POTENTIAL RUNNING RELATED INJURY CONTRIBUTORS IN SOUTH AFRICAN LONG-DISTANCE RUNNERS

BY

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DECLARATION

The following thesis has not been submitted to any university other than Rhodes University, Grahamstown, South Africa. The work presented here is that of the author unless otherwise stated.

ABSTRACT

Running related injuries (RRIs) are a common problem among long-distance runners, with injury rates ranging from 19.4% to 79.3%. Many studies have been done, investigating possible contributors to RRIs however, very few studies have investigated RRIs in South African long-distance runners, a population which may differ from previously studied populations. The current study aimed to build a descriptive profile of South African long-distance runners, as well as to determine associated factors that may contribute to RRIs. In order to do this, a cross-sectional, retrospective study design was employed using a questionnaire which was mostly electronically distributed. The sample consisted of 378 long-distance runners from each province in South Africa (SA). Using the Chi-square analysis and Fisher exact tests, significant associations were established ($p<0.05$). The current study found that certain RRI variables were associated with specific aspects of the participants' personal characteristics and demographics, training characteristics, running experience, footwear, and cross training activities. Footwear and training characteristics produced the largest number of significant RRI associations. The findings of the current study could assist future research on RRIs in South African long-distance runners, by informing researchers of potential areas where more in-depth research is needed. In the long term, researchers may be able to narrow down the main contributors to RRI, possibly decreasing RRI rates in the unique population of South African long-distance runners.

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LIST OF ABBREVIATIONS

BMI – Body Mass Index

EVA – Ethylene Vinyl Acetate

FFS – Forefoot Striking

GRF – Ground Reaction Force

HS – Heel Striking

ITBS – Iliotibial Band Syndrome

MFS – Midfoot Striking

PFPS – Patellofemoral Pain Syndrome

ROM – Range of Motion

RRI – Running-Related Injury

SA – South Africa

CHAPTER I

INTRODUCTION

1.1 Background to the study

Long-distance running has been a popular form of exercise and recreational activity for many decades (Dugan & Bhat, 2005; Lieberman, Davis, & Nigg, 2014) and continues to grow exponentially. The increase in running popularity has similarly been demonstrated in SA. For example, the world's largest and oldest ultramarathon, the Comrades marathon in SA (Guinness World Records, 2022), was established in 1921 where only 48 runners were entered into the first race. These numbers increased to 1 500 runners in 1975 and was limited to 25 000 entrants in 2019 (Comrades.com, 2019). These increases in entry numbers, demonstrate the exponential growth in the popularity of long-distance running in SA.

Despite its worldwide popularity, running is a particularly injurious activity (Buist et al., 2008) and with the increase in the number of runners, this is an area of growing concern. Reports on the injury rates among distance runners vary substantially, ranging from 19.4% to 79.3% (Daoud et al., 2012; van Gent et al., 2007); regardless, the upper limit is alarmingly high. In attempt to reduce the prevalence of these injuries, an understanding of the potential risk factors related to running injuries is imperative. Unfortunately, much contention exists regarding the associations between potential risk factors and injury (Saragiotto et al., 2014; van Gent et al., 2007), which may be a result of varying study methods, populations and definitions, as well as focusing on one potential risk factor as opposed to several (Fredericson et al., 2000; Hesar et al., 2009; Daoud et al., 2012).

Epidemiological studies are one of the methods used to establish potential risk factors of RRIs using retrospective data, as done in studies by Fordham (2004), Fredericson and Misra (2007), Hespanhol Junior, Costa, Carvalho, & Lopes (2012) and Reinking, Austin, & Hayes (2013). Performing an epidemiological study could assist in informing future studies by determining where associations lie between specific variables and Running-related injuries (RRIs). At the time of this study, there were only two epidemiological studies done on long-distance runners in a South African context

(Puckree, Govender, Govender, & Naidoo, 2007; Ellapen, Satyendra, Morris, & Van Heerden, 2013). Ellapen et al. (2013) focused solely on half-marathon runners in KwaZulu-Natal, while the study by Puckree et al. (2007) was done on only Indian runners in Durban, KwaZulu-Natal, and primarily looked at the effect of the quadriceps angle on injury. Therefore, there is an ample amount of potential for future research on South African long-distance runners.

The last two decades of research into RRIs, has been the elucidation of the extrinsic and intrinsic factors contributing to these injuries. It is possible that runners are intrinsically predisposed to being susceptible to specific injuries (Novacheck, 1998; Mokone et al., 2005) however external stimuli may exacerbate that susceptibility (Taunton et al., 2002; Lieberman et al., 2010; Saragiotto et al., 2014). Intrinsic factors such as the personal characteristics and demographics of the runner (Taunton et al., 2002; van Gent et al., 2007; Puckree et al., 2007; Buist et al., 2008), need to be investigated to determine their influence on running related injury risks. Additionally, extrinsic factors such as training characteristics (Jin, 2014; Saragiotto et al., 2014), running experience (Taunton et al., 2002; Fredericson & Misra, 2007; Jin, 2014), footwear (Lieberman et al., 2010), and cross training (van Gent et al., 2007; Malisoux, Frisch, Urhausen, Seil, & Theisen, 2013) may be associated with RRI risk and occurrence, and therefore should be included in investigations.

1.2 Potential risk factors

1.2.1 PERSONAL CHARACTERISTICS AND DEMOGRAPHICS

There is much disagreement surrounding the effect that age has on developing an RRI. Studies such as those done by Taunton et al. (2002) and Buist et al. (2008), found that younger runners were more susceptible to RRIs than older runners. However, Satterthwaite, Norton, Larmer, and Robinson (1999) and Taunton et al. (2003) found that older runners were more prone to injuries. The disagreement throughout the literature indicates a need for further research to tentatively identify the age bracket in which a runner may be at a higher risk of injury. In addition to age, the sex of a runner is likely to have an effect on the risk of developing a running related injury, according to Taunton et al. (2002), Taunton et al. (2003), Buist et al. (2008), Wentz, Liu, Hay, & Ilich (2011) and Zwingenberger et al. (2014). However, these studies disagree as to how sex influences injury risk. A large amount of the literature agrees that females are at a higher risk of running related injury (Bell, Mangione, Hemenway, Amoroso, & Jones, 2000; Chumanov, Wall-Scheffler, & Heiderscheit, 2008), however there are studies that disagree (Zwingenberger et al., 2014). Although this contention may exist in the literature, Taunton et al. (2002), Buist et al. (2008) and Wentz et al. (2011), found that certain RRIs are more prevalent in females while others occur more often in males. Body Mass Index (BMI), stature and mass, are considered part of body morphological characteristics. Similar to previous findings on age and sex, and RRI; research on the associations between certain body morphological characteristics and RRI, is also conflicting. A high BMI has been reported as an injury risk factor in some studies (Jones, Bovee, Harris III, & Cowan, 1993; Buist, et al., 2010a; Buist, Bredeweg, Lemmink, van Mechelen, & Diercks, 2010b; Nielsen et al., 2013; Malisoux, Nielsen, Urhausen, & Theisen, 2015a; van Poppel, de Koning, Verhagen, & Scholten-Peeters, 2016; Chaudhary, Bellam, & Shenoy, 2016), whereas in other studies, a low BMI was found to be more dangerous (Wen, Puffer, & Schmalzried, 1997; Taunton et al., 2002; Hall, 2007). It is clear that the literature is contentious in being able to identify the impact of individual factors on the risk of RRIs, thus further research is necessary.

In terms of ethnic origin, it is likely that performance and sports related injury risks are strongly related to genetic factors, which are partially determined by historical geographical origin. For example, Kenyan distance runners often dominate the long-distance races with some tribes excelling over other tribes (Tucker, Onywera, & Santos-Concejero, 2015). Kenyans and other East African runners have been found to have a higher VO_2 max than Black South African runners as a result of, not only training, but optimal genetics too (Larsen, 2003). In addition to this, East African runners have been reported to have low RRI rates, which is likely influenced by their running form (Kong & de Heer, 2008) which again, is a result of favourable genetics. From this, it can be seen that the ethnic origin of a runner (forming part of the runner's genetic predisposition) is likely to have an influence on both performance and injury risk. The prevalence of injuries has been found to differ between various ethnicities (Sulsky, Mundt, Bigelow, & Amoroso, 2000), although there is little literature investigating the potential associations. As large genetic diversity exists within the South African population, investigating the ethnicity of the runners, and whether this factor is associated with RRIs, may provide interesting and useful findings in the area of running injuries, and demonstrate how the South African population may differ from previously studied populations.

The socioeconomic background that governs the SA population, presents a highly diverse range of income brackets and living situations. Poverty is rife in SA Lehohla (2015) and Cubbin, LeClere, & Smith (2000) found that injury risk increases with a decrease in socioeconomic status. Moreover, low income accompanies a lack of affordable medical treatments (Morrow, Barnett, & Vujcich, 2014). The current study intended to determine if an association was present between the socio-economic background of South African runners, and RRIs. This is important as the different socio-economic backgrounds, as well as ethnic origins, sets the South African population apart from previous studies done on the injury risks of long-distance runners.

The factors that make up personal characteristics and demographics, are mostly non-modifiable, meaning the association is likely to be causal. Knowledge on how these factors may be associated with RRI risk, could therefore create awareness around the type of South African runner who is at risk for RRIs, allowing for behavioural changes to reduce injury risk. Age, sex, ethnic origin, body mass index (BMI) and socioeconomic status of South African long-distance runners, formed part of the personal characteristics and demographics investigated in the current study. These particular factors were of interest as they assisted in creating a descriptive snapshot of profiles of South African long-distance runners. Additionally, most of the afore-mentioned factors have been investigated in several previous studies regarding sport related injuries, however many of the findings have been contentious.

1.2.2 TRAINING CHARACTERISTICS

In most studies investigating RRIs, training characteristics refer to the weekly frequency, duration and distance of running. A few studies additionally include the terrain that the runner trains on or whether the runner is part of an organised running club.

Malisoux et al. (2015a), stated that training related characteristics are the largest determiner of RRI risk. The majority of literature is in agreement with Malisoux et al. (2015a), however the contention arises in how training characteristics and RRIs are associated. A higher weekly running volume has been found, by some, to increase the risk of RRIs (Macera et al., 1989; Fredericson & Misra, 2007). Not only could overtraining be harmful, but a sudden increase in the frequency, intensity or duration of training may cause a runner to become injured (Fredericson & Misra, 2007; Jin, 2014; Saragiotto et al., 2014). In contrast to the findings that support the injurious nature of high training volumes, several studies found high running training volumes to be protective (Satterthwaite et al., 1999; van Middelkoop, Kolkman, Van Ochten, Bierma-Zeinstra, & Koes, 2008b), and low running training volumes to be a risk factor (Taunton et al., 2003; Rasmussen, Nielsen, Juul, & Rasmussen, 2013; Reinking et al., 2013). The debate around running training volume and the association with RRIs, provides an interesting area that needs additional research, which the current study aimed to provide.

Running injury risk has additionally been found to be influenced by the terrain that the athletes train on (Fordham, 2004; Buist et al., 2008), with the hardness, uniformity and compliance of the terrain affecting the biomechanics of the runner (Tessutti, Trombini-Souza, Ribeiro, Nunes, & Sacco, 2010). The association between running terrain and RRI has however, been understudied in long-distance runners, thus creating a gap in the research and an area of interest in the current study.

The combination of several aspects of training should be considered. Since training is modifiable, the results of the current study could assist in modifying training to reduce RRI risk, although causal relationships will not be evident through a cross sectional study. It is therefore imperative that training characteristics of long-distance runners are investigated as a whole, as these habits are likely to play a role in the risk of developing an injury.

1.2.3 RUNNING EXPERIENCE

The majority of research indicates that novice runners are more susceptible to running injuries than experienced runners with strongly supported explanations for these findings (Taunton et al., 2002; Fredericson & Misra, 2007; van Poppel et al., 2016).

Nevertheless, there are studies that have found that the runners with more years of experience, appear to be more prone to RRIs (Satterthwaite et al., 1999; Knobloch, Yoon, & Vogt, 2008; Roos et al., 2015). The reasons for the contention are unknown, however it can be speculated that different mechanisms are responsible for RRIs in novice runners, compared with more experienced runners. In contrast to the abundance of research on the years of running experience, few studies have investigated the potential associations between RRIs and the calibre of the runner. The distance of the races that runners elect to run, appears to be related to the risk of RRI (Knobloch et al., 2008; van Middelkoop et al., 2008b; Rasmussen et al., 2013; van Poppel et al., 2016), although conclusions are challenging as the samples and conditions of the previous studies, differed. Lastly, whether the runner is a professional or sponsored runner, may impact RRI risk and prevalence, however the research in the area is scarce.

In the current study, the aspects that formed part of running experience were not only the number of years that the participant has been running for, but also the calibre of the runner – did the runner prefer longer distance races such as ultramarathons, or was the participant a half-marathoner? Was the participant a professional runner, or did they run recreationally? These are the questions that the current study aimed to gain answers to, in order to build a framework around the overall experience of the runner, and how this experience may have been associated with RRIs.

