 6- 24 months.

4.2.6 PREVIOUS RUNNING INJURIES

The majority of the participants (92%, 46 of 50) had sustained running injuries prior to the study. Among the participants who had sustained previous injuries, males (94.1%, 32 of 34) were more likely to be injured than females (93.3%, 14 of 16). Participants reported that 52% of previous injuries re-occurred prior to the study. Table 4.6 illustrates the percentage of participants who had sustained running injuries prior to the study.



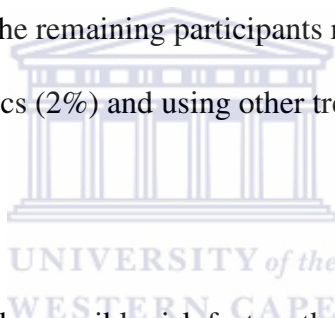
The participants reported that muscle strains (72%) were the most common running injury sustained, followed by ligament and joint sprains (40%). Muscle and ligament tears (6%), stress fractures (2%) and other fractures (2%) were reported as occurring less frequently. The participants also reported that 42% (n=21) had felt pain during running, 24% (n=12) could not continue running due to pain, 20% (n=10) experienced pain after downhill running and 16% (n=8) felt pain before and after running and while sleeping respectively.

Table 4.6 Percentage of participants who sustained previous running injuries at various locations on the body

Location of injury	Frequency (N)	Percentage (%)
Back	12	24
Buttock	5	10
Hip	8	16
Groin	8	16
Front thigh	4	8
Back thigh	10	20
Iliotibial band	8	16
Knee	31	62
Shin	8	16
Calf	10	20
Achilles Tendon	5	10
Ankle	6	12
Foot	6	12

The percentage represents the total amount of participants who had a previous injury.

The participants commented on the medical treatment sought for the running injuries sustained. It was found that 44% (n=22) of the sample had sought and received some sort of medical assistance. The following health professionals were seen by the injured runners; doctor (20%, n=10), physiotherapist (34%, n=17), orthopaedic surgeon (10%, n=5), biokineticist and podiatrist respectively (2%, n=1). The participants reported on the medical treatment that they found effective in the treatment of the injuries. The majority (60 %, n=30) found that ice, heat and massage was an effective treatment, 34% (n=17) found resting to be effective, 22% (n=11) reported that reducing the running distance was effective, some said that stretching and strengthening was effective (16%, n=8), 14% (n=7) found that medication was effective and a small percentage of the participants (12%, n=6) said that changing their shoes helped their symptoms. The remaining participants reported that changing surfaces (6%), changing training (4%), using orthotics (2%) and using other treatment methods (4%) were effective in the management of their injuries.



Finally, the participants reported on the possible risk factors that were associated with their running injuries. It was reported that the majority (36%, n=18) found excessive running distance to be a possible factor associated with their injuries. Table 4.7 illustrates the findings of this study regarding possible risk factors.

Table 4.7 Possible Risk Factors associated to previous running injuries

Risk Factors identified	Frequency	Percentage
Excessive running distance	18	36
Training with incorrect shoes	16	32
Too many races	12	24
Sudden change in training	6	12
Training in hills	11	22
Change in surface	5	10



SECTION B: PROSPECTIVE DATA

4.3 CUMULATIVE INCIDENCE OF INJURY

4.3.1 Prevalence of new injuries

A total of 16 participants (32.6%), of these 8 were male and 8 were female, sustained new injuries during the 16 week study period. Of these new injuries, 87.5% (14 of 16) of the participants had sustained a previous injury prior to the study, thus the remaining 12.5% (2 of 16) of participants sustained new injuries. A higher percentage of female participants (50%) reported sustaining new injuries than males (23.5%).

The prevalence rate of new injuries was 32%.

$$P = \frac{16}{50} = 0.32$$

= 32%

Overall, 50 injuries were reported. Of these, 72% were new injuries and 28% were recurrent injuries.

4.3.2 Location of new injuries

The majority of new injuries occurred in the calf (20%), knee (18%) and lower back (18%) respectively. The lowest number of injuries was sustained in the gluteus maximus (4.0%), quadriceps (4%), hip (2.0%), piriformis (2.0%) and groin (2.0%) as illustrated in figure 4.2.

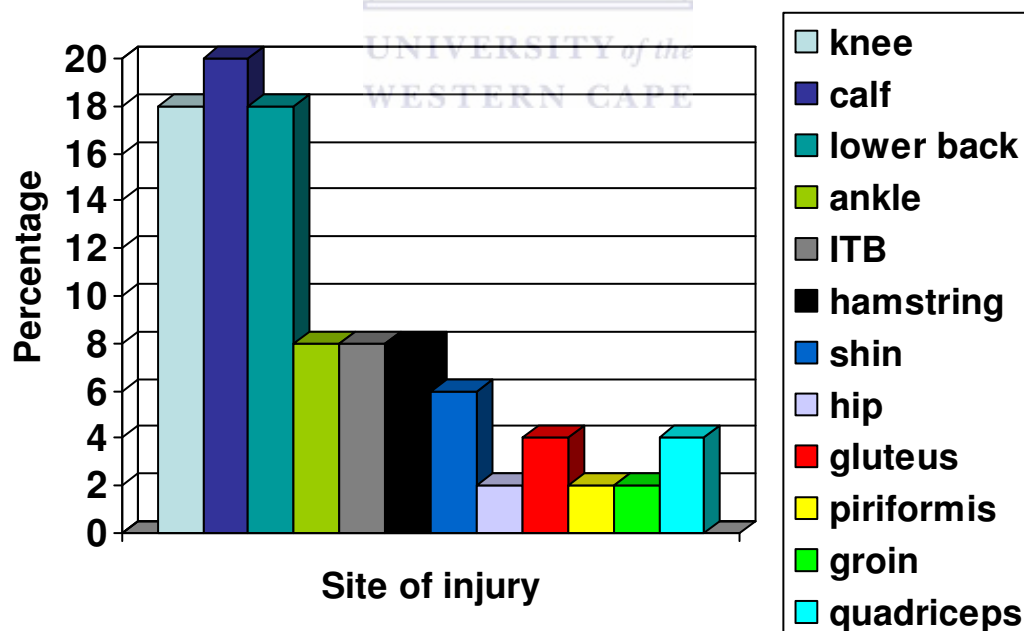


Figure 4.2 Location of new injuries

4.3.3 Recurrence, common types and severity of new injuries

Of the new injuries, a total number of 14 (28%) re-occurred. The most prevalent re-occurring injury was lumbar sprains of the lower back (8%). The other locations of re-occurring injuries were the ankle (6%), shin (4%), knee (2%), calf (2%), ITB (2%), gluteus (2%) and the hip (2%).

The most common type of injury was muscle strain (44%) followed by joint sprain (34%). The remaining injuries were ligament sprain (8%), ITB strain (8%) and shin splints (6%).

The majority of new injuries reported were classified as mild (36%) and moderate (36%), as illustrated in Figure 4.3. According to McManus (2002), the severity of injury are categorised as minor (the athlete was able to return to sport or training in which the injury occurred; mild (the athlete missed 1 week of training or sport); moderate (the athlete missed 2 weeks) and severe (the athlete missed more than 2 weeks).

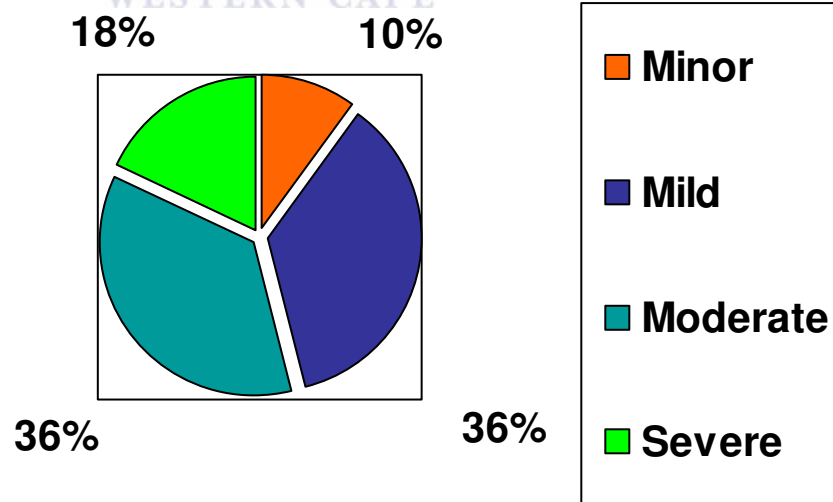


Figure 4.3 Severity of new injuries

4.3.4 Mechanism of injury

Participants reported on the factors that were closely associated to their injuries as possible mechanisms of injury. The majority of injuries were sustained from unknown causes (34%), followed by new shoes (22%), downhill training (18%), uphill training (16%), uneven surfaces (4%). Sloped surfaces (2%), too much training (2%) and orthotics (2%) were seldom reported as being associated to injury.

4.3.4 Incidence rate of injury

During the 16 week observation period, a total of 50 injuries were sustained and reported by the participants (N=16). When calculating the incidence rate of injury, the athletic exposure, or estimated rate of injury it was expressed in terms of 1000km run whereby a confidence interval estimate of that rate was given by using a Poisson Regression model

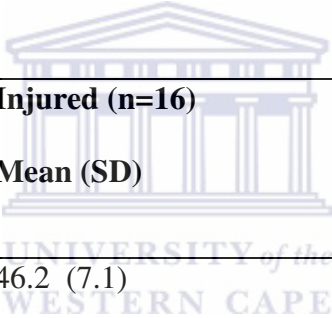
It was found that the estimated rate of injury was 0.67 injuries per 1000km run at a 95% confidence interval of 0.41, 1.08.

4.4 RISK FACTORS ASSOCIATED TO RUNNING INJURIES

4.4.1 Injured participants and non-injured participants

It was found that the mean and standard deviation of the risk factors identified (age, running distance, BMI and leg-length discrepancy) that were highlighted previously are slightly different for the injured and non-injured participants. These minor differences will be illustrated using means and standard deviation in Table 4.8.

Table 4.8 Risk factors in injured and non-injured participants. Mean and (SD)



Risk factor	Injured (n=16)	Non-injured (n=34)
	Mean (SD)	Mean (SD)
Respondent's Age (years)	46.2 (7.1)	45.9 (9.1)
Running distance (km)	45.0 (21.9)	53.4 (23.5)
BMI (kg/m ²)	27.1 (4.4)	25.1 (4.0)
Leg length discrepancy (cm)	0.6 (1.1)	1.0 (0.7)

4.4.2 Risk factors identified in literature

Some variables (risk factors) that were found to be significant to injury were selected from the questionnaire as predicting factors and were analysed. Some of the predictors were extrinsic and others intrinsic. The extrinsic factors were running distance, stretching and participant's age. The

intrinsic factors were Q-angle, BMI, running experience, leg-length discrepancy and history of previous injury. Results of regression analysis of the above-mentioned risk factors showed no statistical significance at the $p = 0.05$ level to the risk of running injury. However there was a trend (marginal significance) noticed with running distance ($p = 0.08$) and leg-length discrepancy ($p = 0.06$).