1.2.4 FOOTWEAR

In the last several years, some long-distance runners have become interested in minimalist footwear and running completely barefoot, in attempt to reduce the risk of sustaining an RRI or to eliminate running-induced pain (Lieberman, 2012). However, there is much disagreement regarding whether running barefoot or in minimalist shoes is indeed advantageous, compared to running in the standard running shoe. Some studies have supported the standard running shoe (Franz, Wierzbinski, & Kram, 2012; Olin & Gutierrez, 2013; Willson et al., 2013), while others have supported barefoot running (Divert, Mornieux, Baur, Mayer, & Belli, 2005; Hanson, Berg, Deka, Meendering, & Ryan, 2011; Lieberman, 2012; Hryvniak, Dicharry, & Wilder, 2014). Minimalist shoes (Cauthon et al., 2013), racing flats (Wiegerinck et al., 2009; Queen, Abbey, Wiegerinck, Yoder, & Nunley, 2010) and trail running shoes, have not been incorporated in many footwear and RRI studies, subsequently creating a gap in the literature investigating potential associations between various types of footwear and RRI risk.

1.2.5 CROSS TRAINING

In the current study, cross training refers to frequent athletic activities that the runner participates in, apart from long-distance running. In a review, van Gent et al. (2007) stated that participating in certain sports such as cycling and aerobics, in addition to running, influences RRI risk. Malisoux et al. (2013) found that runners who participated in other sports were at a lower risk of injury than runners who only ran, which could be explained by other types of activity, correcting strength imbalances in muscles that are not primarily used in running (Taunton et al., 2003). In contrast, Satterthwaite et al. (1999) stated that cross training may increase injury risk as a result of cumulative stress from additional activities. Thus, the association between various types of cross training, and RRI, was of interest in the current study.

The contrasting literature relating to several of the above-mentioned factors may arise from different populations being investigated in previous studies that have examined similar concepts. This again emphasises the need for a further investigation into the long-distance runners in SA, and any associations that may exist between the previously mentioned characteristics and RRI.

1.3 Statement of the problem

It is known that running injuries are prevalent in long-distance runners worldwide, however, currently there is limited information regarding the numbers of RRIs in South African long-distance runners, as well as the specifics of these injuries. Furthermore, the potential associations between characteristics of the runner and RRIs are unknown, within the unique population of South African long-distance runners.

1.4 Research aims

The aim of the current study was two-fold: to create a descriptive profile of South African long-distance runners; and to identify associations between the characteristics of South African long-distance runners, and RRIs.

1.5 Research objectives

The primary objective of this study was to develop a descriptive profile of South African long-distance runners. A general profile could assist in understanding the population of South African long-distance runners and assessing whether this population is similar to other running populations and whether the research relating to other running populations could be applied to the South African population.

The secondary objective of the current study was to identify associations between characteristics of South African long-distance runners and RRIs, which could contribute to developing injury risk profiles, which in turn could aid in the prevention or decrease of RRIs in South African long-distance runners and help to inform future studies.

The anticipated outcomes stemming from the objectives of the current study, were to broaden the RRI understanding and knowledge of runners, coaches, health practitioners and the general running industry, which could subsequently decrease RRI risk and prevalence. Furthermore, the findings of the current study could assist in informing fellow researchers of potential areas of further study, as the current study provides a broad overview of RRI associations.

1.6 Research questions

1.6.1 DESCRIPTIVE

What are the most common characteristics of South African long-distance runners?

What does the descriptive profile of South African long-distance runners look like?

1.6.2 INFERENTIAL

Do associations exist between personal characteristics and demographics, training characteristics, running experience, footwear, and cross training activities of South African long-distance runners, and RRIs?

If so, where do these associations lie?

1.7 Research hypotheses for inferential objectives

1.7.1 HYPOTHESIS 1:

There are significant associations ($p<0.05$) between the participant characteristics and demographics (age, sex, BMI, ethnicity, monthly income) of South African long-distance runners, and running related injuries.

Sub-hypothesis 1A:

There is a significant association ($p<0.05$) between age and RRIs in South African long-distance runners.

Sub-hypothesis 1B:

There is a significant association ($p<0.05$) between sex and RRIs in South African long-distance runners.

Sub-hypothesis 1C:

There is a significant association ($p<0.05$) between ethnicity and RRIs in South African long-distance runners.

Sub-hypothesis 1D:

There is a significant association ($p<0.05$) between stature, mass, and BMI, and RRIs in South African long-distance runners.

Sub-hypothesis 1E:

There is a significant association ($p<0.05$) between monthly income and RRIs in South African long-distance runners.

1.7.2 HYPOTHESIS 2:

There are significant associations ($p<0.05$) between training characteristics (frequency, duration, distance, terrain) of South African long-distance runners, and

RRIs.

Sub-hypothesis 2A:

There is a significant association ($p<0.05$) between running club involvement and RRIs in South African long-distance runners.

Sub-hypothesis 2B:

There is a significant association ($p<0.05$) between weekly running frequency and RRIs in South African long-distance runners.

Sub-hypothesis 2C:

There is a significant association ($p<0.05$) between weekly running duration and RRIs in South African long-distance runners.

Sub-hypothesis 2D:

There is a significant association ($p<0.05$) between weekly running distance and RRIs in South African long-distance runners.

Sub-hypothesis 2E:

There is a significant association ($p<0.05$) between running terrain and RRIs in South African long-distance runners.

Sub-hypothesis 2F:

There is a significant association ($p<0.05$) between changes to training and RRIs in South African long-distance runners.

1.7.3 HYPOTHESIS 3:

There are significant associations ($p<0.05$) between running experience (years of running, number of races, preferred race distance) of South African long-distance runners, and RRIs.

Sub-hypothesis 3A:

There is a significant association (p<0.05) between years of running experience and RRIs in South African long-distance runners.

Sub-hypothesis 3B:

There is a significant association (p<0.05) between race distances and RRIs in South African long-distance runners.

Sub-hypothesis 3C:

There is a significant association (p<0.05) between the professional status of a runner and RRIs in South African long-distance runners.

1.7.4 HYPOTHESIS 4:

There are significant associations (p<0.05) between the running footwear of South African long-distance runners and RRIs.

Sub-hypothesis 4A:

There is a significant association (p<0.05) between running footwear type and RRIs in South African long-distance runners.

Sub-hypothesis 4B:

There is a significant association (p<0.05) between the number of different running footwear types and RRIs in South African long-distance runners.

Sub-hypothesis 4C:

There is a significant association (p<0.05) between changes in running footwear type and RRIs in South African long-distance runners.

Sub-hypothesis 4D:

There is a significant association (p<0.05) between the number of running footwear pairs and RRIs in South African long-distance runners.

Sub-hypothesis 4E:

There is a significant association ($p<0.05$) between the use of orthotics and RRIs in South African long-distance runners.

1.7.5 HYPOTHESIS 5:

There are significant associations ($p<0.05$) between cross training factors of South African long-distance runners and RRIs.

Sub-hypothesis 5A:

There is a significant association ($p<0.05$) between cross training participation and RRIs in South African long-distance runners.

Sub-hypothesis 5B:

There is a significant association ($p<0.05$) between the type (weight bearing or non-weight bearing) of cross training activities and RRIs in South African long-distance runners.

Sub-hypothesis 5C:

There is a significant association ($p<0.05$) between the number of different cross training activities and RRIs in South African long-distance runners.

1.8 Conclusion

RRIs are a common issue around the world; an issue that has been investigated by many researchers in attempt to reduce injury rates. The RRI research is, however, lacking within the unique population of South African runners. Potential risk factors are known, and the previous research has assisted in formulating the research questions and hypotheses of the current study, in order to fill the gap of missing RRI knowledge within the population of South African long-distance runners.

CHAPTER II

REVIEW OF LITERATURE

2.1 Introduction

There are many potential risk factors that are important to consider when investigating running injuries, but to ensure that this chapter did not become convoluted, only the factors of importance to this particular study have been discussed. The following chapter will firstly discuss the mechanisms and common characteristics of RRIs in order to gain understanding of the basis of RRIs before delving into the factors that may be linked to RRIs. Following a review of RRIs, the chapter will be broken down into sections discussing potential RRI risk factors including personal characteristics and demographics, training characteristics, running experience, footwear, and cross training. Reviewing each variable group separately allows a thorough understanding of how RRIs and specific variables interact, as reported on in previous studies.

2.2 Running related injury mechanisms and characteristics

With regards to the common anatomical sites of RRIs, it is useful to know the most prevalent areas of injury locations in order to better the understanding of RRIs. The most common RRIs are those of the lower extremities (Satterthwaite et al. 1996; Roos et al., 2015). Most of these RRIs of the lower extremities, occur in the lower leg (Malisoux et al., 2013; Kerr et al., 2016), specifically from, and including, the knee down (Van Middelkoop, Kolkman, Van Ochten, Bierma-Zeinstra, & Koes, 2008a; van Ginckel et al., 2009; Buist et al., 2010a; Malisoux et al., 2013; van Poppel et al., 2016).

The definition of an RRI differs across studies which can prove challenging when analysing the existing research. It is, however, important to have a clear understanding of what an RRI is, therefore

Table I below provides the different definitions of RRIs from previous studies.

Table I. Definitions of RRIs according to different authors

Study	Injury definition
Taunton et al. (2002)	Pain occurring while running, directly after a run, or pain resulting in the runner having to decrease running duration or stop completely.
Dick, Agel, & Marshall (2007)	A reportable injury as a result of training, needed medical attention or caused the athlete to lose one day of training.
Buist et al. (2008)	Musculoskeletal pain or discomfort in the lower limbs or back caused by running, which results in not being able to run for at least one day.
Van Middelkoop et al. (2008b)	Injury of the lower extremities as a result of running that caused a reduction in distance, speed, duration or frequency of running training.
Lopes et al. (2011)	Running-related musculoskeletal pain which does not have to result in a cessation of training.
Hespanhol Junior, Costa, & Lopes (2013)	"…any pain of musculoskeletal origin attributed to running by the runners themselves and severe enough to prevent the runner from performing at least one training session."

The above definitions, apart from that of Lopes et al. (2011), are considered time-loss definitions which are the most commonly used method of describing an injury as it describes the extent of the injury and how it affects the athletes training (Clarsen, Myklebust, & Bahr, 2013). However, as Lopes et al. (2011) pointed out, athletes do not always stop training when suffering from an injury. Similarly, more than three times the amount of non-time loss RRIs occurred in collegiate cross-country runners, compared to time-loss injuries (Kerr et al., 2016), emphasising the importance of not limiting RRI definitions to time-loss definitions. To further understand RRIs, the basic mechanisms of the development of an RRI should be reviewed. The following figure, adapted from Hreljac (2004), describes the theoretical stress-frequency curve of how most overuse injuries occur.

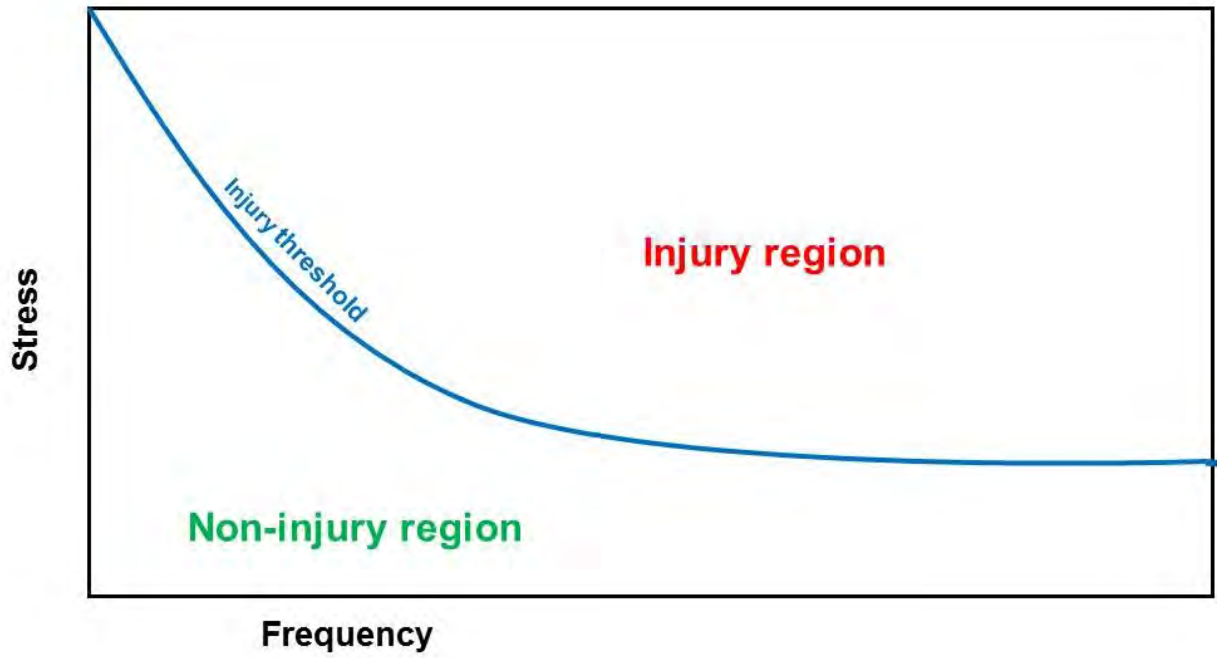

Figure 1. Theoretical stress-frequency curve adapted from Hreljac (2004).

The stress-frequency curve illustrates the relationship between stress applied to the body, and the frequency at which this stress occurs (Hreljac, 2004). During running, the body is exposed to external forces which are compensated by internal forces of the musculoskeletal system (Bahr & Krosshaug, 2005). When an injury occurs, in biomechanical terms, the load has either exceeded the stress limit as a result of one inciting event (acute) or the stress limit has been reduced over time, causing the regular load to be intolerable (overuse) (Damsted, Parner, Sørensen, Malisoux, & Nielsen, 2017).