Various frequencies and percentages were found of non-injured and injured runners associated to some factors (running distance, stretching, age, Q-angle, BMI, running experience, leg-length discrepancy and previous running injuries) identified in literature as risk factors associated to running injuries. The p-values ($p < 0.05$) of the identified risk factors and the frequencies and percentages are illustrated in Table 4.9.



Furthermore, the Q-angle values were categorized in groups of $<10^\circ$, $10-14^\circ$, $15-19^\circ$ and $>19^\circ$ but for regression analysis it was adjusted for gender (males/ females). It was calculated (using literature) that should the average Q-angle measure $>20^\circ$ for females, they were at a higher risk of injury. Should the average Q-angle measure $>15^\circ$ for males then they were at a higher risk of injury. Thus for the analysis of association between Q-angle and injury, the calculated Q-angle at risk (q-risk) was used.

Table 4.9 Risk factors, frequency and percentages of injured and non-injured participants

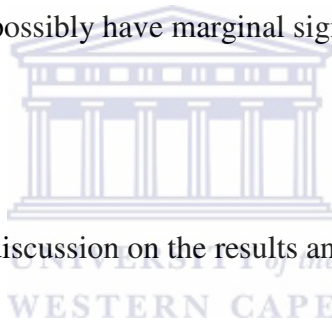
Risk factor	Categories	Non-injured runners Frequency (n=34) (%)	Injured runners Frequency (n=16) (%)	P value	Total
Running distance	0-32km	11 (32.3%)	6 (37.5%)	0.0812*	17
	32-50km	9 (26.4%)	5 (31.2%)		14
	50-80km	8 (23.5%)	4 (25%)		12
	80-100km	6 (17.6%)	1 (6.2%)		7
Stretching	< 20 seconds	26 (76.4%)	13 (81.2%)	0.8879	39
	> 20 seconds	8 (23.5%)	3 (18.7%)		11
Respondent's Age	25-39 years	8 (23.5%)	1 (6.2%)	0.9114	9
	40-59 years	23 (67.6%)	15 (93.7%)		38
	60-74 years	3 (8.8%)	0 (0%)		3
Q-angle (q-risk)	<10	4 (11.6%)	1 (6.2%)	0.6269	5
	10-14	12 (35.2%)	6 (37.5%)		18
	15-19	9 (26.4%)	8 (50%)		17
	>19	9 (26.4%)	1 (6.2%)		10
BMI	18.5-24.99	17 (50%)	5 (31.2%)	0.5043	22
	25-29.99	10 (29.4%)	8 (50%)		18
	30-40	7 (20.5%)	3 (18.7%)		10
Leg-length discrepancy	<0.5	7 (20.5%)	8 (50%)	0.0622*	15
	0.5-1	15 (44%)	7 (43.7%)		22
	1.01-1.5	6 (17.6%)	0 (0%)		6
	>1.5	6 (17.8%)	1 (6.2%)		7
Running experience	< 1 year	1 (2.9%)	1 (6.2%)	0.3292	2
	< 5 years	17 (50%)	9 (56.2%)		26
	< 10 years	4 (11.6%)	0 (0%)		4
	> 10 years	12 (35.2%)	5 (31.2%)		17
Previous running injury	Yes	32 (94%)	14 (87.5%)	0.1937	46
	No	1 (2.9%)	2 (12.5%)		3

(Statistical Significance $p < 0.05$) * Trend toward statistical significance

4.5. SUMMARY

The results of the study showed that the majority of the participants (92%) sustained running injuries in the past prior to the study. A total of 16 participants sustained 50 new injuries over the 16 week study period. The prevalence rate of new injuries was 32%. The incidence rate of injuries for this study was 0.67 per 1000km run at a 95% confidence interval of 0.41, 1.08.

There was no statistical significance found between running injuries and risk factors (running distance, stretching, age, Q-angle, BMI, running experience, leg-length discrepancy and previous running injuries) identified for analysis. However, some factors such as running distance ($p = 0.08$) and leg-length discrepancy ($p = 0.06$) could possibly have marginal significance or indicate a trend toward injury.



The following chapter undertakes a discussion on the results and a comparison with relevant studies found in the literature.

CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

The aim of this study was to determine the incidence and the various risk factors that are associated with injuries in road runners at a local athletic club. The study objectives will be discussed under the headings: the prevalence and incidence rate, location and re-occurrence of running injuries and possible risk factors associated to lower limb injuries in runners. Furthermore, a discussion on the prevention strategies of the participants will be undertaken. Thus, this chapter discusses the findings of the study and compares the similarities and differences found in previously published studies.

5.2 PREVALENCE AND INCIDENCE OF RUNNING INJURIES

Running contributes positively to an individual's health; however, there are some concerns about the high incidence of running injuries that could occur (Van Gent et al., 2007). Several prospective and retrospective studies have been done to determine the prevalence and incidence of injuries in runners, although these studies have predominantly been conducted in international, developed countries. To date there are few studies at a national level that have investigated the prevalence and incidence of running injuries, which identifies a gap in the baseline literature. Thus, in the current study, the prevalence of previous running injuries and the incidence of injuries over the period of 16 weeks were determined to fill this gap on a national level.

5.2.1 Prevalence of previous injuries

According to Van Mechelen (1992), a history of previous injury was found to be strongly associated with an increased risk in the occurrence of running injuries. In the current study, the participants reported on any previous running related injuries to investigate any possible association between previous injury and risk of new injury. It was reported that 92% (n=46) of the sample had sustained previous running injuries before the commencement of the 16 week study period. A higher percentage of males (94%, n=32) reported having a previous injury than female participants (93%, n=14). This information gives rise to the assumption that a high percentage of the participants are supposedly at risk in sustaining a new injury.

5.2.2 Prevalence over 16 week period

The prevalence rate of injury in the current study was 32% (50 injuries from 16 out of 50 runners) over a 16 week study period. This is comparable to a prospective study by Wen et al. (1998) who found a prevalence rate of 32.9% (84 injuries from 255 participants) over a 32 week period. The possible reasons for similarities between the studies could be that the outcome and methods of the studies were similar. A slight discrepancy was found in the number of participants in the study by Wen et al. (1998), where it was higher than the current study's participation rate. A difference in the ratios of injured participants was noted. However, the results with regards to the prevalence rate of injury were still the same.

Schwellnus et al. (2006) reported that a total of 93 injuries were sustained by 47 runners (experimental group) and 115 injuries by 55 runners (control group). Thus, the prevalence rate was 50% for the experimental group and 66% for the control group. The results are higher than the current study's

prevalence rate (32%), which could be due to the smaller sample size (n=50) and the lower number of runners who sustained an injury (n=16). Furthermore, the comparative results are valuable since they were conducted in South Africa and therefore used participants from similar training backgrounds and living environments to the participants in this study.

A comparison can be made with an African study by Davey and Tilahun (2002), which found a prevalence rate of minor injury of 2.4 % (227 of 9380 runners) with diagnoses of only soft tissue injury (0.09%) and heat stroke (0.14%). Davey and Tilahun (2002) only evaluated the number of injuries sustained after the completion of a 10 km race in Ethiopia. The current study followed the participants over a period of 16 weeks during which the participants had completed either the Two Oceans Marathon (21km or 56km) or the Comrades Marathon (89km) which could further predispose them to sustaining an injury, thereby increasing the prevalence rate. The prevalence rate was much lower than the current study's rate which shows no similarities. The possible reasons for the huge discrepancy in prevalence rates could be due to the difference in outcomes of the participation in races studied, the number of participants in the study, and differences in the definition of a running injury, as well as methodologies.

5.2.3 Incidence rate of running injuries

The estimated rate of injury or athletic exposure for this study was 0.67 per 1000km run at a 95% confidence interval of 0.41, 1.08. This finding is much lower than what other studies have found. Furthermore, some authors have reported on the incidence rate or athletic exposures of running injuries internationally and only one local study was found that had reported on the incidence of running injuries. This highlights a gap in literature on a local level in South Africa.

A study by Rauh et al. (2005) found an incidence of 17.0 per 1000 athletic exposures of 421 runners during 5-8 weeks study period. This rate is higher than the current study's findings and the possible reasons could be a difference in the age of the sample and the type of runner who participated as the runners were high school cross country runners. These differences could produce different outcomes of the study and possibly the higher injury incidence rate.

Furthermore, an international study by Lun et al. (2004) found an injury incidence of 59% per 1000 hours of running with a total of 81 injuries sustained among 69 runners (35 men and 34 women). These results are not similar to the current study, however the methodology of the study was very similar to the current study's. The methods of the study of Lun et al, (2004) included; runners older than 18 years, no current injuries, static measurements such as height, weight, BMI, leg length, Q-angle and ROM of hip were taken. The runners also had to report and document any new injuries and visited an injury clinic for an assessment if thought necessary. Up to this point the methods used in both studies were similar and the only differences compared to the current study were that the runners were followed for 6 months and the runners had to complete a running log reporting on shoe type, running mileage and time, terrain, temperature and training versus races. This extra information reported by the runners could have contributed to the high incidence rate per 1000 hours run.

A comparison to a local study by Schweltnus et al. (2006) found an incidence rate of 6.04 per 1000 running sessions in an experimental group (93 injuries among 47 runners) and 6.71 per 1000 running sessions in the control group (115 injuries among 55 runners). This finding is closer to the results of the current study (0.67 per 1000km run) compared to the other studies highlighted. The similarities could be that the studies were conducted in the same city, the participants were training for the same

races (Two Oceans and Comrades Marathons) and the training surfaces and terrain were similar. The difference in the methods used could be that the runners were from three different elite running clubs compared to the local running club used in the current study; the ratio in gender was similar (Experimental = 53 males, 47 females; Control = 66 males, 34 females) in comparison to the current study (males= 34 and females= 16) and the study period was over 12 months whereas the period of the current study was approximately 4 months (16 weeks).

Another aspect that could affect the outcome of the study is the definition of athletic exposure used in the various studies. Some studies calculate the incidence rate according to 1000 hours of running whereas the current study calculates the incidence rate according 1000 km run.

Overall, the studies mentioned highlight the need for future local prospective studies to identify the incidence rate or athletic exposure of running injuries by using a standard formula for the calculation.

5.3 LOCATION AND RECURRENCE OF INJURIES

5.3.1 Common location sites of injury

A vast amount of literature states that the most common running injury occurs in the knee. The Academy of Orthopaedic Surgeons (2003) conducted a survey among 853 runners where 76% reported sustaining a running related injury. It was found that the knee (28%) was the most commonly reported location of injury and the foot (22%) as the second most common location. Similarly, a higher percentage (70%) of injuries to the knee and below was reported by 629 runners with a total of 163 injuries sustained in the Netherlands (Buist et al., 2010).

In the current study, the most common location of new injuries were the calf (20%) and the second most common locations were the knee (18%) and lower back (18%). These results do not coincide with the literature previously mentioned. However, there are other studies that show similarities in the results found. Van Middelkoop et al. (2007) found an incidence of injury of 18.2 % (118 of 647 runners) during a race in Rotterdam. The injured runners reported that the calf (33.9%) was the most common site of injury, followed by the knee (27%). Buist et al. (2010) agrees with this finding as the lower leg (calf and shin) was the most common anatomical site of injury in women (35 of 98) and the knee was reported in men (25 of 65). Thus the findings of the current study are in agreement with both Buist (2010) and Van Middelkoop's (2007) findings. Similar results were possibly found among these studies because they used a similar methodology such as the prospective study design, inclusion criteria for runners, data capturing instrumentation, duration of the study period and outcomes.

In South Africa, the only study found for comparison was by Puckree et al., (2007), who reported an incidence of knee injuries of 51% (45 of 88 runners) reflecting the most common location of injury predominantly in Indian marathon runners. Unfortunately, this does not agree with the results of the current study, possibly due to the differences in the study samples. Another reason for the difference could be that this study only focused on the Comrades marathon which could introduce a bias towards long distance marathon runners. Thus a need arises for future prospective research to identify common sites of injury in runners both male and female, of all races and cultures on a national and local level to eliminate any possibility of bias.

5.3.2 Recurrence of running injuries

The occurrence of running injuries is increasing as more people participate in the sport. However, this popularity in participation in races especially, places a high demand on the structures of the body to perform at their peak. According to Van Mechelen (1992), a previously injured anatomical structure is more prone to recurrence of the injury due to the previous physiological break down.

In the current study, a total number of 50 new injuries were sustained during a period of 16 weeks. Of the new injuries, a total of 14 injuries (28%) re-occurred. The most prevalent re-occurring injury was lumbar sprain of the lower back (8%). The other locations of re-occurring injuries were the ankle (6%), shin (4%), knee (2%), calf (2%), ITB (2%), gluteus (2%) and the hip (2%). As mentioned previously, the calf (20%), knee (18%) and the lower back (18%) were reported as the most common locations of new running injuries. However, only the lower back was reported as the most frequent site of re-occurring injury. This finding is not consistent with the literature regarding recurrence of injury to the same anatomical structure. It could be due to the difference in the severity of the injuries sustained, as the lower back and ankle joints tend to result more in a chronic injury especially if not rehabilitated completely. However, no analysis was done for this relationship since the association between types of new and recurrent injury and severity were not assessed in this study.

A comparison of the current study can be made to a study by Lun et al. (2004) who found an incidence of injury of 79% of a total of 81 injuries (69 of 87 runners), of which 49% of the injured runners reported a new injury and 29 % reported a recurrent injury. The results shown of the re-occurrence of injury are consistent with the results of the current study's injury rate of 28%. However, the percentages reported are for different variables. The current study is reporting the number of recurrent

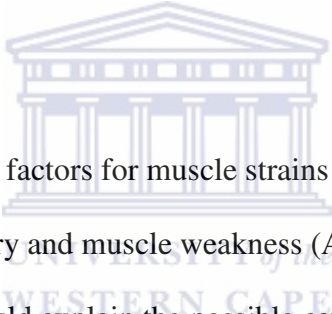
injuries and the comparative study is reporting the percentage of injured runners. Unfortunately, there were no results found on the location sites of the recurrent injuries in the latter study. Another study by Taunton et al.(2003) found that 29% of runners (249 injuries out of 844 runners) reported sustaining new and recurrent injuries during a 13 week training programme. It was found that half of the injured runners had sustained a prior injury in the same anatomical location. The knee was the most common site of injury, followed by injuries to the shin, foot, ankle, hip/pelvis, lower back and hamstring/ thigh across all sexes. The findings of that study are consistent with the current study in terms of injury location. However, the knee was reported as being the most common location of new and recurrent injuries, which is different to the findings of the current study.

Unfortunately, there are few studies date that report on the location of recurrent injuries and only highlight the percentage of recurrent injuries. This highlights a gap in the literature with respect to the sites of recurrent injury. This information is important since it is relevant to the history of previous injury which will assist with the rehabilitation of injured runners and the prevention of such injuries.

The possible reasons for the difference in the common locations and recurrence of running injuries in other studies could be: the different sample sizes within the studies; differences in study design; differences in definitions of running injury and the severity of injury; differences in the ratio in gender among participants and perhaps the different training and racing environments available in international countries. Thus, further research is needed to identify the location of both new and recurrent injuries sustained by runners in order to develop effective prevention rehabilitation programmes.

5.4 COMMON TYPES OF RUNNING INJURIES

The common types of running injuries reported and treated in the literature are muscle strains and tendonitis (Anderson et al., 2001). The most common types of running injuries found in the current study were muscle strain (44%) followed by joint sprain (34%). The remaining types of injuries were ligament sprain (8%), ITB strain (8%) and shin splints (6%). This coincides with the most common location of injury of the current study, the calf, as previously reported. Furthermore, this high incidence of muscle injuries could be linked to the majority of injured runners (81%, 13 out of 16) who reported on inadequate stretching. Yeung et al. (2001) agrees with this statement as inadequate stretching (less than 20 seconds) can be associated to injury as mild stretching cause damage to the muscles at a cellular level.



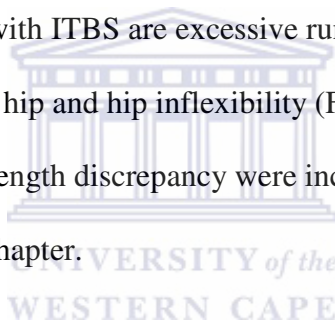
According to the literature, some risk factors for muscle strains have been identified, including; an increase in age, previous muscle injury and muscle weakness (Arnason et al., 2008; Tyler et al., 2001; Emery & Meeuwisse, 2001). This could explain the possible causes for the high incidence of muscle strains, since the majority of the injured runners (93.7%, 15 of 16) were between the ages 40 to 59 years. Although no statistical significance ($p=0.9$) was found between increasing age and the risk of overuse running injuries, some clinical significance is evident. Previous history of muscle injury was the other factor that was mentioned and in the current study, it was found that 87.5% of injured runners (14 of 16) had reported running injuries prior to the study. This high percentage of previous injuries could in turn have an effect on the high incidence of muscle strain reported. However, no significance was found between previous running injury ($p=0.1$) and risk of injury. Muscle weakness was also assessed in this study and it was found that a small percentage of runners (10%, 5 of 50)

showed a below average (<30%) muscle strength of the lower limb. This could probably not lead to an association with muscle strains as has been highlighted in the literature.

The second most common reported injury in this study was joint sprains (34%), in which the knee, back, ankle and hip joints were injured. The knee (18%) and lower back (18%) were the second most common location of injury reported in the study and PFPS was the most common type of knee injury diagnosed, followed by lumbar joint sprain and ITBS. This finding is in agreement with Taunton et al. (2002) who found PFPS, ITBS and plantar fasciitis to be the most common running injuries.

ITBS has been reported as the most common cause of lateral knee pain in runners (Paluska, 2005).

The possible risk factors associated with ITBS are excessive running distance, leg length discrepancy, genu varum, muscle weakness of the hip and hip inflexibility (Fredericsson, 2000 & Wexler, 1995). In this study, running distance and leg length discrepancy were included in the regression model analysis and will be discussed further in the chapter.



Furthermore, the diagnoses of the injured runners were not included in the injury report form of this current study and only the type of injury was reported, which could be a limitation of the study.

5.5 SEVERITY OF INJURY

The severity of any sport related injuries are usually assessed according to the definition of injuries given. This definition of severity of injury usually includes the duration of symptoms and training time lost due to the injury (Lun et al., 2004). This study used the definition of injury severity by McManus (2000), who identified four levels of injury severity. These were: minor (the athlete was able to return to sport or training in which the injury occurred); mild (the athlete missed 1 week of training or sport);

moderate (the athlete missed 2 weeks) and severe (the athlete missed more than 2 weeks). However, there is a limitation whereby comparisons of the severity of injuries with other studies become difficult due to the difference in definitions, difference in methodological designs and sample sizes of studies.

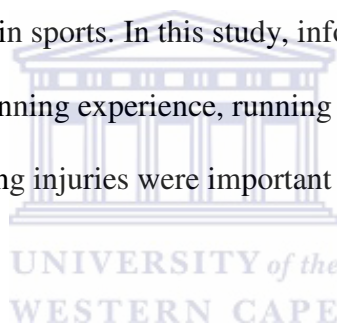
In the current study, a large percentage of new injuries were reported as being mild (36%) and moderate (36%). The remaining injuries were categorised as being severe (18%) and minor (10%). Therefore, the majority of injuries reported by the participants resulted in them missing 1-2 weeks of training. These results could possibly be associated with muscle strains. However, the association between severity and type of injury were not included in the regression analysis of this study. The implications of this time lost in training could mean that the runner would have had to train more frequently and with greater intensity to return to their original level of fitness. It could even have lead the runner to return to running before the injury had completely healed. This would obviously place more strain on the previously injured structures, and possibly cause re-injury.

A lower percentage of running injuries were reported as being severe. This duration of time lost could possibly be linked to ligament sprains reported by the injured runners. However, no associations between the severity of injury and the specific type of injuries were included in the regression model for analysis. Thus further research is needed to investigate the possible running injuries (different types of injury) associated with the levels of severity of injury. The implications of this longer duration of time lost places even more pressure on the athlete to return to running and performance. The runner will either push harder in training to return to the original performance before the injury but against a much longer timeframe for healing than a mild or moderate injury. The runner might

even decide to take it easy and gradually return to running performance taking the nature of the injury into consideration. The more severe the injury, the more difficult it will be for the runner to return to their level of performance prior to the injury.

5.6 MECHANISM OF INJURY

Numerous studies have identified many risk factors associated with the occurrence of running injuries sustained during training or races. To be able to manage and prevent the injuries of the runner appropriately, a holistic approach is necessary. According to Meeuwisse (1994), the identification of the cause of the injury together with the risk factors (both intrinsic and extrinsic) is important to determine optimal injury prevention in sports. In this study, information regarding the anthropometric measurements, demographic data, running experience, running environment, training habits, lifestyle factors and history of previous running injuries were important to determine the possible cause of the injuries.



In this study, the majority of injured runners reported that the cause of injury was unknown (34%), whereas some runners reported that wearing new shoes (22%) were possibly the cause of their injuries. Other runners reported that the training surfaces (downhill, 18%; uphill training, 16%; uneven surfaces, 4% or sloped surfaces, 2%) were possibly contributing to the cause of their injury. These factors were unfortunately not included in the regression model to analyze the association to running injuries. However, many researchers have done analysis on these factors and found them to be risk factors for running injuries. Taunton et al. (2002) and Johnston et al. (2003) found that inappropriate running surfaces and incorrect shoes were significantly associated with running injuries.

The mechanism of a sports injury and knowledge of both the intrinsic and extrinsic factors can assist with injury prevention. However, a key component in the understanding of the cause of injury is a description of the causal event. In order to describe this, the biomechanical context (situation, behavior and positions of player and opponent) as well as the joint biomechanics of the event leading to the injury need to be identified and understood (Bahr et al., 2005). This event is often not well described in running, as opposed to team sports like soccer, rugby and basketball. Thus, it is difficult to identify the causal event in running, which could lead to an inaccurate identification of the mechanism of injury. For this reason, this study could only report on the probable causes of injury (risk factors) identified by the runners themselves.



5.7 RISK FACTORS ASSOCIATED WITH INJURIES IN RUNNERS

Meeuwisse (1994) and Van Mechelen (1992) developed various models of injury prevention in sports. They determined that a sports injury is the result of a complex interaction between internal and external factors. More recently, it was identified that the sum of risk factors and the interaction between them allows the athlete to become susceptible to injury. In this study, various risk factors identified in literature were analyzed to highlight the associations with the occurrence of running injuries. The following risk factors (running distance, stretching, age, Q-angle, BMI, running experience, leg-length discrepancy and previous running injuries) will be further discussed in terms of their association with running injuries.