RRIs are described as either acute injuries or overuse injuries. An acute injury occurs suddenly during sport or exercise and results in an instant trauma (Knobloch et al., 2008; Ristolainen et al., 2010). Acute injuries are far less common in running than overuse injuries (Knobloch et al., 2008; Saragiotto et al., 2014; Folscher, Grant, Fletcher, Christina, & Rensberg, 2015; Kerr et al., 2016). An overuse injury occurs gradually during exercise but with few or no visible indications, and worsens with continuation of the exercise (Knobloch et al., 2008; Ristolainen et al., 2010). Overuse RRIs are a result of microtraumas that occur when the body tissues are overloaded and have not had time to recover between exercise sessions (Difiori, 2010; Knobloch et al., 2008). Tibial stress syndrome, plantar fasciitis, Achilles tendinopathy and iliotibial band syndrome (ITBS) are common overuse RRIs (Taunton et al., 2002). The load imparted on the body from running is repetitive in nature (Hreljac, 2004). This constant loading of the musculoskeletal system often results in the 'thickening' of the bone as a protective mechanism, increasing the bone density, making the bone stronger and less susceptible to injury (Lane et al., 1986; Hall, 2007). This phenomenon can be explained by Wolff's law; the bone remodels itself in response to functional forces (Hall, 2007). Repetitive loading is necessary to enable the body to strengthen and adapt to external forces, however inadequate recovery time between bouts of repetitive loading hinders the strengthening process, subsequently increasing the risk of overuse RRIs. Although forces from the repetitive loading are smaller than those from acute injuries, the constant loading of stress onto the same area of the body, the lower extremities, can lead to weakened tissue and consequently overuse injuries (Hall, 2007).

2.2.1 RECURRENT INJURY

Most research shows that previous injury is associated with recurrent injuries (Taunton et al., 2003; van Gent et al., 2007; Knobloch et al., 2008; Buist et al., 2010b; Bennett, Reinking, & Rauh, 2012; Hespanhol Junior et al., 2013; Reinking et al., 2013; Malisoux et al. 2014; Saragiotto et al., 2014; van der Worp et al., 2015). A recurrent injury has been defined as an injury of the same type and location as a previous injury and has occurred after the athlete has returned to training after the original injury (Fuller et al., 2006). Recurrent injuries could be a result of inadequate recovery, continuous biomechanical issues and other factors that may have originally increased susceptibility to injury (Rasmussen et al., 2013; van der Worp et al., 2015).

Inadequate recovery before returning to training is a major risk factor in the recurrence of an injury (Nicholl, Coleman, & Williamst, 1995; Taunton et al., 2003; Buist et al., 2008). When a load is placed on unrecovered tissue, further damage could occur and the recovery process, hindered. Additionally, it has been hypothesised that an injury may cause the body to create different biomechanical, movement pathways to avoid stress to the damaged tissue (Hespanhol Junior et al., 2013). However, an overuse injury may then occur to the new tissue, as a result of not being adapted to running loads (Saragiotto et al., 2014). Knobloch et al. (2008), found that a quarter of previously injured runners reported not fully recovering before resuming training, and coincidentally, almost a third of the runners in this study reported recurrent RRIs, thus emphasising the importance of full recovery.

If an injury has fully recovered prior to returning to training, it should not increase the risk of a recurrent injury unless the original injury permanently compromised the biomechanics, structure or coordination of the injured area (van der Worp, van der Horst, de Wijer, Backx, & Nijhuis-van der Sanden, 2012). However, it is possible that the recovered tissue is weaker as a result of the injury, and then an external factor, such as overtraining, may cause further damage, subsequently resulting in a recurrent RRI (Saragiotto et al., 2014). It is also possible that an injury produces scar tissue which can cause the tissue to become resistant to movement, increasing the risk of further injury as a result of restricted range of motion (ROM) (Bahr & Holme, 2003). After rehabilitation of an RRI, runners should gradually return to running to avoid recurrence of an injury (Nicholl et al., 1995; Taunton et al., 2003; Buist et al., 2008).

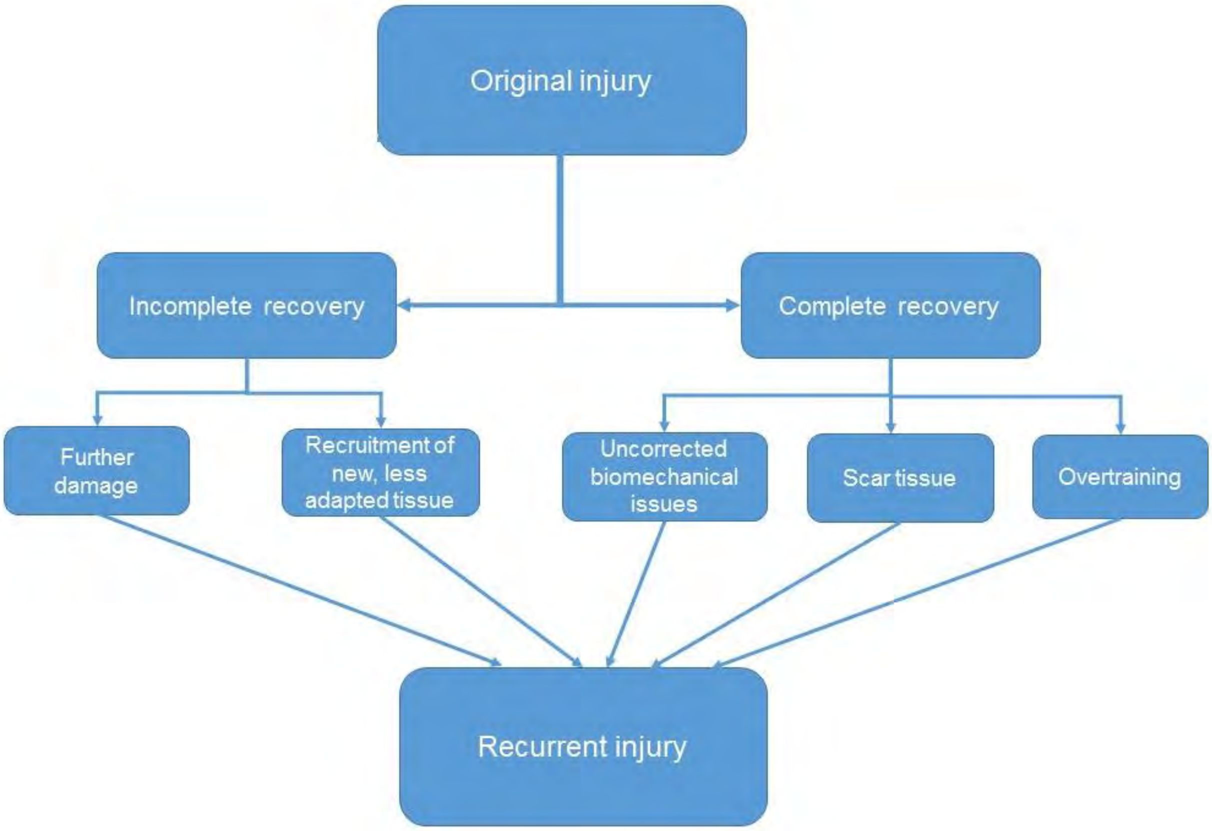

Figure 2. Potential mechanisms for recurrent injuries

The above figure summarises the theoretical mechanisms behind a recurrent injury, as described in the previous paragraph. Due to the several mechanisms that could potentially cause recurrent injuries, it is likely that runners that have already suffered from an RRI are at an increased risk of further injury.

2.3 Potential Risk Factors

Prevention is better than cure thus improving the knowledge surrounding the contributors of RRIs can assist in providing a proactive approach to avoiding or reducing injuries, as opposed to a reactive approach of attempting to repair injuries (Bahr & Krosshaug, 2005).

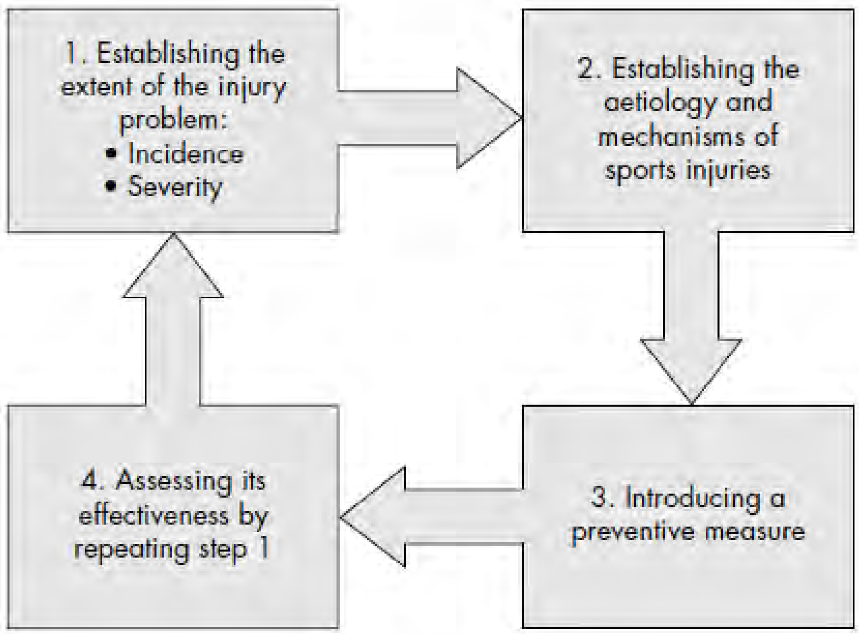

Figure 3. The four steps of injury prevention research (Bahr & Krosshaug, 2005).

Bahr & Krosshaug (2005) suggested a method to assist in the prevention of injuries by following four steps (Figure 3). The particular area of interest to the current study focuses on step one and step two in particular as this knowledge forms an integral part in injury prevention. Establishing injury incidence and aetiology can further the understanding of RRIs and give insight into the direction of future research. Steps three and four are of equal importance, however, extend beyond the scope of the current study. Little is known regarding the exact mechanisms behind RRIs (van Gent et al., 2007; Saragiotto et al., 2014), however it has been stated that the causes or contributors are not limited to one particular factor (Bahr & Holme, 2003; Bahr & Krosshaug, 2005; Malisoux et al., 2015a), thus it is imperative to investigate as many potential injury contributing factors as possible. The “Injury Iceberg” model proposed by Hanson et al. (2005) and discussed by Hulme & Finch (2015), describes the injury prevention research approach as a pyramid-like, or iceberg, structure. Much research focuses on the tip of the iceberg; a single level including the intrinsic factors of the individual at risk, however, below the surface, extends the iceberg, encompassing more levels pertaining to the individual’s environment, community and larger society. This “Injury Iceberg” model underlines the importance of looking further than solely the individual at risk and the intrinsic factors, but also the interacting extrinsic factors and this is what the current study aimed to achieve.

When investigating potential RRI risk factors, both intrinsic and extrinsic characteristics of the runners, must be considered (van Mechelen, Hlobil, & Kemper, 1992; Bahr & Krosshaug, 2005; Buist et al., 2010a; Bennett et al., 2012).

Table II. Summary of previously investigated factors in injury studies

Previously investigated factors	**References**
Age	Taunton et al. (2002); Buist et al. (2010a); Rasmussen et al. (2013)
Sex	Taunton et al. (2002); van Gent et al. (2007); Buist et al. (2010a); Ellapen et al. (2013)
BMI	Buist et al. (2010b); Rasmussen et al. (2013)
Ethnic origin	Onywera (2009)
Socioeconomic background	Hespanhol Junior et al. (2012)
Previous injury	van Gent et al. (2007); Buist et al. (2010b); Rasmussen et al. (2013); Malisoux et al. (2014); Saragiotto et al. (2014)
Training characteristics	Rasmussen et al. (2013); Malisoux et al. (2014); Saragiotto et al. (2014)

Running experience	Taunton et al. (2002); Fredericson & Misra (2007); Rasmussen et al. (2013)
Footwear	Lieberman et al. (2010); Hryvniak et al. (2014)
Cross training	van Gent et al. (2007); Buist et al. (2010b); Malisoux et al. (2013)

The subsequent paragraphs deconstruct each factor and report on the relevant RRI research.

The load imparted on the body during running, and the way that the body reacts to this load is influenced by both intrinsic factors and extrinsic factors, however the load tolerance is strongly influenced by intrinsic factors (Meeuwisse, 1994). The importance of investigating intrinsic or non-modifiable variables, is to assist in recognising runners who are intrinsically predisposed to RRIs and identifying their load tolerance. This may enable them to be increasingly precautious when taking up running, or during training. The importance of investigating modifiable variables, is to be able to adjust these variables to minimise injury risk, and to inform future intervention programs (van der Worp et al., 2015). Due to the cross-sectional nature of the current study, following the athlete and tracking the possible 'inciting' event was difficult, therefore collecting as much available information regarding the intrinsic factors that may predispose the runner to injury, and the extrinsic factors that may exacerbate this predisposition, may point towards the combination of multiple injury contributors.

2.4 Personal Characteristics and Demographics

The following section on personal characteristics and demographics, reviews the literature on the links between RRI, and the sex, age, ethnic origin, BMI, and socioeconomic background of the long-distance runner.