5.7.1 EXTRINSIC FACTORS

Running injuries usually occur via extrinsic (an external force impacting on body) factors or from intrinsic factors (factors that are inherent in the body or internal) (Noakes, 2003). Furthermore, the

extrinsic risk factors (running distance, stretching, respondent's age) identified in this study were deemed to be significant in other studies and of clinical relevance in the current study.

Running Distance:

As mentioned in the literature review, an increase in weekly running distance is closely associated with an increase risk in running related injuries (Brill, 1995). Furthermore, Johnston (2003) found that 60% of all running injuries are the result of increasing running distance too quickly and that a running distance of more than 60 km per week may be associated with injury. Furthermore, Hreljac (2006) agrees that an increase in running distance would ultimately increase the number of running steps taken which increases the number of repetitions. This increased applied stress caused by increased running distance places the musculoskeletal structures more to the right on the stress-frequency curve, entering the injury zone on the stress-frequency graph.

In this study population, running distance showed marginal significance toward injury ($p=0.08$), which could possibly explain why 25% of the runners who sustained an injury after running a distance of more than 60 km per week. However, the remaining 68.7% of the injured runners, (11 of 16) ran a distance of 0-50km per week. This could mean that some runners sustained an injury even while running within the normal parameters of training per week. Thus, inconclusive evidence was found between risk of injury and excessive running distance. This finding is different to what Van Gent et al. (2007) found, that an increase in running distance per week was a risk factor contributing to the high incidence of running injuries.

Van Middelkoop (2007) found similar results to this study as 27% of the runners with a weekly running distance more than 60 km a week were injured, compared to the 30.5% of injured runners with a weekly running distance of 0-40 km a week. The results of this study show some inconsistencies with regards to the association between weekly running distance and the occurrence of running injuries. This becomes a problem as many researchers are providing information to runners that to prevent a running injury, a reduction in weekly running distance (<60km/week) should occur. However, it seems that an increase in running injuries can also occur at shorter weekly running distances (Van Middelkoop, 2007).

A limitation of the current study was identified whereby the questionnaire used in the study had asked the runner to indicate the weekly distance covered using categories from 0-32km, 32-50km, 50-80km and 80-100km, whereas an open ended question reporting the weekly distance may have been more appropriate to use for the analysis. Other limitations could be; the difference in studies mentioned in identifying the normal running distance per week that will not predispose the runner to injury as some discrepancies are noted; the different sample sizes used; the different caliber of runners who participated (short, middle and long distance runners) and possibly the different categories of runners (novice, intermediate and advanced). All these limitations could have had an impact on the results provided and possibly be the reason for the marginal significance found between running distance and risk of injury in runners.

Stretching:

Yeung et al., (2001) found that inadequate stretching may be associated with injury as mild stretching could cause muscular damage at a cellular level. Furthermore, Pope et al.(1998) agrees with this

statement as holding a stretch for longer than 30 seconds reduces the risk of injury .

The results of this study showed that 78 % (n=39) of runners engaged in a regular stretching programme, whereby 81% (n=13) of the injured runners incorporated stretching into their running programme and held each stretch for fewer than 20 seconds. The remaining 19% (n=3) of the injured runners also engaged in stretching and held a stretch for more than 20 seconds, for up to a minute. Thus, it seems that the runners who held a stretch for less than 20 seconds were more prone to injury than those who held a stretch for longer than 20 seconds. However, this finding did not show any statistical significance ($p=0.8$) according to the regression model.

Even though no statistical association was found between stretching and the risk of injury, some literature does support the clinical finding of this study. According to Pope et al. (1998), holding a stretch for longer than 30 seconds reduces the risk of injury. There is some evidence to show that pre-participation stretching does reduce the risk of muscle strains (Hadala & Barrios, 2009).

Furthermore, Hreljac (2006) found that data from studies relating to stretching were primarily sourced from self-reported questionnaires giving rise to recall bias, which could lead to unreliable data. This means that caution should be taken when making reference to these findings as it might be unreliable. The findings of the current study suggests that there is possibly a clinical relationship between holding a stretch for longer than 20 seconds and reducing the risk of injury in runners, even though there was no statistical significance found. Thus further research is needed to confirm this clinical finding by using a larger sample size and more reliable methods of testing to rule out any bias.

Respondent's Age

There is evidence that age was found to be significantly associated with the risk of injury in runners. Taunton et al.(2002) found that a younger age (< 34 years) showed a significant association to the risk of running injuries, especially patellofemoral pain syndrome (PFPS) both in men and women. Furthermore, Taunton et al. (2002) found that older women (> 50 years) had a higher risk of sustaining an injury than younger women.

In the current study, it was found that 94% of the injured runners fell into the age category 40-59 years. It seems as if increased age (>40 years) could possibly show clinical significance to the risk of running injuries, however, the regression model of this study showed no statistical significance ($p=0.9$) between age and risk of running injuries.

The clinical significance of the current study agrees with Taunton et al. (2003) who found that an age greater than 50 years was a risk factor for injury. However the results indicated that this was true only for women. Furthermore, a more recent study done in Brazil (Hino et al.,2009) had similar results to the current study in which a higher prevalence rate of injury amongst runners between the ages 30- 45 years was found. These results show a closer relationship to the current study as it provides evidence from a developing country similar to South Africa. The possible reasons for similarities in the latter study could be due to similar training environments, socio-economic status, gender ratio (males > females) and possibly due to similar methods of testing the associations between variables (Poisson regression model). The possible reason for the low statistical significance could be the small sample size and the small number of participants who sustained running injuries.

Even though some clinical relevance was found in this study with higher age being related to higher prevalence rates of injury, there are still inconsistencies found in the literature. Some researchers state that older age is not a predictor for injury in runners (Van Middelkoop, 2007) and that injury is less likely to occur in very young and older runners (Satterthwaite, 1999). Thus further research is necessary to provide stronger evidence on whether age is directly associated to the risk of running injuries.

5.7.2 INTRINSIC FACTORS

Some sport professionals lack the knowledge of the biomechanical mechanisms associated with overuse injuries in runners. These mechanisms are commonly identified as underlying anatomical or biomechanical variables (intrinsic factors) which are not within the runner's control, thereby making diagnoses, treatment and prevention of running injuries difficult (Hreljac, 2005). Furthermore, some intrinsic factors (leg length discrepancy, Q-angle, BMI, running experience and previous injury) highlighted in this section were identified as being significantly associated with the risk of running injuries.

Leg length discrepancy

A leg length discrepancy ($>1.01\text{cm}$) could possibly result in muscle imbalances and predispose athletes to lower limb injuries associated with running (Noakes, 2003). Furthermore, researchers, (Wen et al., 1998 & Johnston et al., 2003) found leg length mal-alignment to be significantly associated with the risk of running injuries. Leg length discrepancy was identified as a contributing factor to ITBS amongst runners (Fredericsson, 2000 & Wexler, 1995).

In this study, the true leg length measured from the ASIS to the medial malleolus was recorded. It was found that 26% (13 of 50) of runners had a major leg length discrepancy ($>1\text{cm}$). The results of the regression model showed a marginal significance ($p=0.06$) to the risk of lower limb injuries in runners. However, only 6.2% of the injured runners (1 of 16) had a leg length discrepancy ($>1\text{cm}$) and 43.7% (7 of 16) runners, who had normal leg length (0.5-1.0), still sustained an injury during the study period. These results do not concur with the marginal significance found as there is no clinical evidence found with the results concerning the injured runners. The reasons for this are unknown as leg length was analyzed as a single predictor and not in conjunction with other factors. Thus there is no clinical evidence that leg length discrepancy is associated with running injuries.

To compare this study's findings to literature, it was found that leg length discrepancy (a shorter leg) was significant in athletes who sustained stress fractures compared to a control group, thus leg length discrepancy was found to be significant to the risk of sustaining stress fractures (Korpelainen et al., 2001). However, no relationship was found between the frequency of stress fractures and the degree of leg length discrepancy, as the male jumpers who sustained six stress fractures had equal leg lengths. Some inconsistencies were found in this study around the relationship between leg length discrepancy and the risk of injury in athletes. The differences in results could be that the current study only assessed the relationship in runners whereas the latter study had studied all athletes including those who completed in jumping, cross country skiing, power events and ball games.

Possible limitations of the study could be methodological differences between the studies highlighted, such as study design, sample size, definition of injury, environmental factors of training and races in the studies, gender and multiple factors identified and analysed as predictors. Another limitation with

regard leg length discrepancy could be the inconsistency of measurements recorded by the research assistants. Thus further research is needed to investigate a direct relationship between leg length discrepancy and injuries in runners using more consistent methods of measuring and the use of a larger sample perhaps.

Q-angle

The Q-angle provides an approximation of the angle of the quadriceps muscle on the patella in the frontal plane, whereby the normal Q-angle values are between $11^{\circ} \pm 3^{\circ}$ (men) and $15^{\circ} \pm 5^{\circ}$ (women) (Horton et al., 1989). Rauh et al. (2005) found that runners with an increased Q-angle ($>15-20^{\circ}$) had a higher risk of lower limb injuries. This could be due to a larger lateral pull on the patella against the lateral femoral condyle possibly contributing to patella subluxation and patellofemoral pain disorders (Powers, 2003). Furthermore, Puckree et al. (2007) found that increased Q-angle ($>22^{\circ}$) in Indian male runners were directly proportional to the incidence of knee injuries in runners. It is therefore evident that an increased Q-angle ($\geq 20^{\circ}$) is an important risk factor contributing to possible knee injury in runners.

For this study, the Q-angle values were categorized in groups of $<10^{\circ}$, $10-14^{\circ}$, $15-19^{\circ}$ and $>19^{\circ}$ and for regression analysis it was adjusted according to gender (males/ females), thus the analysis was done using the calculated Q-angle at risk (q-risk). The current study's results show that the majority (56%) of the injured runners (9 of 16) had an increased Q-angle of 15° and more ($>19^{\circ}$), whereas the remaining injured runners (44%) had normal Q-angles of less than $10^{\circ}-14^{\circ}$. There was no statistical significance found between an increased Q-angle and a higher risk of injury ($p=0.85$). However, this finding shows some clinical relevance but with a very small difference in percentage between the two

categories (normal and increased Q-angle). In comparing the non-injured runners of the study, it was found that the majority (52.8%) of them (18 of 34) also had an increased Q-angle of 15° and more ($>19^{\circ}$). This finding is contradictory to the latter finding as there is no difference found amongst the non-injured and injured runners with regards to an increased Q-angle and the risk of injury in runners. In other words, an increased Q-angle cannot be a single predictor for risk of injury as there was no clinical association found between the two groups. Clearly other factors placed the injured runners at a higher risk in sustaining an injury.

Some possible reasons for the inconclusive results of this study could be the small sample used for the study resulting in the small number of runners injured and non injured. Another factor could be that muscle weakness may have played a role in the risk of injury. Literature agrees with this statement as an increased Q-angle ($>20^{\circ}$ in females, 15° - 20° in males) and weakness of hip (external rotators), pelvis and trunk muscles could be associated with PFPS of the knee in runners (Souza et al., 2009; Rauh et al., 2007; Mascal, 2003). A limitation to the current study is that muscle weakness was not included in the regression analysis of the study, although it was initially assessed. Another limitation to the study could be the discrepancy between the various standard values for Q-angle, in which some researchers assume that a Q- angle $>15^{\circ}$ is increased and others assume it is normal. This discrepancy in standard values could lead to possible inaccurate categories for normal and abnormal Q-angles of the knee which could lead to incorrect results.