2.4.1 SEX

Determining whether the sex of a runner is associated with injury risk is pertinent in furthering the understanding of injury mechanisms. It is known that males and females differ biomechanically, anatomically and physiologically (Conoboy & Dyson, 2006) however what needs to be understood, is whether these differences affect the risk of RRI. Most of the literature has found female runners to be at a higher injury risk than male runners (Bell et al., 2000; Taunton et al., 2002; Willems et al., 2005; van Gent et al., 2007; Chumanov et al., 2008; Boling et al., 2009; Daoud et al., 2012; Phinyomark, Hettinga, Osis, & Ferber, 2014; Roos et al., 2015; Kerr et al., 2016). There are a few theories that may provide explanations for a higher injury risk in females, which is discussed in the following paragraphs.

Physical characteristics such as anatomical structures and running kinematics differ slightly between males and females (Conoboy & Dyson, 2006; Phinyomark et al., 2014; van der Worp et al., 2014), and these differences may influence RRI rates and risk. For example, van der Worp et al. (2014) found female runners to have a significantly lower navicular drop than male runners, which is relevant as Buist et al. (2010b) reported that navicular drop was associated with RRIs in female runners, and Bennett et al. (2012) found that runners with a navicular drop of less than 10 mm were at an increased risk of medial exercise-related leg pain (ERLP). Tiberio (1987) and Ferber, Davis, & Iii, (2003), found that the male body is less susceptible to RRIs due to favourable kinematics. In the frontal plane and transverse plane, Ferber et al. (2003), Chumanov et al. (2008) and Phinyomark et al. (2014), found that female runners had larger peak hip angles than males, which places strain on the patellofemoral joint, potentially resulting in misalignment and subsequently patellofemoral pain syndrome (PFPS) (Tiberio, 1987; Robinson & Nee, 2007; Boling et al., 2009). Furthermore, excessive frontal plane hip movements, such as those found in females as previously mentioned, have also been linked to the occurrence of ITBS, specifically when combined with weak hip abductors (Fredericson et al., 2000; Leetun, Ireland, Willson, Ballantyne, & Davis, 2004; Noehren, Davis, & Hamill, 2007), again, a physical trait which has been more commonly found in female athletes (Leetun et al., 2004).

Muscular activity has additionally been found to differ between male and female runners. Chumanov et al. (2008) found that females had higher gluteus maximus activity during running, compared to males. High muscle activation levels potentially result in muscular fatigue which in turn has been said to lower shock absorption ability, subsequently increasing the risk of RRIs (Beck, 1998; Chumanov et al., 2008). Moreover, muscular fatigue can result in injury of that particular muscle if activation is continued past fatigue.

Female runners could additionally be at risk for RRIs due to the female triad and hormonal factors. In 2014, 44.1% of female Comrades runners were found to be at risk for the female triad (Folscher et al., 2015). The female triad is made up of three disorders; menstrual dysfunction, eating disorders and reduced bone mineral density (Hall, 2007) which have all been linked to the incidence of stress fractures (Folscher et al., 2015). Moreover, bone density decreases with age, however the decrease is greater in females and occurs earlier, resulting in more brittle bones and higher risk of osteoporosis in elderly females than elderly males (Riggs et al., 2004; Hall, 2007). This being said, weight-bearing exercise such as running often results in increases in bone mineral density (Lane et al., 1986), although with excessive training, these benefits can be lost (Marcus et al., 1985), specifically in post-menopausal females. Apart from reduced bone density, soft tissues may additionally be affected by the menstrual cycle. Slauterbeck et al. (2002) found that ACL injuries are more likely to occur around the time of a female’s menstrual cycle. It could be theorised that this does not only apply to ACL injuries, but other soft tissue injuries too, thus female athletes may be at an increased risk of RRI when menstruating.

An additional explanation for increased RRI incidence in female runners may be linked to fitness levels. Bell et al. (2000) hypothesised that females may have lower fitness levels compared to males, at the beginning of a training period, making them more susceptible to injury because when fitness level was controlled for in this particular study, sex had no significant effect on the injury rates. Additionally, previous research has shown that lower fitness levels are associated with an increase in injury risk (Jones et al., 1993; Jones & Knapik, 1999), however there is little concrete evidence to say that females do have lower fitness levels than males, thus fitness may be a cofactor more than a characteristic of most female runners.

With the aforementioned factors in mind; there are other factors that may falsely give the appearance of higher RRI risk in female runners. For example, the amount of female runners has increased drastically since the 1980s (Bennett et al., 2012) therefore the increase in injury of female runners may be due to the overall number of female runners increasing (Taunton et al., 2002). Moreover, it has been theorised that females may be more likely to report injuries than males (Taunton et al., 2002; Roos et al., 2015; Kerr et al., 2016) which may partially explain the higher RRI incidence reported by females in some studies.

Musculoskeletal structures, hormonal factors, fitness levels and behavioural aspects appear to be in favour of the male runner in terms of low RRI risk and incidence. However, when investigating the other side of the spectrum, Buist et al. (2010a), Buist et al. (2010b) and van der Worp et al. (2015) found male runners to be more prone to RRIs compared to female runners. One explanation could be the lower ROM in most males compared to females (Hall, 2007). Joint ROM, if too low, can result in injury to the soft tissue surrounding the joint during physical activity (Hall, 2007). Another explanation for higher RRI rates in male runners, may be behavioural as it has been found that male athletes tend to push through pain, potentially causing an injury (Malcom, 2006).

Some studies found no differences or associations between injury risk and sex (Lun, Meeuwisse, Stergiou, & Stefanyshyn, 2004; Bennett et al., 2012; Rasmussen et al., 2013; Saragiotto et al., 2014; Chaudhary et al., 2016), however this is not to say that the sex of a runner has no influence on RRI characteristics. Apart from injury risks differing in males and females, Taunton et al. (2002) reported that males and females are predisposed to different types of RRIs. Females have been found to be more susceptible to ITBS, PFPS (Boling et al., 2009), tibial stress fractures (Taunton et al., 2002), and hip and groin injuries (Satterthwaite et al., 1999; Kerr et al., 2016), while male runners are more susceptible to hamstring, calf and ankle RRIs (Satterthwaite et al., 1999; Kerr et al., 2016). Interestingly, it is also possible that different mechanisms in male and female runners may contribute to the same RRIs. Phinyomark, Osis, Hettinga, Leigh, & Ferber, (2015) found that males with ITBS exhibited excessive internal ankle rotation while females with ITBS exhibited excessive external hip rotation. Furthermore, neuromuscular strategies differ between males and females during running (von Tscharner & Goepfert, 2003) which may be the reason for different injury mechanisms in males and females. Hespanhol Junior, van Mechelen, Postuma, and Verhagen, (2015) and Kerr et al. (2016) hypothesised that different running behaviour in males and females could explain the RRI rate difference.

Overall, the sex of a runner appears to be associated with RRI rates and RRI characteristics. Although the literature is in support of female runners being more susceptible to RRIs than male runners, it appears as if the sex of a runner influences aspects of injuries in different ways.

2.4.2 AGE

The degeneration of the musculoskeletal system is part of the process of aging (Taunton et al., 2002). Bone density decreases with age, a process known as osteopenia. Subsequently, the risk of osteoarthritis increases, which results in weakened bones making them more susceptible to fractures, especially with participation in weight-bearing exercises such as running (Lane et al., 1986; Hall, 2007). In older runners, the maximum loading rate of vertical ground reaction forces (GRFs) is higher than in younger runners, suggesting a poor ability to absorb shock (Bus, 2003; Fukuchi, Stefanyshyn, Stirling, Duarte, & Ferber, 2013), further increasing the risk of stress fractures. In addition to osteopenia, muscle mass and strength decline with aging; a condition known as sarcopenia (Doherty, 2001; Karamanidis & Arampatzis, 2005). This decrease in strength usually occurs from 50 years old (Doherty, 2001). In elderly runners, Karamanidis & Arampatzis (2005) found a reduction in the muscle strength and tendon stiffness of the triceps surae and quadriceps femoris muscle-tendon units. Furthermore, Ruan et al. (2015) found decreased elasticity of the Achilles tendon, part of the triceps surae muscle-tendon unit, in older runners. The reduced functionality of the muscle-tendon units lowers the ability to absorb shock, increasing the risk of stress fractures (Bus, 2003; Buist et al., 2010b; Devita et al., 2015).

Apart from reduced shock absorption abilities, compared to younger runners, older runners demonstrate limited sagittal ROM at the knee (Bus, 2003; Karamanidis &

Arampatzis, 2005; Fukuchi & Duarte, 2008; Phinyomark et al., 2014; Devita et al., 2015) and ankle (Fukuchi et al., 2013). This limited ROM means that the soft tissue surrounding the joints are susceptible to injury when at maximum length and maximum tension (Bahr & Holme, 2003). Moreover, Wearing, Smeathers, Urry, Hennig, & Hills, (2006), found that decreased sagittal ROM at the ankle was associated with plantar fasciitis, an RRI that is less likely to occur in younger, male runners (Taunton et al., 2002). Supporting the increased risk of RRI in older runners, Taunton et al. (2003) found female runners over the age of 50, to have a higher RRI risk than younger female runners. Additionally, being younger than 34 years old, was found to be protective against RRIs such as meniscal injuries and Achilles tendinopathy (Taunton et al., 2002) which may be exacerbated in elderly runners as a result of degradation of musculoskeletal tissue, limited ROM and reduced shock absorption ability.

Although, the elderly body should theoretically be more susceptible to injury as previously discussed, many studies have found that younger runners demonstrate higher RRI rates and risk (Marti et al., 1988; Taunton et al., 2002; Rasmussen et al., 2013; Kluitenberg et al., 2015b). Younger runners below the age of 34 years have been found to be at a higher risk for developing PFPS than older runners (Taunton et al., 2002). When separated by sex, younger male runners, were more susceptible to developing specific RRIs, namely ITBS, patellar tendinopathy and tibial stress syndrome, than the older male runners (Taunton et al., 2002).

One potential reason for older runners being less injured may be a result of employing protective gait mechanisms to counteract the reduced shock absorption and limited ROM (Karamanidis & Arampatzis, 2005; Devita et al., 2015). Studies have found decreased stride length (Bus, 2003; Fukuchi & Duarte, 2008) and slower running pace (Conoboy and Dyson, 2006; Devita et al., 2015) to be characteristics of elderly runners. Reduced stride length and pace can lower GRFs and accommodate reduced ROM, however, may also be a result of less power and strength to propel the aged body forward when running.

Years of running experience may additionally play a role in lower injury rates in older runners as years of running has been found to be associated with age, with older runners having more experience than younger runners (Marti et al., 1988; Devita et al., 2015). Experienced runners are often older than novice runners (Rasmussen et al., 2013; Devita et al., 2015) and therefore, in some instances, older runners may be less prone to RRIs, due to more years of running experience and the benefit of the repeated loading of running over many years. The repetitive forces to the bone from running cause the bone to strengthen itself over time (Hall, 2007), adapting the body to the stresses of running (Devita et al., 2015). Hence, studies in which younger runners were found to be more prone to injury than older runners, may be due to less running experience in the younger runners (Buist et al., 2010a; Rasmussen et al., 2013; Devita et al., 2015). In novice runners, Nielson et al. (2013) found an association between increased injury risk and being between 45 and 65 years of age. Another study on novice runners by Kluitenberg et al. (2015b), found an increase in age to be associated with RRIs, supporting the idea that more experience is likely the reason for lower injury rates in older runners in previous studies.

Further reason for lower injury rates in older runners, is the fact that there may be less injured older runners due to the “survival phenomenon” or “healthy runner bias”, which states that uninjured runners continue to run throughout their lives and injured runners stop running (Wen et al., 1997; Buist et al., 2010a). In other words, when young runners become injured from running, they may stop running completely, whereas the young uninjured runners are more likely to remain runners until old age, thus producing a group of elderly, uninjured runners.

It has been thought that younger runners have a higher training volume (Gibson, Lambert, & Noakes, 2004) which has been shown to contribute to increased injury risk (Satterthwaite et al., 1999; van Gent et al., 2007; Malisoux et al., 2014). In marathon runners, being younger than 35 years old was found to be a risk factor for developing injuries after a marathon (Rasmussen et al., 2013). Runners under 30 years of age appear to be at higher risk for calf RRIs (Satterthwaite et al., 1999). With regards to ERLP in the year preceding the race, younger runners presented significantly more cases of ERLP than older runners (Reinking et al., 2013).

Older runners are at risk of injury as a result of aging and the degradation of musculoskeletal tissue, while younger runners are at risk as a result of possible higher training volume (Gibson et al., 2004), the “survival phenomenon” (Wen et al., 1997; Buist et al., 2010a), as well as potentially being inexperienced runners (Rasmussen et al., 2013). Because of the complex relationship between the effects of age and experience on RRIs, it can be difficult to determine if it is older or younger runners that are at a higher risk for RRIs. Again, this highlights the importance of investigating more than one possible injury contributor in order to find where associations exist.

2.4.3 ETHNIC ORIGIN

Ethnicity is often described by the pigmentation of one’s skin (Parra, Kittles, & Shriver, 2004). Yet, some have argued that it is not sufficient to examine ethnicity alone, but rather the historical geographical origins of populations, as genetic variation can exist within an ethnic group (Parra et al., 2004). To support this statement, Bosch, Goslin, Noakes, and Dennis (1990) pointed out that out of the top 10 marathon runners of that time, six were Black. To this day, a similar trend is still present. The top ten fastest male marathoners are all Black and six out of the top ten fastest female marathoners, are Black (Nakamura & Douglas, 2015). However, what may be more crucial than the commonality of their ethnicities, is the fact that all these Black runners are from East Africa. To further this concept, Scott & Pitsiladis (2007) pointed out the contrast in the literature regarding Black athletes; some studies found these athletes to excel at endurance running (Weston, Mbambo, & Myburgh, 2000), while others found sprinting to be dominated by Black athletes (Ama et al., 1986). A probable reason for these findings is the grouping of athletes solely by their ethnicity. When investigated more thoroughly, it was found that it is East Africans that excel at long-distance running (Larsen, 2003; Onywera, Scott, Boit, & Pitsiladis, 2006; Tucker et al., 2013) while runners of West African descent are generally better at sprinting (Deason et al., 2012; Tucker et al., 2013). The difference in performance niches in East and West African runners emphasise the findings of previous studies (Tishkoff & Williams, 2002; Yu et al., 2002); that more genetic variation is present between Africans than between non-Africans. Taking this into consideration, the following section discusses literature pertaining to both ethnicity and origin, and their possible influences on RRI risk.

Physiological, biomechanical and anthropometrical differences have been found between people of various ethnicities and origins (Prentice & Jebb, 2001; Larsen, 2003; Abraham, 2010; Braun, Wolfgang, & Dickersin, 2013). However, very little research has examined the associations between ethnic origin and running injuries, making it challenging to review this particular area. Nonetheless, existing literature on differences between ethnicities assists in hypothesising the way in which RRIs may be influenced. Due to the various ethnicities and origins that make up the South African population (Stats SA, 2010) the potential role that this area might have on RRI risk in SA, cannot be ignored.

Hall (2007) stated that osteoporosis is most prevalent in Caucasian and Asian populations. Osteoporosis weakens the bone, increasing susceptibility to stress fractures (Hall, 2007). To support this, military studies done in the United States found that Caucasians and Asians were most susceptible to injuries such as stress fractures and knee injuries (Friedl, Nuovo, Patience, & Dettori, 1992; Jones & Knapik; 1999; Sulsky, et al., 2000). The relation of South African runners to U.S. military personnel is questionable, however running is the primary choice of organised exercise in the military (Friedl et al., 1992), making these studies of interest.

Differences in skeletal muscle physiology between ethnicities have been previously found (Ama et al., 1986; Coetzer et al., 1993; Weston et al., 1999; Weston et al., 2000; Fukashiro, Abe, Shibayama, & Brechue, 2002; McKune et al., 2009), however mostly between Black and Caucasian populations. Caucasian males have been found to have higher relative levels of creatine kinase, post-exercise, than Black African males, which implies that muscle damage is more likely in the Caucasian group (McKune et al., 2009). It should be mentioned that the opposite was found in a study by Ama et al. (1986), in which Black African males showed higher levels of creatine kinase, however this study was done on sedentary participants. Further contention is evident in the area of muscular fatigue. With a higher proportion of Type II muscle fibres, fatigue sets in sooner (Verrall, Slavotinek, Barnes, Fon, & Spriggins, 2001). Muscular fatigue has been found to increase injury risk (Chumanov et al., 2008). Kohn et al. (2007) found a higher predominance of Type II muscle fibres in Black South African runners, implying a fast onset of muscular fatigue, and thus increased injury risk. In contrast, Coetzer et al. (1993) found no difference in proportions of Type II muscle fibres between Black and Caucasian South African runners, however, did find that the Black South African runners fatigued slower, regardless of the muscle fibre proportion. Weston et al. (1999) further confirmed the enhanced fatigue resistance in Black South African runners, theoretically lowering their risk of injury if the findings by Chumanov et al. (2008) are accurate. As the evidence is contrasting in this area, it is difficult to conclude which ethnic origin group is more susceptible to RRI, however it is clear that a difference is present.

As previously mentioned, the literature on the role of ethnic origin in RRI prevalence and risk, is sparse. On the other hand, reviewing research on other sports injuries and the influence of ethnic origin, may provide guidance for the current study. Football players of aboriginal descent (Verrall et al., 2001) and of Black ethnic origin (Woods et al., 2004) were at a higher risk of hamstring injuries. These hamstring injuries could possibly be due to a higher proportion of Type II muscle fibres, or an anteriorly tilted pelvis. Gurney, Kersting, & Rosenbaum (2009) researched foot morphology and function in Caucasian, Maori and Pacific Island male rugby players. Differences in plantar loading and foot geometry were found. Foot geometry plays a role in footwear, and the Maori and Pacific Islanders reported difficulty finding appropriately fitting footwear. Poor-fitting footwear could increase the risk of injury as different plantar loading during running means that the placement of cushioning and support in footwear may not be in the correct areas of the shoes for all athletes who may wear them (Gurney et al., 2009). In support of this, Malisoux et al. (2015a) found that foot morphology does indeed influence RRI risk.

Anthropometry is an additional area in which differences between ethnic origins have been recorded (Prentice & Jebb, 2001; Abraham, 2010). Moreover, some aspects of anthropometry have been found to influence injury risk, as previously discussed. With regards to BMI, a higher BMI specifically related to high fat mass, has been found as an injury risk during sports such as running (Malisoux, et al., 2013; Chaudhary et al., 2016; van Poppel et al., 2016). When examining body fat levels, Abraham (2010) found that young Indian distance runners were highly endomorphic with a low ectomorphic component compared to African distance runners who exhibited the opposite – high ectomorphic properties with a low endomorphic component. Coetzer et al. (1993) reported lower BMIs in Black South African runners compared to their Caucasian counterparts. As previous literature points to lowered fat mass in Black African runners compared to Indian and Caucasian runners, RRI risk could be linked to lower BMI in Black African runners if BMI and RRI are associated.

East African runners have presented low injury incidence during a 10 km race (Davey & Tilahun, 2002) and it has been suggested that one of the contributing factors, is an optimal running gait with shorter ground contact time (Kong & de Heer, 2008). The lower injury rates may also be attributed to behavioural differences. The East African population could be less prone to RRIs as they might be 'hardened' as a result of the environment in which they have trained. Another theory suggests that East African runners have learnt to 'listen' to their bodies as they have had very little coaching, or under experienced coaches (Onywera, 2009). Moreover, Maffulli et al. (2003) stated the importance of considering the varying sports habits and cultures in different countries, which is likely to influence injury risk.

Overall, the research on direct links between ethnic origin and RRIs, is lacking. However, the existing literature does indicate that injury-influencing differences are present between ethnicities. The notion that differences are also apparent within ethnicities, may further solidify these theories, with insight into the RRI characteristics of South African ethnicities and if these characteristics differ from those of the same ethnicities but different geographical origin.

2.4.4 BODY MASS INDEX

Body Mass Index (BMI) is a method of standardising the measure of mass between people of various statures and is measured as "the ratio of body mass to stature squared" (McArdle, Katch & Katch, 2010). The World Health Organisation categorises BMI into four main categories; underweight (<18.50 $kg.m^{-2}$), normal (18.50 – 24.99 $kg.m^{-2}$), overweight (25.00 – 29.99 $kg.m^{-2}$) and obese (>30.00 $kg.m^{-2}$). Runners have been found to have a lower BMI when compared to soccer players, cross country skiers and swimmers (Ristolainen et al., 2010). Striving to have a normal BMI is ideal as this is likely to decrease the risk of disorders such as osteoarthritis (Lane et al., 1986; Gelber et al., 1999) and subsequently stress fractures (Baltich et al., 2016).

BMI as a measure of ‘overweightness’ does have its limitations; it does not take body composition into consideration (Prentice & Jebb, 2001). Having a high percentage of muscle mass could result in a person being considered overweight as a result of their BMI, although their fat mass is low (McArdle et al., 2010). Considering the limitations, when no other method is available to measure the normalcy for body weight, BMI is inexpensive and easy to use (Prentice & Jebb, 2001), and is used widely throughout studies.

Several studies have found that runners with a higher BMI were at an increased injury risk (Jones et al., 1993; Buist et al., 2010a; Buist et al., 2010b; Nielson et al., 2013; Malisoux et al., 2014; van Poppel et al., 2016; Chaudhary et al., 2016) which may be a result of a few factors. With a higher BMI, heavier runners carry additional weight that needs to be supported by the body (Abate, Oliva, Schiavone, & Salini, 2012) which can increase strain on the bones, joints and soft tissue of these runners (Macera, 1992 as cited by Buist et al., 2008). In a study by Abate et al. (2012), overweight non-runners (BMI > 25 $kg.m^{-2}$) presented more abnormalities in the Achilles tendon structures than non-runners of normal weight, however the most Achilles abnormalities were found in overweight runners. Thus, a high BMI may contribute to the risk of Achilles tendinopathy as added weight on the tendon during running, results in a higher force impact in the tendon (Abate et al., 2012).

With a higher BMI, forces and stresses acting on the body are proposed to be higher during running (Taunton et al., 2002). If a high BMI is a result of higher fat mass as opposed to higher muscle mass, the absorption and dampening of shock may be insufficient due to lower muscle mass. Lower muscle mass is associated with less muscular strength which reduces shock absorption abilities (Bus, 2003; Buist et al., 2010b; Devita et al., 2015). Consequently, more shock is distributed to the bone (Beck, 1998), increasing the risk of injuries such as stress fractures (van der Worp et al., 2016). Furthermore, the risk of problems such as knee osteoarthritis later on in life, has been found to be three times higher, in young males with a BMI of between 24.7

kg.m^{-2} and 37.6 kg.m^{-2}, compared to young males with a lower BMI (Gelber et al., 1999). With a high BMI increasing the risk of stress fractures as well as osteoarthritis, it is probable that overweight runners will face RRIs related to the bones of the lower extremities.

A high BMI has also been associated with unfavourable running kinematics (Chumanov et al., 2008). A correlation between high BMI and increased peak hip adduction while running, was found in the study by Chumanov et al. (2008). Excessive peak hip adduction has been found to be a risk factor for tibial stress fractures in female runners (Pohl et al., 2008) as well as being associated with the increased incidence of ITBS, specifically when combined with weak hip abductors (Fredericson et al., 2000, Leetun et al., 2004; Noehren et al., 2007).

Overall, several studies found a high BMI to be associated with RRIs. Female runners with back RRIs had a higher BMI than uninjured female runners (Wen et al., 1997). In a study by Buist et al. (2010b), males with a higher BMI were at an increased RRI risk. Nielson et al. (2013) found an increased risk of RRI with an increasing BMI and similarly, a higher incidence of heel injuries was found with a higher BMI (Wen et al., 1997). BMI of higher than 26 was a significant injury risk factor in half marathon and marathon runners (van Poppel et al., 2016).

Opposing the argument of a high BMI being a risk factor for injury; an abnormally low BMI may also contribute to RRI risk. Firstly, a low BMI may indicate less muscle mass and strength (Baltich et al., 2016), and subsequently lower shock absorption abilities (Bus, 2003; Buist et al., 2010b; Devita et al., 2015). Secondly, being underweight increases the chance of osteoporosis, leading to possible stress fractures in runners (Hall, 2007). The combination of porous bones and inadequate muscle strength to compensate for the external loads imparted on the body during running, makes the underweight runner highly susceptible to stress fractures (Hall, 2007). To substantiate this risk of stress fractures from low BMI, Taunton et al. (2002) found that a BMI of less than 21 kg.m^{-2} in female runners, increased the risk for tibial stress fractures and spinal injuries. Similarly, Friedl et al. (2003) found that stress fractures were more likely to occur in underweight female runners under the age of 25 years. In support of a low

BMI being a risk factor, Taunton et al. (2003) found that male runners with a BMI of more than 26 $kg.m^{-2}$ were less likely to be injured. Wen et al. (1997) found that male runners with foot RRIs had a significantly lower BMI than those without foot RRIs.

Apart from studies that found a clear link between BMI and RRI, a few studies exist where BMI and RRI were not associated. Bennett et al. (2012) and Rasmussen et al. (2013), did not find associations between BMI and RRI, however the BMI ranges in these studies were small which may account for the lack of associations found; Bennett et al. (2012) had no overweight participants and the mean BMI in the study by Rasmussen et al. (2013) was 23 $kg.m^{-2} \pm 2.3$. This being said, in the study by Reinking et al. (2013) that had a larger BMI range (18 – 37 $kg.m^{-2}$), no significant difference was found between BMI in runners with and without a history of ERLP. Another study by Marti et al. (1988) reported the highest injury incidence in the groups of runners with the lowest BMI and the highest BMI, suggesting that those with a normal BMI were least susceptible to injury. Similarly, Wen et al. (1997), found the least amount of shin injuries in male runners with normal BMI, compared to those with low and high BMI. From these studies, it could be theorised that both overweight and underweight runners are susceptible to injury, and runners with normal BMIs are less likely to develop injuries, which was further hypothesised by Nielsen et al. (2013).

2.4.5 SOCIOECOMONIC BACKGROUND

Socioeconomic background refers to the living conditions, monthly income and education of a population (Faelker et al., 2000). Little research exists that focuses primarily on the potential association between socioeconomic background and general injury risk (Smith, 1999). Cubbin et al. (2000), reported socioeconomic status to be negatively associated with general injury risk. Moreover, to the knowledge of the investigator of the current study, research on the possible association between socioeconomic background and RRI, was limited to three studies at the time of the current study (van Middelkoop et al., 2008b; Hespanhol Junior et al., 2012; Hespanhol Junior et al., 2013). The scarcity of literature on this possible link, prove it challenging to effectively review the literature, however reviewing the literature on health status and socioeconomic background, and physical injury may assist in theorising potential associations between RRI and socioeconomic background. It is therefore worth highlighting that this is particularly useful in a South African context, with our complex socio-political background that has resulted in a highly unequal society.