Even though literature states that an increased Q-angle ($>20^{\circ}$ in females, 15° - 20° in males) is significantly associated with the risk of running injuries, the findings of the current study show inconclusive results compared to others. Thus further research is necessary to identify the possible

factors associated with an increased Q-angle and the risk of injury in runners, as increased Q-angle was not found to be a single predictor for the risk of running injuries.

BMI (body mass index)

Body Mass Index is another common intrinsic factor assessed in prior studies for any relationship found to the risk of sustaining injury in runners. According to Rauh et al. (2005), it was found that the normal BMI is between 18.50kg/m²-24.99kg/ m², where anything more is considered to be high. Furthermore, Noakes (2003) found a low body mass index (BMI) significantly related to the risk of sustaining running injuries.

The current study found that the majority (56%) of the sample (n=50) fell into the overweight (25-29.99 kg/m²) and obese categories (30- 40 kg/m²). Of the injured runners, 69% (11 of 16) fell into this category. In this study, BMI was not significantly associated (p=0.4) to running injuries according to the poisson regression model, however, it seems that an increased BMI (≥ 25 kg/m²) could possibly have clinical significance to the risk of injury in runners. Should the non injured runners be taken into account, it is found that 50% runners (17 of 34) also fell into the increased BMI category which could probably mean that a relatively high percentage of both injured and non injured runners have an equal chance in sustaining an injury. These results could possibly be the reason for the low statistical significance found in the regression model.

The findings of the study about the majority of injured runners having an increased BMI are in agreement to what literature states about increased BMI and risk of injury. Buist et al.(2008) found a higher BMI significantly associated with sustaining a running injury mostly in females. The reasons

are possibly due to the added physical stress of the additional weight placed on anatomical structures, causing the runners to be more prone to injury. Conflicting evidence was found by Taunton et al.(2003), who found that an increased BMI (greater than 26 kg/m²) was a protective factor against injury in men thus reducing the risk of injury whereby the findings of the this current study says otherwise. There is a clear difference found between the two studies which lead to contradictory evidence of what the association between a higher BMI and injury in runners are. The differences could come from the methodology used in the studies such as the difference in definitions of a running injury, the differences in sample size and gender and possibly the different associated factors included in the regression model.

The results of this study shows no significance between BMI and the risk of injury in runners, however some clinical relevance is found where the majority of injured runners had a higher BMI. This is in agreement with findings of Buist et al (2008), however inconclusive evidence is found in literature with regards to a higher BMI and the risk of injury. Further research is necessary to find stronger evidence on the relationship between increased or lower BMI and the risk of injury in runners.

Running experience

A lack of running experience has been identified by Van Mechelen (1992) as a contributing factor to overuse running injuries. Furthermore, participants that did not previously run a marathon were 50% more likely to sustain an injury while running a marathon. Thus there was a positive association between a lack of running experience and running injuries (Satterthwaite et al.,1999).

The current study found that the majority (56%) of the sample (28 of 50) had been running for less than five years, whereas the remaining runners (42%) had run for longer than five years (8% ran <10 years; 34% ran >10 years). Furthermore, it was found that the majority (62%) of injured runners (10 of 16) had a running experience of less than five years. This could probably mean that a lower amount of years of running experience is positively related to injury in runners. However, there was no statistical significance ($p=0.32$) found with the association of running experience and the risk of injury.

I also found that a lower percentage (31%) of injured runners had been running for more than ten years. This finding is similar to Fredericson et al. (2007) who found that more experienced runners are less prone to injury as the number of running years being inversely associated to incidence of injuries. Even though there was no significance found statistically, some clinical relevance is evident as the majority of injured runners had a lack of running experience (<5 years) and a small percentage of injured runners had more experience (>10 years) which could further explain the clinical relevance.

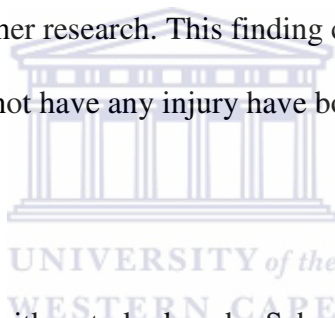
The possible reasons for the low statistical significance could be due to the small sample size and the small number of injured runners; the short follow up period of 16 weeks; the uneven ratio of runners with lack of experience and runners with more experience and the uneven ratio of male/ female runners. Thus further research is needed with better methodology to provide evidence that lack of running experience is directly proportional to incidence of injuries in runners.

Previous Running Injury

Van Mechelen (1992) concluded that previous injury is found to be strongly associated to an increased risk in the occurrence of running injuries. A prospective study by Taunton et al. (2003) showed that

half of the 844 runners had sustained an injury and had reported a previous injury to the same anatomical site. Furthermore, 42% of the runners that had a previous injury had indicated that they were not completely rehabilitated before starting their training programme. Thus prior injury has been found to be one of the strongest predictors of injury in runners (Ryan et al., 2003).

I found in the current study that 88% of injured runners (n=16) had reported a previous injury, however, 94% of non-injured runners (n=34) had also reported a previous injury. It seems as if a higher percentage of runners that had previous injuries did not sustain any new injuries in this prospective study. Thus previous running injury was found not to be significantly associated ($p=0.1$) to running injuries as stipulated in other research. This finding could assume that runners that had previous injury and runners that did not have any injury have both equal chance and risk to sustaining running injuries.



The findings of this study coincides with a study done by Schwellnus (2006), a South African researcher, who found that runners in an experimental group (n=94) reported a higher annual incidence of past injuries compared to the control group (n=83). Furthermore, there was no significance found between the runners that had past injuries and the runners that had no past injuries, and the incidence of subsequent injuries. A possible limitation in the latter study was the small number of runners in the groups that could have affected this study's finding. A possible limitation to the current study could be the small amount of injured runners (n=16) and the non-injured runners (n=34) which could lead to a low statistical power or significance within the regression model. Thus further research is needed for stronger evidence on the association between previous injury and risk of injury in runners.

5.8 PREVENTION STRATEGIES

The results from the questionnaire regarding information on training methods, inclusion of stretching and strengthening exercises, running shoe purchase and medical treatment sought when injured assisted with determining the prevention strategies implemented by the participants.

Training methods

It was found that the majority (78%) of participants trained approximately 3 days per week; 44% of participants ran 5-7 hours per week; the majority (54%) of participants ran 5-7 min/km and 34% of participants ran 0-32 km/ week. The participants had indicated that 46% rested every second day during the training week. Furthermore, it was found that 84% of the participants reported that they train on hard surfaces. It seems as if some of the participants have an idea of how often to train, how far and how long to run and when to rest. Literature highlights that an appropriate training programme should gradually increase the running mileage, frequency of training and should include appropriate resting periods (Johnston et al., 2003). However, some inconsistencies are found within the percentages reported by the participants, thus caution needs to be taken when considering these figures as recall bias could be the reason for the inconsistencies.

Stretching and strengthening exercises

It was found that 38.8% of runners engage in some sort of strengthening exercises, 14% does strengthening twice a week and the remaining runners exercise either once or 3 times per week. The runners indicated that 78% included stretching as part of their training programme, whereby 34% stretched before and after training. Furthermore, the majority (60%) of the runners reported holding a stretch for 10-20 seconds whereas only 26.7% held a stretch for 30-60 seconds. Once again some

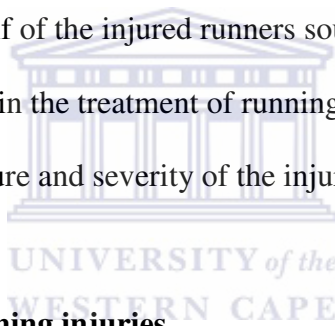
inconsistencies were found with the percentages of stretching which could be due to recall bias from the participants. It seems as if some of the runners had some idea when to do strengthening exercises, however there is no consistency in the exercise programme and it is not performed by all of the runners. Some of the runners also indicated when they had stretched and how long it was held for. This information gives an idea that only a portion of runners know about including strengthening and stretching exercises in their training programme. However, there is no standard exercise program that the runners are following and this raises a concern as some runners could be implementing the exercise program and others would not, which in turn could leave some runners more prone to injury.

Running shoes

The runners reported that 45% buys one pair of shoes per year, 40% reported that they buy at least two pairs of shoes per year and 15% reported that they sometimes buy three to four pairs of shoes per year. They also reported that 56% have normal arch type of foot; whereas 36% has flat feet and 6% reported having high arched feet. This information is rather necessary to understand how often the runner exchanges their running shoes. There are some that changes their shoes up to three or four times but there are also some that only changed their shoes after one to two years. Literature highlights that running shoes needs to be changed regularly as shoes that exceed 700km mark could lose the ability to absorb shock optimally which could in turn result in injury (Fredericson, 1996). Literature also states that wearing incorrect shoes that have insufficient height, rigid soles, twists easily or that are worn out can easily result in running injuries during training or competing in a race (Kvist, 1994).

History of previous injury

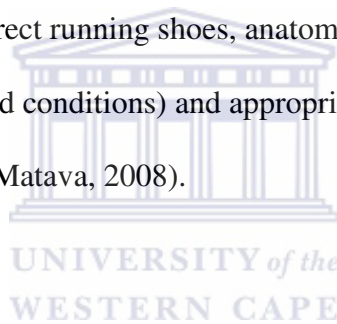
The participants reported that 92% had previous running injuries before the commencement of this study. However, only some of these injured runners sought medical treatment for their injuries (doctor- 10%, physiotherapist- 34%, orthopaedic surgeon- 10% and biokineticist- 2%). The majority (60%) of the injured participants reported that ice, heat and massage were an effective treatment for their injuries, whereas 34% found resting to be effective. The remaining participants (22% and 16%) found reducing running distance and stretching and strengthening exercises to help treat their injuries respectively. Only a small percentage (12%) found that changing their shoes and 6% found that changing surfaces helped to treat their injuries. It is quite alarming to find that such a high percentage of injuries were reported but only half of the injured runners sought medical attention. This could either be due to a lack of knowledge in the treatment of running injuries, a lack of resources such as money, transport and time or the nature and severity of the injuries.



Factors associated to previous running injuries

The possible factors associated to previous running injuries were reported by the participants whereby 36% found that excessive running distance was a risk factor. Furthermore, 32% found that training in incorrect shoes was a factor; 24% found that too many races were a factor; 12% found that a sudden change in training was a factor and only 10% found that a change in training surface was a factor associated to their injuries. This information highlights the possible factors that probably could be associated to the injuries sustained by the participants. However, many of these reported factors cannot be single predictors for injury but rather in conjunction with each other. According to literature, it is difficult to identify the exact cause of running injuries as the aetiology of these injuries are multifactorial and diverse (Van Mechelen, 1995).