Low income and poor health often go hand-in-hand (Smith, 1999; Haddad, 2002) and a population ridden with health issues causes a vulnerable population (Bourne, Lambert, & Steyn, 2002). In a poor area in Peru, poor perceived health in adolescents, increased the risk of sport and recreational injuries (Morrow et al., 2014). In a study on children in Canada, Faelker et al. (2000) reported that non-fatal injury rates of the most poverty-stricken group were 1.67 times higher than the least poor group. Poor health, specifically during childhood and foetal development, has been theorised to have negative life-long effects on health (Smith, 1999), thus it could be hypothesised that injured youth, may be prone to injury as adults.

Poor nutrition is rife in areas of low household income and can lead to reduced bone mineral density and consequently an increased risk of injuries such as stress fractures (Duckham et al., 2012; Folscher et al., 2015). With weakened bones, the added stress of running long-distance may the risk of injury (Lane et al., 1986; Hall, 2007).

Inaccessibility of quality health care (Parra et al., 2004), and lack of affordable medical treatments, accompany low income (Morrow et al., 2014). As a result, injuries are not always treated properly, or medical treatment is delayed (Morrow et al., 2014) thus increasing the likelihood of recurrent injuries or the exacerbation of the existing injury (Morrow et al., 2014). Morrow et al. (2014), reported a minor injury to an adolescent in a poverty-stricken area of Ethiopia, which worsened to a major injury due to the use of traditional healing as opposed to proper medical treatment. With high socioeconomic status, more resources could be allocated towards health, thus improving the health of wealthier individuals (Smith & Kington, 1997).

Low education levels, another aspect of socioeconomic background, could suggest poorer understanding of injuries and treatment, which could cause minor injuries to become more serious (van Middelkoop et al., 2008b). It is likely that better education will improve knowledge on how to better health status and avoid injury (Smith & Kington, 1997). In agreement, higher education levels have been reported as being protective against musculoskeletal complaints (Reynolds, Williams, Mathis, Dettori, & Miller, 2000) and in male long-distance runners specifically, van Middelkoop et al. (2008b), found that higher education was protective against calf RRIs. This being said, Hespanhol Junior et al. (2012) and Hespanhol Junior et al. (2013), found no associations between education levels and the risk of RRI, however the reason for this was not discussed.

In contrast to a poor socioeconomic background increasing the risk of injury, Onywera (2009) suggested that poorer populations may present lowered RRI risk. These populations mostly have little coaching or inexperienced coaches which could cause the runners to become more skilled at understanding their own bodies, and adapting to avoid injury (Onywera, 2009). This however is only a theory and most research points towards poor socioeconomic backgrounds increasing the risk of injury or prolonging the healing of injuries.

2.5 Training Characteristics

Training characteristics such as frequency, distance and duration may be the most important contributors to running related injuries (Malisoux et al., 2014). According to Malisoux et al. (2014), previous studies have not been specific enough in the investigations into the association between training characteristics and RRIs. Moreover, the research that has been done presents much disparity, which is most likely due to the variation in methodologies between studies as previously mentioned (Saragiotto et al., 2014). The following section discusses the link between RRIs, and running training characteristics such as training volume, training adaptations, running terrain and organised running.

2.5.1 TRAINING VOLUME

Training volume is the combination of weekly running frequency, distance and duration. There are theories that explain high injury risk with both high and low weekly running volume, which this section will delve into. These differing theories may be a result of potentially different injury mechanisms caused by running too much or too little. Hreljac (2004) argued that faults in training could be responsible for all overuse

RRIs as these occur when the stress limit of the body has been exceeded. It has been suggested that training programs should be adjusted according to one's physical fitness levels, as training at a level that is too high is likely to result in training-related injuries (Bell et al., 2000). With regards to high running volume, overtraining can lead to overloading of the musculoskeletal system (Satterthwaite et al., 1999; van Gent et al., 2007; Malisoux et al., 2014) which could potentially result in the body not recovering fully after a training session and therefore being vulnerable to injury (Saragiotto et al., 2014). If the training is too frequent, the body is not given enough time between running sessions to adapt to the training volume and recover, thus overuse injuries may occur (Hreljac, 2005). Running five to more than 7 times per week has been linked to increased risk of RRIs such as shin splints (Knobloch et al., 2008; Saragiotto et al., 2014). Soft tissues, such as tendons, are likely to be at an increased injury risk as a result of overtraining (Magnusson, Langberg, & Kjaer, 2010). Tendons contain collagen and after exercise, collagen synthesis and collagen degradation occur, however more degradation is evident. Without rest between exercise bouts, there may constantly be more degradation than synthesis, thus leading to overuse tendinopathies (Magnusson et al., 2010).

When looking at weekly running distance specifically, the risk for back RRIs was increased in elite runners who reported running more than 65 km per week (Knobloch et al., 2008). A higher incidence of hamstring injuries was significantly associated with higher weekly running distances (Wen et al., 1997). Running less than 40 km per week was a protective factor for calf RRIs in male recreational marathon runners (van Middelkoop et al., 2008b). An increase in RRI rates was seen with an increase in weekly running distance (Marti et al., 1988) which has been described as a dose-response relationship (Buist et al., 2008). It is possible that more injuries are seen with higher weekly running volume as RRIs cannot occur with zero weekly distance as there is no risk exposure (Wen et al., 1997).

In contrast, low running volume may increase RRI risk due to under-conditioning (Satterthwaite et al., 1999; Malisoux et al., 2014). Low training volume prior to a long-distance race may result in the body not being conditioned to run long-distances, thus resulting in overload and subsequently injury (Rasmussen et al., 2013). Running more frequently throughout the week may be a preventative measure for avoiding injury, as this allows the body to adapt to the continuous loading of running (van Middelkoop et al., 2008b). In support of a low running volume increasing RRI risk, less than two running sessions per week have been associated with RRIs (Taunton et al., 2003; Malisoux et al., 2014). Moreover, covering less than approximately 30 km per week was found to be a characteristic of injured runners (Satterthwaite et al., 1999; Rasmussen et al., 2013; Reinking et al., 2013). Regarding low duration, Malisoux et al. (2014), reported that the duration of a training session in recreational runners was an RRI risk factor, with injured runners running for significantly shorter durations than uninjured runners.

The varying results found in the numerous studies done on training characteristics and RRIs, prove the contention surrounding the current literature. An issue in many retrospective studies is that it cannot be known as to whether the occurrence of injury is a result of decreased training volume, or whether the runner decreased training volume as a result of an injury (Wen et al., 1997). This issue may be the reason for some studies reporting low weekly running volume with high injury rates (Wen et al., 1997). Furthermore, the contrasting findings could be due to undefined types of RRIs (Taunton et al., 2003), as specific RRIs may be linked to high training volume, whereas others may be associated with low training volume. Either way, because most studies find that low or high volume is a risk factor, it could be suggested that runners should find the perfect balance between high running volume and low running volume (Satterthwaite et al., 1999). Additionally, training volume should be structured according to the individual, as specific training loads are likely to have different outcomes on various runners (Gabbett, 2016).

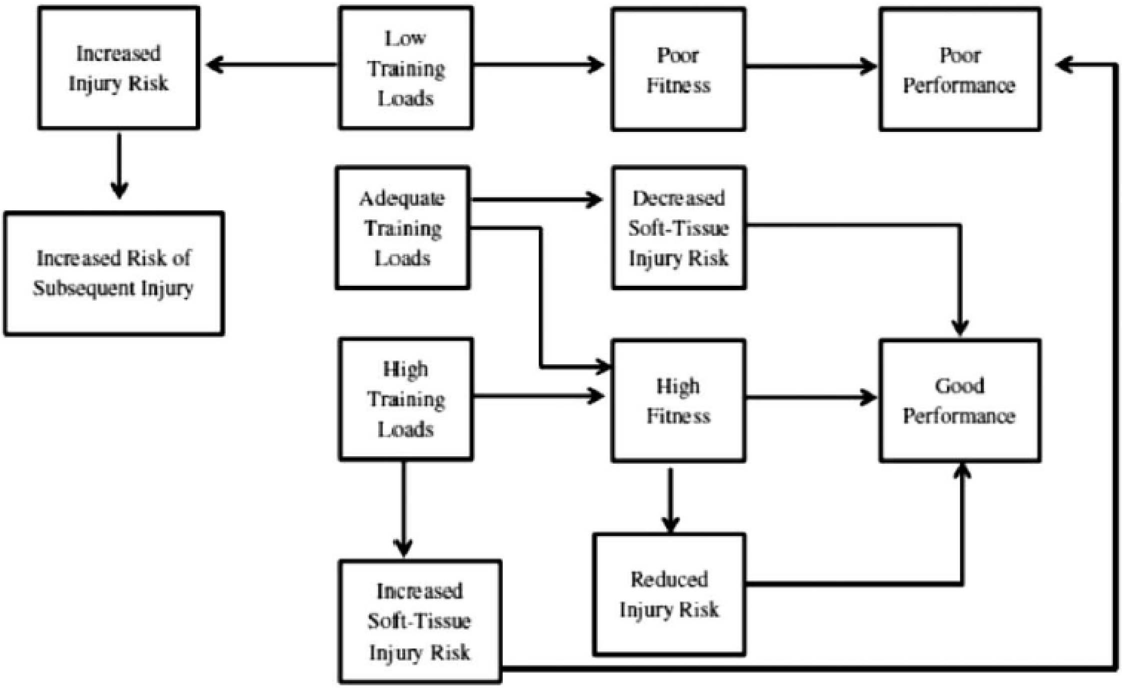

Figure 4. Possible outcomes of varying training loads (Gabbett, 2016)

The figure above displays the possible injury risks linked to both high training loads and low training loads, emphasising the importance of finding the optimal training load balance, based on the capabilities of the individual.

2.5.2 TRAINING ADAPTATIONS

Changes made to running training programs have been suggested as an additional reason for the unclear literature on the optimal training loads. A drastic increase in training load does not allow the body enough time to adapt and can therefore result in injury (Beck, 1998; Taunton et al., 2003). A radical change in training habits is a common cause of RRIs such as stress fractures (Beck, 1998; Castro, Joosse, Unlu, & Stellar, 2014) which often develop within the first two months of increased or altered training (Beck, 1998). As previously discussed, gradual loading of the bone results in remodelling to increase the strength of the bone (Hall, 2007). However, when the bone is undergoing the process of remodelling, it becomes more porous and therefore more susceptible to fractures during this time (Beck, 1998). For this reason, athletes should gradually build up their training to allow their body to adapt (Beck, 1998). Satterthwaite et al. (1999) reported that increasing weekly running frequency by one day was associated with anterior thigh RRIs and a weekly increase in distance run was associated with the incidence of hamstring injuries.

Fredericson & Misra (2007) suggested a progressively increasing training programme to reduce the likelihood of developing RRIs. To allow the body to adapt to the stresses of increased running, the theory of the 10% rule has been suggested, which states that running volume should only be increased by up to 10% (Johnston et al., 2003). This steady increase in training load should allow the athlete's body to gradually adapt, thus reducing injury risk (Beck, 1998). In opposition, when testing the theory of the 10% rule, Buist et al. (2008) found that increasing training by 10% had no effect on the risk of injury in novice runners, however this may be linked to the runners' lack of experience.

More evidence is needed to assess the potential association between changes to running training and the risk and occurrence of RRIs. Additionally, training adaptations in South African long-distance runners and the possible associations with RRIs, have not yet been studied, and therefore present a gap in the literature.

In addition to changes to training, the injury rates and risks leading up to a long-distance race present equal importance, as several studies have found increased RRIs during this period. In three out of four collegiate cross-country divisions, the rates of RRI in female runners during competition seasons, were higher than during practices (Kerr et al., 2016). Van Poppel, Scholten-Peeters, van Middelkoop, & Verhagen (2014), reported that 6 months prior to a race, the incidence of RRIs increased in recreational runners, and subsequently decreased 3 months after the race. Up to 3 months preceding a race, 22% - 35.1% of runners reported ERLP, musculoskeletal pain or RRI (van Middelkoop et al., 2008b; Lopes et al., 2011; Reinking et al., 2013). In these 3 months prior to a race, Reinking et al. (2013) specifically found that ERLP was associated with training distance. When training for a long-distance race, runners may increase their training loads (van Poppel et al., 2014), as high training volume and intensity have been shown to increase performance in runners (Scrimgeour, Noakes, Adams, & Myburgh, 1986). However, some runners may increase this load too much or too quickly, and as previously discussed, may expose themselves to a higher risk of RRIs. On the other hand, if training volume is not sufficient to prepare the runner for a race, the risk of injury may be increased during or directly after the race, as a result of under-conditioning (Satterthwaite et al., 1999). In line with this, running less than 30 km per week when training for a marathon, was reported as a risk factor for RRI (Rasmussen et al., 2013). Rasmussen et al. (2013) suggested that, a minimum weekly distance should be set as opposed to a maximum weekly distance to avoid under-conditioning before a race. It is, however, of the utmost importance that training is gradually increased to allow the body to adapt progressively.

2.5.3 ORGANISED RUNNING

Organised running includes running clubs, training sessions with coaches, athletic associations or any group of runners that train together on a regular basis. 67% of the marathon runners studied by Rasmussen et al. (2013), were part of a running club. In the study by van Poppel et al. (2016), 44.3% of marathoners and half-marathoners trained in organised running groups, and in the group of marathon runners, training in a running group was independently associated with the risk of RRIs. Van Middelkoop et al. (2008b), found that membership of an athletics association was protective for calf injuries just before or during a marathon, however it was theorised that this finding may be related to other training factors. Although not much research has investigated whether being part of organised running is associated with RRI rate or risk, it is thought to be an interesting factor to investigate in terms of training characteristics and RRI.