The information extracted from the participants highlights clearly the need for an appropriate training and prevention programme. There is evidence of some type of prevention strategies implemented by the participants; however, it is only implemented by some of the runners. In order for all the runners to reduce the likelihood of sustaining an injury, or to manage an existing injury appropriately and to be able to return the runner to their desired level of fitness and original performance, an evidence based training and preventative programme is needed. Thus a holistic approach is necessary to effectively rehabilitate an injured runner. Such a programme needs to include patient education on rest, modification of training to allow optimal healing; once strength and endurance has regained the runner can return to running by gradually increasing running mileage weekly (10% of volume per week). Factors such as training errors, incorrect running shoes, anatomic abnormalities, fluid intake (increase fluid intake during warmer and humid conditions) and appropriate clothing should also be considered to optimally rehabilitate the runner (Matava, 2008).



5.9 SUMMARY

In this chapter, the findings of the study were discussed. This chapter highlighted the prevalence, incidence of injury, the common location of injury, the recurrence of injury, the various extrinsic and intrinsic factors that were associated with the risk of running injuries and the prevention strategies implemented by the participants. There was no statistical significance found between the identified factors and the association with running injuries (running distance, stretching, respondent's age, Q-angle, leg-length discrepancy, BMI, running experience and previous running injuries). However, there was a marginal significance found between running distance ($p = 0.08$) and leg-length discrepancy ($p = 0.06$) which could possibly show a trend toward injury. The low level of statistical significance as well as the limitations of each variable identified was highlighted and discussed in the

light of other studies. The next chapter summarizes and concludes the findings of the study. The limitations of the study and the recommendations for future research and for all stakeholders involved in the study are also outlined in the following chapter.



CHAPTER SIX

SUMMARY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This final chapter of the thesis summarizes the findings and concludes the research study. The limitations of the study as well as the recommendations to the relevant stakeholders are outlined in this chapter.

6.2 SUMMARY

A vast amount of literature highlighted that physical inactivity was found to be a contributing factor to cardiovascular and chronic diseases of lifestyle which in turn leads to premature death. Thus the importance for physical activity is emphasised and strongly recommended by WHO as regular physical activity contributes to the primary and secondary prevention of common chronic diseases of lifestyle (diabetes mellitus, obesity, hypertension, bone and joint disease and cancer) thereby reducing the risk of premature death. This global health awareness has led thousands of people across the world to engage in daily physical activity such as running as it is a convenient and an affordable sport. Apart from the health benefits that regular running provides, it can also contribute to a number of running related injuries. It is evident that with the increase in popularity in running in the past 30 years, an increase in the incidence of running related injuries has been reported. Thus, preventative strategies are needed to reduce this high rate of incidence of injury amongst runners to allow the runner to train and compete at the highest performance without injury. However, baseline data such as prevalence, incidence rate of injuries and severity of injury in conjunction with the identified aetiological factors

involved in running injuries are needed before any prevention programmes can be implemented (Van Mechelen ,1997a).

The aim of this study was to determine the incidence of injuries among road runners at a local athletic club and to identify the various predisposing factors associated with injuries. The objectives of the study were: to determine the prevalence rate and incidence rate of injury; to establish the location of new and recurrent injuries in runners; to identify various extrinsic and intrinsic factors that were associated to an increased risk in injury; and to determine the prevention strategies implemented by the participants. A prospective cohort study design over a period of 16 weeks using quantitative research methods were used. The study population was the entire adult group (n=91) of athletes of the local athletic club, with 50 runners consenting to participate in the study. The local athletic club is in Mitchells Plain, a residential area in Cape Town and was established in 2006. Measurements were taken at the Biokinetics clinic at the University of the Western Cape. These included ROM, Q- angle, leg-length, muscle strength of the lower limb, height and weight and completion of a self-administered questionnaire. The questionnaire recorded personal data, history of training, running experience and previous injury of all participants. Furthermore, an Injury Report Form was given to the participants to record information regarding injuries that occurred during the 16 week time period of the research study.

The data was analyzed using The Statistical Package for Social Science (SPSS) version 18.0.and software SAS v9 (SAS Institute Inc., Cary, NC, USA). Both descriptive and inferential statistics were employed and was expressed as frequencies, percentages, means and standard deviations by using tables, graphs and pie charts. Injury prevalence and cumulative incidence was calculated as a

proportion rate along with 95% confidence interval. The Poisson regression model was used to analyse the association between running injury and the independent variables of interest such as demographics, anthropometric measurements, running environment and running experience and previous injury.

The study found that the majority of the sample was males (68%) and remaining 32% was females. The mean age of the study sample was 46.02 years and mean BMI was 27.59 kg/h². The majority of the participants (92%) sustained running injuries prior to the study. A total of 16 participants (male-8 and female-8) sustained a number of 50 new injuries over the 16 week study period. Thus the prevalence rate of injuries was 32%. The incidence rate of injuries for this study was 0.67 per 1000km run (CI: 0.41-1.08).

It was found that the most common location of new injuries reported were the calf (20%), the second most common locations were the knee (18%) and lower back (18%) respectively. The most common types of running injuries found in the current study was muscle strain (44%) followed by joint sprain (34%). The severity of injury was reported and found that a large percentage of new injuries were reported as being mild (36%) and moderate (36%). Thus, the majority of injuries reported by the runners resulted in missing 1-2 weeks of training. The implications of this time lost in training to the injured runners could mean that the runner now has to train more frequently and even harder to return to their original fitness level before the injury. It could even lead the runner to return to running before the injury has completely healed. This will obviously place more strain on the previously injured structures, possibly causing re-injury.

The associations between the identified extrinsic and intrinsic factors (running distance, stretching, age, Q-angle, BMI, running experience, leg-length discrepancy and previous running injuries) and the risk of running injuries were also highlighted. The results showed that none of the identified factors were directly associated with running injuries. However, a marginal significance was found for running distance ($p = 0.08$) and leg-length discrepancy ($p = 0.06$). Furthermore, the results show that no single identified predictor factor could alone be associated with running injuries thus the low level of significance. Perhaps if multiple factors were analysed to determine the association with running injuries, maybe then a positive association would exist.

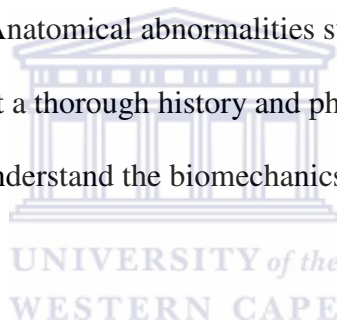
6.3 CONCLUSION

Running has become a preferred choice of sport by thousands of people across the world to improve the overall health and wellbeing of individuals. This increased popularity in running across the world has inevitably resulted in an increase in the incidence of running injuries, thus placing an emphasis on the development and implementation of rehabilitation and preventative programmes. This study found a prevalence rate of 32% and an incidence rate of injury of 0.67 per 1000km run (95% CI: 0.41, 1.08). This prevalence and incidence rate is consistent to other studies however, generalization cannot be made to the rest of the country as the results are only a reflection for this local athletic club.

The study found that the calf was the most common location of injury and muscle strain was the most common type of injury. A preventative programme can thus be developed to target these problematic areas. Furthermore, the study attempted to identify the aetiological factors involved in the running injuries and the results showed that running distance and leg-length discrepancy showed marginal significance to the association with running injuries. The fact that no strong associations were found

between the identified factors and the reported injuries still leaves the problem statement posed at the beginning of the study unanswered. Finally, the study highlighted the need for rehabilitation and preventative strategies through identifying the current practices of prevention implemented by the runners which will help further reduce the likelihood of sustaining running injuries in this local population.

In conclusion, the need for prevention of running injuries is evident in this local running population. The prevention programme must be based on other findings of the study such as including appropriate stretching and strengthening exercises, appropriate training methods such as running distance per week and adequate resting periods. Anatomical abnormalities such as leg-length and Q-angle should also be addressed. It is important that a thorough history and physical examination be done for runners to lead to an accurate diagnoses to understand the biomechanics of the injury and ultimately to manage injuries appropriately.



Thus, this study has acquired the necessary information required to firstly develop and implement an appropriate prevention programme. If such a prevention programme is implemented, the next step would possibly be to evaluate the intervention programme to compare the incidence and severity of injury before and after intervention to be able to evaluate the effectiveness of the programme.

6.4 LIMITATIONS OF THE STUDY

The main findings of study mentioned should be taken with consideration in the light of the following limitations:

- The sample used in the study was very small which could have led to the misinterpretation of the results.
- The response rate was affected by the non availability of the participants due to their work schedules.
- The study period was short in comparison to other prospective studies.
- The data was collected by using a self-administered questionnaire and was thus dependent on self reporting. This method of acquiring information leads to recall bias and probably misinterpretation of the questions. This type of data collection is readily used within literature; however certain parameters can be put in place to help prevent recall bias.
- The definition of a running injury used in this study was different to other studies. Thus, the definition for a running injury in this study was any reported muscle, joint or bone problem or injury of the back or lower extremity (ie. hip, thigh, knee, shin, calf, ankle, foot) resulting from running in a practice or meet and requiring the runner to be removed from the practice or meet or to miss a subsequent one (Rauh et al, 2005).
- The study sample was not categorised into short, middle and long distance runners.
- The athletic exposure for this study was expressed as 1000km of running whereas other studies expressed it as 1000 hours of running.
- The data analysis only included associations of the single predictor factors to running injuries which could have led to the low statistical significance. However, literature shows positive associations between multiple factors and the risk of running injuries.

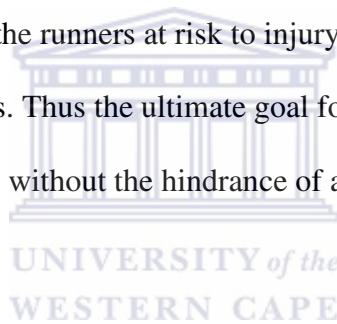
6.5 RECOMMENDATIONS

The following recommendations are suggested based on the findings of the study.

- The use of a larger sample of runners. This would probably have a better impact on the outcome of the study.
- A comparison study between novice runners and professional runners from different athletic clubs could be conducted to determine the incidence of injuries and factors associated to injury.
- Further research is recommended to fill the gap of identifying risk factors associated to running injuries as this study did not find any significant associations between the factors identified and injury.
- It is recommended that all runners should keep a running log book to document daily training such as running distance, training intensity, frequency, pace, surface and terrain for each run performed during training or competition. This will assist the runner to monitor progress in running and to check which factors could have influenced the onset of injury should an injury occur.
- It is useful to categorize all runners according to beginner, intermediate and advanced categories to allow for appropriate training and preventative programmes to be developed and implemented.
- To overcome the barrier related to lack of knowledge amongst the runners about running injuries, workshops or talks could be offered to coaches and runners about the aetiology of running injuries and the management thereof.
- Overall, it is recommended that running clubs should encourage runners to include physiotherapists in their training and rehabilitation programmes. The physiotherapist should

conduct a thorough assessment, including the biomechanics of running and the anatomical malalignments to be able to manage the runner effectively.

- In order to overcome the lack of knowledge in the management and prevention of running injuries amongst runners, it is recommended that all relevant stakeholders (coaches, runners and running associations) should encourage collaboration with nearby sport and recreation centres to arrange to exercise training sessions by the physiotherapist should no running club be made available.
- Furthermore, it is recommended that all major athletic clubs start to develop a screening process that will identify any athlete who is at higher risk of developing a running injury. This screening process will assist the runners at risk to injury to immediately be proactive in the prevention of running injuries. Thus the ultimate goal for a runner is to compete at the best fitness level and performance without the hindrance of an injury.