2.5.4 RUNNING TERRAIN

The various running terrains that have been investigated in previous studies include asphalt, rubber, concrete or cement, grass, synthetic track or tartan, gym or court floor, sand, treadmill, trail or cross-country, and turf (Wen et al., 1997; Knobloch et al., 2008; Chang et al., 2012; Fonseca et al., 2012; Tessutti et al., 2012; Fu et al., 2015; van Poppel et al., 2016; Kerr et al., 2016). In many studies, asphalt or tar is the most common running terrain (Knobloch et al., 2008). In the study by van Poppel et al. (2016), almost 9 out of 10 long-distance runners, trained on hard surfaces most of the time and trained on track or tartan very rarely.

The hardness of the surface, as well as the uniformity, have been suggested as important factors of interest in determining RRI risk. Asphalt and concrete have been reported as the hardest and least compliant surfaces, followed by rubber, synthetic track or tartan; treadmill; grass; and lastly sand (Wen et al., 1997; Tessutti et al., 2012; Hespanhol Junior et al., 2013; Fu et al., 2015). It has been suggested that softer, more compliant terrain absorbs more shock when landing, thus reducing injury risk (Satterthwaite et al., 1999; Chang et al., 2012). Tessutti et al. (2010), proposed that this enhanced shock absorption may be a result of more movement available at the foot-ankle complex when running on more compliant terrain.

When investigating plantar pressure, compared to asphalt, concrete and rubber, running on grass reduced peak plantar pressure and pressure-time integral, by distributing the pressure across the surface of the foot, as opposed to concentrating plantar pressure in a specific part of the foot as seen when running on harder surfaces (Tessutti et al., 2012). In a study by Fu et al. (2015), although no differences in plantar pressure variables were found between grass, treadmill, synthetic track, and concrete, differences existed between concrete and a treadmill with ethylene vinyl acetate (EVA) cushioning underlay (increasing surface compliance). The treadmill with EVA decreased the first plantar pressure peak as well as the pressure-time integral, compared to the concrete surface. The attenuation of plantar pressure on more compliant surfaces is theorised to create a safer running environment, with lower risk of RRI (Chang et al., 2012). Male runners who incorporated treadmill running into their training had 20.5% less RRIs than those who excluded treadmill running (Fonseca et al., 2015). In a group of collegiate, cross-country runners, injury rates were higher (measured as injuries per 100 athletic exposures) in athletic exposures (training or competition sessions) on gym or court floors compared to sessions on less stiff surfaces such as grass, turf and track or trail (Kerr et al., 2016). In marathon runners, training on tartan surfaces was an independently associated risk factor for RRIs in the year preceding the marathon race (van Poppel et al., 2016).

In contrast to higher RRI risk with harder surfaces, some studies suggest that more compliant terrains may increase injury risk. In order to propel the body forward when running on a more compliant surface, leg stiffness must increase, consequently increasing muscle activity (Tessutti et al., 2012) and energy expenditure (Kerdok et al., 2002). The increase in muscle activity of the leg could cause greater strain on muscle complexes such as the triceps surae (Beck, 1998). Supporting the theory of increased RRI risk with more compliant terrain, Wen et al. (1997) reported that runners with back or thigh RRIs ran less often on concrete or asphalt, compared to those without back or thigh RRIs. In elite runners, higher rates of Achilles tendinopathy were found with running on sand, while Achilles tendinopathy rates were lower with asphalt running (Knobloch et al., 2008), which is likely a result of increased range of motion and the need for stronger propulsion against the softer surface (Tessutti et al., 2012). Compared to concrete or asphalt, a more compliant synthetic track (tartan) increased the risk of ankle pain (Chang et al., 2012). Tartan was also found to be independently associated with RRI risk in marathon runners (van Poppel et al., 2016). It should also be noted that the retrospective design of the studies by Wen et al. (1997), Knobloch et al. (2008), Chang et al. (2012) and Fonseca et al. (2012), create "temporal ambiguity" (Wen et al., 1997) with regards to the findings; meaning that the terrain may have not influenced the injury risk or prevalence, but rather that the injured runner changed to a perceivably safer running terrain in order to prevent exacerbation of a current injury or prevent further injury (Wen et al., 1997; Knobloch et al., 2008; Chang et al., 2012).

Examining the uniformity of running terrain has shown few, but nonetheless interesting, findings. In terms of road running, roads camber toward the edges which can create uneven load distribution in the lower extremities if runners consistently run on the same side of the road (Fallon, 1996). Fallon (1996) recorded more RRIs, particularly retropatellar pain syndrome, in the left knee of ultramarathon runners, during a 1006 km road race, in which the runners were made to run on the left side of the road for the entirety of the race. Grass and cross-country terrains have been suggested as being non-uniform, as grass may have obstacles such as holes and tree roots (Tessutti et al., 2012), and surfaces often vary in cross-country running (Kerr et al., 2016). Supporting this, Kerr et al. (2016), did find that ankle sprains were the most diagnosed RRI in male collegiate cross-country runners.

Although some literature reported a specific terrain to reduce RRI risk, there have been several studies that have found no association between running terrain and RRIs (Taunton et al., 2003; van Gent et al., 2007; van Middelkoop et al., 2008b). Proposed reasons for this lack of findings, include the potential effect of the compliancy of running footwear (Chang et al., 2012; van Poppel et al., 2016), and the runners' ability to adapt leg stiffness and lower extremity kinematics, to compensate for the terrain compliancy (Creagh et al., 1998; Kerdok et al., 2002; Hall, 2007; Lieberman et al., 2010; Fu et al., 2015).

When running on harder terrain, muscle activity increases to minimise vibration in soft tissues from impact which can be injurious. This demonstrates the runner's "sensitivity to dynamic loading" (Hall, 2007). The musculoskeletal system adapts in relation to the running terrain, to keep the leg stiffness at a constant. Different running injuries may be associated with different terrains. Surprisingly, it has been theorised that harder surfaces are more likely to contribute to soft tissue injuries as a result of a more compliant limb. When running on softer terrain, leg stiffness increases, putting more strain on the bones. It has been suggested that the training terrain should be varied in order to strengthen different muscles and avoid overuse from using the same muscles, and therefore reduce the likelihood of overuse injuries (Beck, 1998).

From the literature discussed, it could be suggested that a long-distance runner should find a balance in training load, training enough but not too much. Moreover, the way that runners adapt their training loads, and the types of running terrain, are likely to influence RRI risk and therefore form an integral part of the training characteristics of the current study.

2.6 Running Experience

Running experience is usually quantified by the number of years of regular participation in running, although some studies have provided different categories describing experience. Buist et al. (2010a) classified recreational runners as novice; runners with previous experience who had started running again; and runners who were running regularly. Novice runners are those who have had little to no previous running experience, have been running for less than 6 months, or have not been running on a regular basis over a 12-month period (Taunton et al., 2003; Buist et al., 2008). These inexperienced runners have been noted as often being more susceptible to RRIs, than runners with more experience (Satterthwaite et al., 1999; Nielson et al., 2012; van Poppel et al., 2016; Vidabaek et al., 2015).

2.6.1 YEARS OF RUNNING EXPERIENCE

A few theories exist as to why this may be the case. With many years of running, musculoskeletal adaptations are likely to occur (van Middelkoop et al., 2008b), allowing the body to adequately tolerate the stresses and loads of running (Marti et al., 1988). Continuous loading from running over many years, thickens the bone as a protective mechanism (Gibson et al., 2004; Hall, 2007). This bone hypertrophy is amplified if a runner started weight-bearing exercises, such as running, during adolescence due to the high levels of growth hormone at these ages (Hall, 2007). The thickening of the bone reduces the probability of osteoporosis, decreasing the risk of RRIs such as stress fractures (Hall, 2007). A change in loading to the bones, likely contributes to injury more so in inactive people who are new to training, compared to experienced athletes who increase or change their training (Beck, 1998). Novice runners have not exposed their bodies to the stresses of running and therefore need sufficient time for musculoskeletal adaptations (Buist et al., 2008). Taunton et al. (2002), found that participating in regular activity for less than 8.5 years was a risk factor for tibial stress syndrome in runners. Additionally, Marti et al. (1988) reported that the percentage of runners with shin splints, a form of tibial stress syndrome, increased with a decrease in years of running experience.

A second theory explaining why more experienced runners may be less prone to injury is that an experienced runner would have adequate knowledge of their own running capabilities and limits and would therefore know when to stop in the event of any pain (Taunton et al., 2003; Buist et al., 2010a; Rasmussen et al., 2013). Furthermore, inexperienced runners are more likely to train erroneously (such as increasing running volume before the body has adapted to the load) compared to experienced runners (Taunton et al., 2002; Rasmussen et al., 2013).

The last theory explaining experienced runners as less susceptible to RRIs, is the “survival phenomenon”, which states that the runners with several years of experience have continued to run as they may be "injury resistant" (Marti et al., 1988; Satterthwaite et al., 1999; Rasmussen et al., 2013). Runners that may have started running around the same time as these experienced runners, but no longer run, may have dropped out as a result of injury therefore leaving the "injury resistant" runners to continue running, gaining more years of running experience (Rasmussen et al., 2013). Furthermore, Buist et al. (2010a) found that novice runners were less likely to continue running, after an RRI, compared to intermediate runners.

In support of the aforementioned theories of experienced runners being less susceptible to injury, van Poppel et al. (2016) found that half marathon runners with less than 4 years of experience, were at a higher risk of RRIs than those with more than 4 years of running experience. Satterthwaite et al. (1999) found that runners who had never run a marathon before, were 50% more likely to become injured as a result of their first marathon. Similarly, Rasmussen et al. (2013) found that running one marathon previously, lowered RRI risk. Marti et al. (1988) found that less grade III RRIs (classified as 2 weeks of training disruption) occurred in those with more experience; and the percentage of runners with knee pain and shin pain, increased with a decrease in years of experience.

Considering the argument for inexperienced runners being at a higher RRI risk, there are a few theories to support the opposite. Being more experienced may increase the risk of RRI as a result of age-related musculoskeletal degradation (Marti et al., 1988; Taunton et al., 2002), or from years of overuse (Lopes et al., 2011). Runners with the most experience are likely to be older than those with less experience, therefore the increasing age found with increasing experience (Marti et al., 1988), may influence the increased RRI risk as a result of a decline in the regenerative ability of "aging organisms" (Marti et al., 1988).

With many years of exposure to the stresses of running on the musculoskeletal system, RRI risk may be high. Eccentric muscle actions, which occur with every step in running, cause muscle damage, especially after running distances of 21 km or more (Gibson et al., 2004). Knobloch et al. (2008) and Roos et al. (2015) suggested that more years of participation in sport, could increase the likelihood of an overuse injury as a result of accumulative microtrauma and the increased possibility of a previous injury, which has also been linked to a higher risk of further injury.

Results from studies by Knobloch et al. (2008), van Middelkoop et al. (2008b) and Lopes et al. (2011), support these theories of experienced runners having a higher RRI risk. Knobloch et al. (2008) found that runners who have been running for more than 10 years were at a higher risk of back and Achilles RRIs. Runners with Achilles tendinopathy were also found to be physically active for the most years (14.5 years). Van Middelkoop et al. (2008b), reported that male marathon runners with more than 15 years of experience were more prone to knee RRIs than those with less than 15 years of experience. Lopes et al. (2011) found that runners who reported pain from running, had more years of running experience compared to those who did not report pain from running.

It is clear that the existing research on RRIs and running experience is contending, however it is interesting to note that novice and experienced runners may present different injury profiles. For example, van Poppel et al. (2014) found that the most common RRIs in runners with more than 5 years of experience, were knee RRIs, followed by calf RRIs, and then Achilles RRIs. Those with less than 5 years of experience, suffered from mostly knee RRIs, followed by shin RRIs, and then calf RRIs. Furthermore, Marti et al. (1988), found that although RRI incidence increased with a decrease in years of experience, RRI duration was longer in runners with more experience.

2.6.2 CALIBRE OF RUNNER

In addition to the years of running experience, the level of competitiveness or professionalism of a runner could potentially play a role in RRI risk and occurrence. Taunton et al. (2002) suggested that runners of higher competitive levels, may train more and have likely suffered from previous injuries, putting them at a higher risk for further RRIs. Additionally, Daoud et al. (2012) found a higher than usual injury rate of the runners in their study, and theorised that this could be due to the runners being competitive. Running experience is therefore not necessarily restricted to years of running but may also include the calibre of the runner. The potential link between running experience and RRIs is a complicated link and therefore warrants further study. The current study focuses on long-distance runners, however long-distance runners could be predominantly marathon runners, or partake in races of many distances. They may also be recreational runners, or they could be professional athletes. These factors are considered important as they could potentially be associated with RRI and will help create the descriptive profile of South African long-distance runners.