GUIDELINES FOR RUNNERS AND COACHES

INJURY PREVENTION: RECOMMENDATIONS TO THE RUNNERS

The overall goal of rehabilitation for any injured runner is to be able to return the runner to their desired level of fitness and performance (Matava, 2008). It is thus necessary to develop a rehabilitation programme that will address all factors associated using a holistic approach to effectively rehabilitate an injured runner. A vast amount of literature to date exists on the prevention of running injuries as well as the evaluation of such a programme. Literature highlights that a rehabilitation programme needs to include patient education on rest, modification of training surfaces, inclusion of strengthening and endurance exercises and thereafter the runner can return to running by gradually increasing running mileage weekly (10% of volume per week). Factors such as training errors, incorrect running shoes and anatomical abnormalities should also be addressed to optimally rehabilitate the runner. Apart from these factors, fluid intake (increase fluid intake during warmer and humid conditions) and appropriate clothing should also be considered in the rehabilitation programme (Matava, 2008).

Furthermore, runners that follow an incorrect training programme, which includes improper surfaces, too much running distance, frequency and duration per week, are more prone in sustaining injury to the lower limb than those who follow an appropriate training programme (Logan, 2006).

The following recommendations serves as a guideline to what an “appropriate” running programme should be. The recommendations provided are extracted from evidence-based literature to ascertain the level of evidence of the opinions and suggestions given. However, the programme needs to be based on the individual runner’s assessment of previous experiences. It is important for runners to keep a log book documenting injury, training methods and to identify possible risk factors to assist with the development of a prevention plan.

The following guidelines should be taken into consideration when starting a training programme or to modify an existing training programme to help prevent running injuries.

The Runner should do the following:

- Adequate footwear: When selecting a running shoe, the runner should select a shoe that fits comfortably by accommodating the shape of the foot. The running shoe should provide good shock absorption, stability and cushioning. Consider replacing running shoes should it exceed a running distance of 700km as shock absorption tends to get lost.
- Appropriate running surface: An ideal running surface is flat, smooth, resilient and reasonably soft like sand and grass. Try to avoid running predominantly on rough, hard and concrete surfaces. If starting to run, try not to include hill training as it places an increase stress on the joints of the back, hip, knee and ankle.
- Gradual running distance: Try to build up your running distance gradually by increasing your distance by 10% per week.

- Anatomical abnormalities: If a leg length discrepancy is suspected, assessment should be done and appropriate treatment should be given eg. Heel lifts. If an increased Q-angle is suspected, the runner should incorporate strengthening exercises of the hip and knee.
- Training errors: Runners should try to train three times per week for duration of 15 to 30 minutes per session, cover a distance of less than 60 kilometres per week and rest each alternative day.
- Incorporate cross training: Try to include other modes of sport on resting days, such as cycling, swimming or gyming to reduce impact on body while running.
- Strengthening and Stretching exercises: Try to incorporate a stretching and a strengthening programme whereby stretching should be done after warming up, holding each stretch for 30-40 seconds long and including strength training of muscles of the core, back, hip and knee.
- Finally, should an injury occur during running, the runner should discontinue from activity and have an assessment and management done immediately by physiotherapist. Should you not manage the injury immediately, the risk for re-injury is increased.

In overall, an appropriate programme should be tailored to a runner's biomechanical and anatomical abnormalities whereby the runner should warm up, stretch for 30-40 seconds, train three times per week, run at a comfortable pace during which the runner can speak without becoming breathless and increase training volume by 10% per week.

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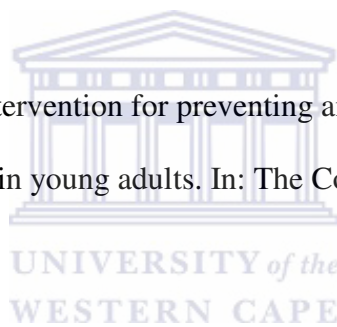
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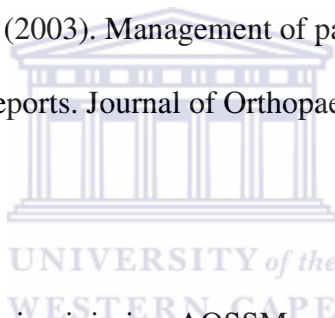
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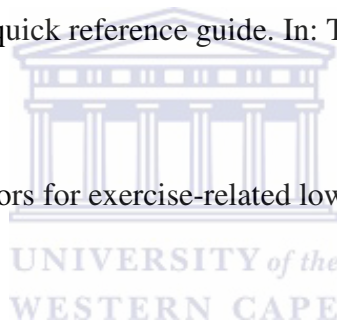
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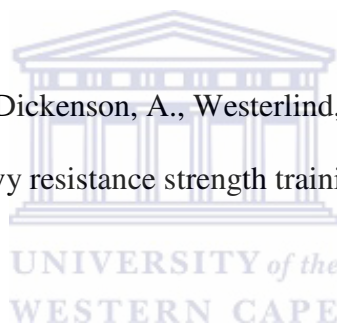
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APPENDICES



APPENDIX A

INFORMATION SHEET

Project Title: Factors associated with injuries in road-runners at a local athletic club

What is this study about?

This is a research project being conducted by **Candice Hendricks** at the University of the Western Cape. We are inviting you to participate in this research project because you are a suitable candidate as you partake in running as a sport and are a registered member of an athletic club. The purpose of this research project is to identify the various factors that are associated with injuries in road-runners and to determine the incidence of injuries.

What will I be asked to do if I agree to participate?

You will be asked to complete a self-administered questionnaire regarding personal data, medical history, history of running injuries, running experience and running environment. Completion of this questionnaire will take approximately 20 minutes, and will be conducted at the Biokinetics Gym at University of the Western Cape. Each participant will be measured by a research assistant to test range of motion (degree of movement in the joint) of the hip and knee, Q-angle (the position of the knee-cap on the knee) and leg length (length of both legs from the hip to the ankle). The duration of this procedure will take approximately 20 minutes. A summary of the questions in the questionnaire consists of medical history (Do you suffer from any chronic diseases?), history of running injuries (What type of injuries did you sustain during running?), running experience (How long have you been running?), running environment (What type of surface do you practice and run on?)

Would my participation in this study be kept confidential?

We will do our best to keep your personal information confidential. To help protect your confidentiality, our questionnaire will not require you to disclose your identity as the participant will remain anonymous that may personally identify you. Testing results will also be kept confidential as the researcher will be the only person to view the results.

If we write a report or article about this research project, your identity will be protected to the maximum extent possible.

What are the risks of this research?

There are no known risks associated with participating in this research project.

What are the benefits of this research?

The benefits are the acquiring of knowledge of various factors resulting in injuries in runners and this information will assist in designing a preventative programme to prevent future complications. This information will assist you, the runner, to be independent in the management of future injuries.

We hope that, in the future, other people might benefit from this study through improved understanding of various factors resulting in running injuries.

Do I have to be in this research and may I stop participating at any time?

Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. If any participant sustains an injury during the study period a referral to a health professional for further management will occur. An early termination of the participant participation in the study will take effect if any participant sustains an injury.

Is any assistance available if I am negatively affected by participating in this study?

If any participant sustains an injury during the study period a referral to a health professional for further management will occur.

What if I have questions?

This research is being conducted by **Candice Hendricks** a *masters physiotherapy student* at the University of the Western Cape. If you have any questions about the research study itself, please contact

Candice Hendricks

46 Auber Avenue

Mandalay 7785

Cape Town

Cell phone: 084 751 6692

E-mail: hendricks.candice@gmail.com

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Head of Department: Prof .J. Phillips

Dean of the Faculty of Community and Health Sciences: Prof. R. Mpufu

University of the Western Cape

Private Bag X17

Bellville 7535

This research has been approved by the University of the Western Cape's Senate Research Committee and Ethics Committee.

APPENDIX B
CONSENT FORM

Title of Research Project:

Factors associated with injuries in road-runners at a local athletic club

The study has been described to me in language that I understand and I freely and voluntarily agree to participate. My questions about the study have been answered. I understand that my identity will not be disclosed and that I may withdraw from the study without giving a reason at any time and this will not negatively affect me in any way.

Participant's name.....

Participant's signature.....

Date.....



Should you have any questions regarding this study or wish to report any problems you have experienced related to the study, please contact the study coordinator:

Study Coordinator's Name: Candice Hendricks

46 Auber Avenue Mandalay

Cape Town 7785

Telephone: (021)959-9343

Cell: 084-751-6692

Email: hendricks.candice@gmail.com

APPENDIX C

FACULTY OF COMMUNITY AND HEALTH SCIENCES

Private Bag X17, Belville, 7535
South Africa
Tel: +27 (0) 21 959 2163
Fax: +27 (0) 21 959 2755
E-mail: csjohnson@uwc.ac.za

HIGHER DEGREES COMMITTEE

13 November 2009

TO WHOM IT MAY CONCERN

Dear Sir/Madam

Research Project of Candice Hendricks (Student Number: 2217461)

This letter confirms that Ms. Hendricks is a registered student in the Faculty of Community and Health Sciences at the University of the Western Cape.

Her research proposal entitled ***"Factors associated with injuries in road-runners at a local athletic club"*** submitted in fulfilment of the requirements for Masters in Physiotherapy has been examined by the Higher Degrees Committee and found to be of high scientific value, methodologically sound and ethical.

We fully support the research and kindly request that you allow her access to your organization.

Sincerely



DR GAVIN REAGON
Chairperson: Higher Degrees Committee

UNIVERSITY of the
WESTERN CAPE



UNIVERSITY of the
WESTERN CAPE

A place of quality, a place to grow, from hope to action through knowledge

APPENDIX D

Mitchell's Plain Titans Athletic Club

Dear Chairman:

RE: Requesting permission to conduct a research study.

I, Candice Hendricks, am a physiotherapist pursuing a Postgraduate Degree (Masters) in Physiotherapy at the University of the Western Cape. The requirement of the postgraduate degree is to conduct and implement a research study in a field of special interest. Thus, my study involves running injuries. The title of my study is “**Factors associated with injuries in road-runners at a local athletic club**”

The purpose of this study is to identify the various predisposing factors that are associated with injuries in road-runners at an athletic club and to determine the incidence thereof. The study will be of great significance to the athletic club. It will provide information to the runners, coaches and their medical team with adequate knowledge and guidelines to prevent running injuries and allowing the runner to be independent in the management of injuries.

I kindly request your permission to conduct my research study at the Mitchell's Plain Titans Athletic Club during the months of February to August 2010. The information gathered from the participants will be kept strictly confidential and their identity will be anonymous.

Yours truly,

Candice Hendricks

hendricks.candice@gmail.com

APPENDIX E

Mitchell's Plain Titans Athletic Club

Dear Participant:

RE: Requesting participation in a research study:

My name is Candice Hendricks, a physiotherapist currently pursuing a Degree (Masters) in Physiotherapy at the University of the Western Cape. The requirement of the postgraduate degree is to conduct and implement a research study in a field of special interest. Thus, my special interest involves running injuries. The title of my study is **“Factors associated with injuries in road-runners at a local athletic club”**

The purpose of this study is to identify the various predisposing factors that are associated with injuries in road-runners at an athletic club and to determine the incidence of injuries. The study will be of great significance to the athletic club. It will provide information to the runners, coaches and their medical team with adequate knowledge and guidelines to prevent running injuries and allowing the runner to be independent in the management of injuries.

I kindly request your participation in my study as you are a suitable candidate as you partake in running as a sport. It is required of you to complete a questionnaire, to be measured for certain tests and to record your weekly training schedule on a training log. The study period will be during the months of February to August 2010. The information provided will be kept strictly confidential and your identity will remain anonymous. Your participation in this research is completely voluntary and you may stop participating at any time or stage of the study.

Thank you for your participation

Yours truly,

Candice Hendricks

hendricks.candice@gmail.com

APPENDIX F

**Biokinetics Department
University of the Western Cape**

To whom it may concern:

RE: Permission to use the Biokinetics Clinic

I, Candice Hendricks, am currently doing my Masters Degree (Full Thesis) in Physiotherapy and a contract worker at the Physiotherapy Department of UWC as the Clinical Co-ordinator.

My research study involves running injuries and the title of my study is “**Factors associated with injuries in road-runners at a local athletic club**”

The *purpose* of this study is to identify the various predisposing factors that are associated with injuries in road-runners at an athletic club and to determine the incidence thereof.

The *objectives* of this study are:

- To establish the prevalence of injuries among athletes at a local athletic club.
- To establish the location and re-currence of injuries among these athletes.
- To determine the cumulative incidence of running injuries among these athletes over a period of 16 weeks.
- To identify possible factors associated with lower limb injuries among the athletes.
- To investigate possible prevention strategies.

Recently I have been made aware that the Biokinetics Department has a clinic available with all different machinery for testing and measurements. The data needed for this study is a questionnaire, and injury report form and anthropometrics which includes the measuring of Q-angle, leg-length, ROM of hip and knee, Muscle strength of the lower limb, height and weight and BMI.

For this reason I kindly request to make use of the Biokinetics Gym to measure all the above anthropometric components as it is part of the data collection of my study.

Kind Regards

Candice Hendricks
BSc. Physiotherapy

APPENDIX G

INJURY REPORT FORM

[illegible]

KEYS

T days missed= Training days missed due to injury

C days missed= Competition days missed due to injury

APPENDIX H

Questionnaire

INSTRUCTIONS:

- All information provided in the questionnaire will be kept confidential.
- Please be truthful and honest in completing the questionnaire.
- Please select one or more responses by using a tick (✓).

Demographic data:

1. Age.....
2. Gender.....
3. Weight.....
4. Height.....
5. BMI.....



6. Leg length: Left..... Right.....
7. Q-angle: Left..... Right.....
8. ROM: Hip: Flexion: Left..... Right.....
Extension: Left..... Right.....
Abduction: Left..... Right.....
Adduction: Left..... Right.....
Int. Rotation: Left..... Right.....
Ext. Rotation: Left..... Right.....
9. ROM: Knee: Flexion: Left..... Right.....
Extension: Left..... Right.....

10. Muscle Strength: ☐ Well above average ☐ Above average ☐ Average
 ☐ Below average ☐ Well below average

Current Medical history:

1. Do you suffer from any chronic diseases?

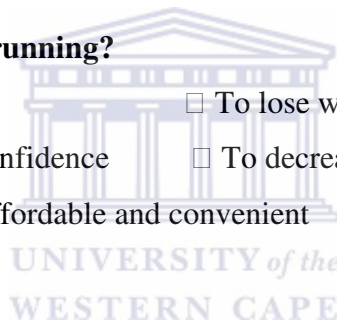
- ☐ Yes ☐ No

2. If yes, please tick off the correct chronic diseases?

- ☐ High Blood Pressure ☐ Diabetes ☐ Cholesterol ☐ Kidney Failure
☐ Osteoarthritis ☐ Other

3. What was your reason to start running?

- ☐ To get healthy ☐ To lose weight or manage weight control
☐ To improve self-esteem and confidence ☐ To decrease stress levels
☐ To start a sport as running is affordable and convenient



Running history:

1. How long have you been running as a sport?

- ☐ Less than 1 year ☐ Less than 5 years ☐ Less than 10 years ☐ More than 10 years

2. How many days per week do you run?

- ☐ Everyday ☐ Three times per week ☐ Once a week

3. What is the normal running pace during your weekly training?

- ☐ Less than 3 min per km ☐ Between 3-5 min per km
☐ Between 5-7 min per km ☐ Between 7-10 min per km

4. What is the average distance that you run weekly?

- ☐ 0-32 km ☐ 32-50km ☐ 50-80km ☐ 80-100km ☐ more than 100km

5. **Have you ever participated in a marathon?**

- ☐ Yes ☐ No

If yes, please answer questions from 6 to 10 if applicable.

6. **In how many 21.1 km marathons did you participate annually?**

.....

7. **What is your average 21.1 km time?**

.....

8. **In how many 42.2 km marathons did you participate annually?**

.....

9. **What is your average 42.2 km time?**

.....

10. **What is your running pace during a race or marathon?**

.....

11. **What is your average running time during training per week?**

- ☐ 3-5 hours per week ☐ 5-7 hours per week
☐ 7-10 hours per week ☐ more than 10 hours per week

12. **How often do you rest during your training per week?**

- ☐ Every second day ☐ Every third day ☐ Once a week

13. **What type of training do you do?**

- ☐ Alternate long and short distances on different days
☐ Almost the same distance every day ☐ Alternate days of high and low effort
☐ Lots of hills ☐ Interval training (multiple runs of short duration with little rest between bursts)
☐ Other

14. **Do you regularly engage in a stretching programme especially during training?**

- ☐ Only before training ☐ Before and after training ☐ Only after training
☐ Only when I have pain ☐ Never

15. If you stretch, how long do you hold each stretch?

- ☐ Less than 10 secs ☐ Less than 20 secs ☐ Less than 30 secs
☐ At least a minute ☐ Do not stretch

16. Do you engage in a regular strengthening programme?

- ☐ Yes ☐ No

17. If yes, how often do you engage in the strengthening programme?

- ☐ Once a week ☐ Twice a week ☐ Three times a week ☐ Everyday

Running environment:

1. What type of terrain do you practice and run on?

- ☐ Flat surfaces ☐ Uneven slopes and surfaces ☐ Mostly hills

2. What type of surface do you practice and run on?

- ☐ Grass ☐ Soft surfaces e.g. sea sand
☐ Hard surfaces e.g. gravel road, tar, asphalt ☐ Artificial track

3. How long do you run in a pair of shoes?

- ☐ 3-6 months ☐ 6-12 months ☐ 12- 18 months ☐ 18-24 months ☐ Older than 2 years

4. How many pairs of shoes do you buy per year?

- ☐ 1 pair ☐ 2 pairs ☐ 3pairs ☐ 4years

5. Do you use orthotics? (Shoe inserts used to correct foot alignment)

- ☐ Yes ☐ No

6. If yes, who prescribed the orthotics to you?

- ☐ Orthopaedic surgeon ☐ Physiotherapist ☐ Biokineticist
☐ Podiatrist/ foot specialist ☐ Other

7. How long are you wearing the orthotics?

- ☐ 0-6 months ☐ 6-12 months ☐ 12- 18 months
☐ 18-24 months ☐ longer than 2 years

8. What type of feet do you have?

- ☐ Flat feet ☐ Normal arches ☐ High arches

9. What part of your running shoe strikes the running surface first?

- ☐ The whole foot ☐ The heel ☐ The toes and ball of foot ☐ Other

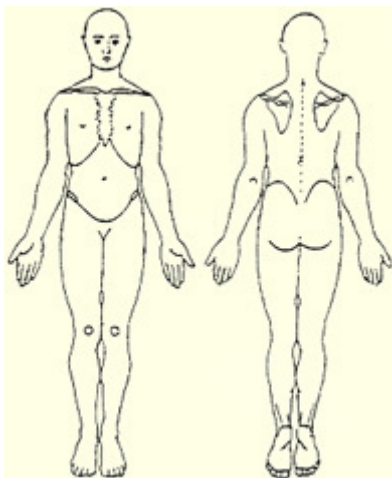
History of running injuries:

1. Have you ever experienced pain during your running career?

- ☐ Yes ☐ No

2. If yes, in which areas of the body did you experience pain? Please tick appropriate box and indicate on the body chart below.

- ☐ Back ☐ Buttock ☐ Hip ☐ Groin ☐ Front thigh ☐ Back thigh
☐ ITB ☐ Knee ☐ Shin bone ☐ Calf ☐ Achilles tendon ☐ Ankle ☐ Foot



3. Have you ever sustained an injury during running?

- ☐ Yes ☐ No

If you have sustained an injury during running please answer questions from 4 to 12.

4. What type of injuries did you sustain during running?

- ☐ Muscle strain ☐ Ligament sprain
☐ Muscle, ligament or meniscus tear ☐ Stress fracture ☐ Fracture

5. How long does it take to recover from the running injuries?

- ☐ Few days ☐ 1-3 weeks ☐ 4-8weeks ☐ more than 8weeks

6. Does the running injury re-occur later in the training?

- ☐ Yes ☐ No

7. Did you seek medical assistance for your running injuries?

- ☐ Yes ☐ No

8.1 Who did you seek medical assistance from?

- ☐ Doctor ☐ Physiotherapist ☐ Biokineticist
☐ Podiatrist/ foot specialist ☐ Orthopaedic surgeon ☐ Chiropractor

8.2 Did you have any operations due to running injuries?

- ☐ Yes ☐ No

8.3 If yes, specify what body structure was operated?

.....

8.4 Do you have any metal implants inserted due to operations?

- ☐ Yes ☐ No

9. What treatment works best for your symptoms?

- ☐ Medication ☐ Ice, heat, electrotherapy, massage ☐ Stretching/Strengthening
exercises ☐ Orthotics ☐ Change in training routine ☐ Reducing running distance
☐ Change in running surfaces ☐ Change in running shoes ☐ Rest ☐ Other

10. Which of the following do you feel can be associated with any of your running injuries?

- | | |
|--|--|
| <input type="checkbox"/> Excessive running distances | <input type="checkbox"/> Sudden change in training routine |
| <input type="checkbox"/> A change in running surface | <input type="checkbox"/> Training on hills |
| <input type="checkbox"/> Race training/ too many races | <input type="checkbox"/> Interval training/ speed work |
| <input type="checkbox"/> Wrong shoes, New shoes, Wornout shoes | <input type="checkbox"/> A biomechanical abnormality such as bow legs, knock knees etc |
| | <input type="checkbox"/> No cause that I could determine |

11. Which type of pain do you experience when having the running injury?

- | | |
|--|---|
| <input type="checkbox"/> Dull pain | <input type="checkbox"/> Sharp, intense pain |
| <input type="checkbox"/> Continuous pain | <input type="checkbox"/> Throbbing pain |
| | <input type="checkbox"/> Burning pain, numbness or pins and needles |

12. Which of the following symptoms do you experience?

- ☐ Pain during workout but after warming up it subsides
- ☐ Pain before and after the training session
- ☐ Pain while sleeping and brings discomfort
- ☐ The pain is so bad that I cannot run at all or have to stop running
- ☐ Pain after running downhill