2.6.3 RUNNING RACE CHARACTERISTICS

The distances and frequency of the races appear to additionally be linked to RRI; however, the results differ throughout the literature. Running six marathons in a year, increased the risk of RRIs in male amateur marathon runners (van Middelkoop et al., 2008b). Running a marathon for the first time was found to be a significant risk factor for developing an RRI (Rasmussen et al., 2013), specifically hamstring RRIs and knee RRIs (Satterthwaite et al., 1999). In contrast, the risk of plantar fasciitis decreased with marathon running (Knobloch et al., 2008). Independently associated risk factors for half-marathon and marathon runners differed slightly in the study by van Poppel et al. (2016). In both marathon and half-marathon of runners, a BMI of less than 26 $kg.m^{-2}$, was a risk factor for RRIs. However, risk factors for only half-marathon runners included the sex of the runner, less than 5 years of running experience, seldom participation in interval training, and training once a week. Risk factors for marathon runners included less than 20 km weekly training distance, less than 5 days of training per week, running on tartan, regular interval training, regular cooling down and stretching, and running in organised running groups (van Poppel et al., 2016). These differences are likely a result of different training and personal characteristics needed to excel in the various race distances, in addition to the exposure in a marathon being two times more than in a half-marathon (Zillmann et al., 2013; van Poppel et al., 2016).

Ultramarathons appear to yield a high rate of injuries during the race. Fallon et al. (1996), reported that 72% of the runners who partook in a 1005 km race over approximately one week, suffered from a minimum of one injury during the race, that impaired performance. Ultramarathon running increased the risk of shin splints (Knobloch et al., 2008), of which medial tibial stress syndrome falls under, which was the third most prevalent RRI reported during an ultramarathon (Fallon, 1996). This shin pain is likely a result of the excessive loading experienced during ultramarathons (Fallon, 1996). An inflamed extensor retinaculum at the anterior aspect of ankle, otherwise known as “Ultramarathoner's ankle”, was noted as an RRI specific to ultramarathoners (Fallon, 1996) and is likely to occur as a result of numerous repetitions of plantar- and dorsiflexion (Fallon, 1996).

Van Poppel et al. (2014), found a higher RRI incidence in recreational runners competing in races of 15 km – 21 km, compared to those competing in races of 5 km – 10 km. Furthermore, RRI location varied slightly between the shorter distance and longer distance runners; 5 km – 10 km runners reported mostly RRIs of the knee, calf and Achilles tendon, while 15 km – 21 km runners reported mostly RRIs of the knee, hip and thigh (van Poppel et al., 2014). The finding that Achilles tendon RRIs were the third most prevalent RRI in shorter distance runners in the study by van Poppel et al. (2014), is in line with the increased injury risk of the Achilles tendon, in shorter distance runners in the study by Knobloch et al. (2008). Running half marathons decreased the injury rate for Achilles tendinopathy while running shorter races (1.5 km – 3 km) increased the risk of Achilles injuries in runners (Knobloch et al., 2008). The differences in RRI locations with different distances may be a result of differing running speeds as speed training has been found to be a risk factor for RRIs (Hespanhol Junior et al., 2013) and a faster running velocity is a risk factor for patellofemoral pain (Bonacci et al., 2014). Increased speed is likely to overload the musculoskeletal system of a runner, increasing susceptibility to RRI (Hespanhol Junior et al., 2013).

The complexity of running experience in long distance runners can be seen from the differing literature as discussed in the section above. It is clear that years of running experience, frequency of races, distance of races and the calibre of the runner is of importance when investigating types of RRIs, prevalence of RRIs and potential risk associations of RRIs.

2.7 Footwear

Research on running footwear has provided conflicting views on their role in RRI risk and occurence. Injuries continue to occur in runners using conventional, tapered shoes, regardless of the technical improvements claimed to be made to these standard running shoes (Richards, Magin, & Callister, 2009). This problem sparked an interest in running barefoot as a solution to reduce injury risk. Following this fad, minimalist shoes entered the market as a way to mimic barefoot running without actually running barefoot. In addition to these shoes, other types of running footwear exist for various terrain or training (i.e. trail shoes for uneven terrain and racing flats for sprinting). A major problem is the lack of unfunded or unbiased scientific information on ideal running footwear as much of the information comes from lay publications, as well as theories (as opposed to empirical evidence) on why barefoot running is better. The following section explores the various footwear types, their influence on running mechanics and the subsequent RRI associations.

2.7.1 SHOD RUNNING

The following section on shod footwear refers mainly to the standard running shoe, unless otherwise stated. The features of the conventional running shoe include an elevated heel, cushioning, and structural support (Logan et al., 2010). A benefit of these standard running shoes includes the protection of the foot from surface wounds due to obstacles such as glass and metal (Squadrone & Gallozzi, 2009). The cushioning is present to lessen the impact when landing, specifically with more cushioning in the heel area, producing an elevated heel (Daoud et al., 2012) as 75% of shod runners are heel strikers (Lieberman et al., 2010; Daoud et al., 2012). However, researchers have speculated that this tapered heel may actually promote heel striking (HS) (Lieberman et al., 2010; Daoud et al., 2012). Unlike forefoot striking (FFS), HS produces an impact peak in vertical GRFs and increases the loading rate. Additionally, HS results in overstride, a less flexed knee and subsequently, a less compliant limb which decreases shock absorption ability (Lieberman et al., 2010). Moreover, overstriding increases the risk of hamstring strains and knee injury (Hall, 2007). Although there is controversy in the literature regarding whether or not high GRFs are associated with RRIs, a systematic review by van der Worp et al. (2016) found that there is evidence to support GRFs contributing to the risk of stress fractures, however insufficient evidence to indicate that GRFs are linked to any other running injuries. Furthermore, twice as many repetitive stress fractures have been found in shod runners who heel strike compared to runners who forefoot strike (Daoud et al., 2012). When looking at heel strikers only, Logan et al. (2010) found that running in a more cushioned shoe produced a lower peak vertical impact force and lower loading rates compared to racing flats and distance spikes, supporting the theory that the heel cushioning is essential for runners who heel strike. Moreover, Barcellona et al. (2017) found that instructing a shod runner to land more softly resulted in greater favourable changes in lower limb kinematics, compared to only having the runners change to minimalist footwear (Vibram FiveFingers™). Although less common, shod forefoot and midfoot striking do occur. Unlike heel striking, forefoot and some midfoot strikes do not produce an impact transient at landing, as seen in Figure 5 (Daoud et al., 2012). Furthermore, loading rate is lowered when avoiding heel strikes (Daoud et al., 2012).

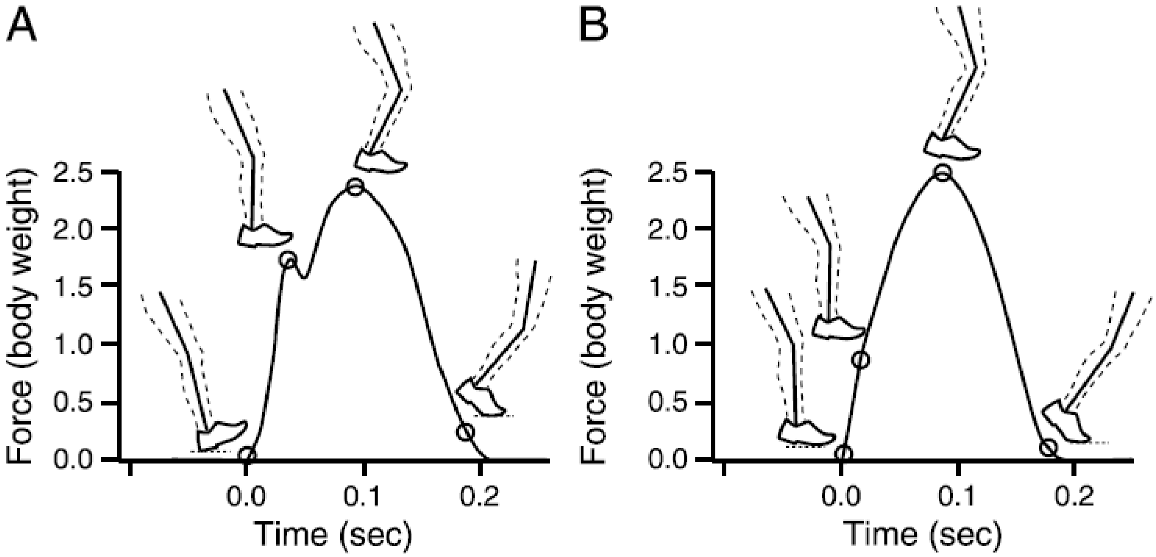

Figure 5. GRF and kinematics with standard running shoes during HS (A) and FFS (B) (Daoud et al., 2012).

Various foot strike patterns produce different torques in the lower limbs (Daoud et al., 2012). Due to the elevated heel of the standard modern running shoe, joint torques at the hip, knee and ankle are often higher in shod running than when running barefoot (Arendse et al., 2004; Kerrigan et al., 2009). Increased torque in the joints adds more strain to the surrounding nonskeletal tissue, increasing the risk of injury (Kerrigan et al., 2009). High knee torque increases the risk of patellofemoral stress and medial tibial stress (Reilly & Martens, 1972; Sharma et al., 1998; Lieberman et al., 2010;

Bonacci et al., 2013) and decreasing the joint loading at the hip and knee may reduce the likelihood of tibial stress syndrome (Heidersheit et al., 2011).

Within the category of shod running footwear, exists a wide range of shoes with different features. For runners who train on uneven terrain, trail running shoes are usually worn as they provide extra grip and flexibility. According to Giandolini et al. (2013), racing flats have been defined by the running footwear industry as a midpoint between the conventional cushioned running shoe, and minimalist shoes such as Vibram FiveFingers™.

2.7.2 BAREFOOT RUNNING

Bramble and Lieberman (2004) proposed the theory that our human ancestors ran barefoot over long-distances, making barefoot running the more natural way to run, implying that runners should be running barefoot to avoid injury. It has also been suggested that since the standard running shoe became the most popular running footwear, RRI rates have increased, suggesting that standard running shoes may be increasing injury risk. This idea also stems from the mismatch hypothesis stating that runners have maladapted to running shoes, resulting in reduced foot proprioception, altered running form and weak foot muscles; all of which is likely to increase injury risk. Subsequently, barefoot running gained popularity as a way to decrease RRI risk. In a survey done on runners who had tried barefoot running, 53% reported doing so in order to reduce injuries (Hryvniak et al., 2014).

The purported benefits of barefoot running include increased proprioception and sensory feedback, strengthening of foot muscles and promotion of a ‘natural’ landing pattern (Lieberman et al., 2010). Robbins & Hanna (1987) originally proposed the idea that proprioception and sensory feedback are enhanced with barefoot running as the foot in is direct contact with the ground, unlike when running shod. Proprioception and sensory feedback allow the runner to adjust their running technique according to the terrain (Hall, 2007), thus decreasing the risk of injury (Lieberman et al., 2010). Movements during running that result in high loading rates and impact forces may be attributed to poor proprioception in runners (Kurz & Stergiou, 2002; Riskowski, Mikesky, Bahamonde, Alvey III, & Burr, 2005; Hesar et al., 2009). With regards to foot muscle strength, shoes may help to support the structure of the foot, however this rigid support provided by the shoe does not allow for the muscles of the foot to strengthen thus resulting in weak foot muscles (Lieberman et al., 2010). Since there is no structure surrounding the foot when barefoot running, it is thought that strengthening of the foot muscles is enabled. However, the evidence contradicts these theories on improved proprioception and strength. Mullen, Cotton, Bechtold, & Toby (2014) conducted an 8-week barefoot running intervention study where no significant changes were found between pre- and post-test results regarding strength as well as proprioception.

With regards to the 'natural' way of running that is said to accompany barefoot running, forefoot striking is thought to be the most common footstrike employed by habitual barefoot runners (Lieberman et al., 2010; Daoud et al., 2012). Most habitual barefoot runners avoid heel striking, therefore reducing loading rates and eliminating the vertical GRF impact peak seen when heel striking (Lieberman et al., 2010). A negative aspect of barefoot midfoot and specifically forefoot striking is that the impact from landing travels through the metatarsals, potentially increasing the risk of metatarsal stress fractures. Moreover, this part of the foot is not layered with fatty tissue as the calcaneus bone is, to help absorb forces (Laughton et al., 2003). Furthermore, without the cushioning of a shoe, the shock is not absorbed before travelling through the foot. This being said, other mechanisms such as reduced stride length are often employed to reduce the landing impact when barefoot forefoot striking. Limb compliance is increased by reducing stride length, which increases knee flexion, additionally lowering joint torque (Kerrigan et al., 2009; Bonacci et al., 2014). These common barefoot adaptations have been found to decrease peak patellofemoral joint stress by 12%, supporting barefoot running as beneficial for runners prone to knee RRIs (Bonacci et al., 2014). In support of this, Hryvniak et al. (2014) found that 46% of knee injuries were alleviated with changing to barefoot running.

Different muscular mechanisms are employed with the various strike patterns. Midfoot and forefoot striking increase the duration and angle of plantarflexion before landing (Cauthon et al., 2013). In order to do this, plantar flexors such as the gastrocnemius, soleus and flexor digitorum longus are activated for longer (Cauthon et al., 2013). Higher and longer duration of muscle activation is likely to result in a faster onset of muscle fatigue (Olin & Gutierrez, 2013) which is associated with overuse injuries. Strong contractions of the calf muscles are needed when forefoot striking over long-distances, which is linked to the increased risk of Achilles RRIs (Azevedo et al., 2009; Barcellona et al., 2017). Extended activation of the flexor digitorum longus can add compression strain to the metatarsal bones, increasing the risk of metatarsal stress fractures (Cauthon et al., 2013), an RRI which is already provoked by landing impacts during barefoot FFS and MFS (Giandolini et al., 2013). This is supported by Hryvniak et al. (2014), who found that foot injuries were the most common injury in barefoot runners, whereas foot RRIs were only the fifth most prevalent RRIs in shod runners (Malisoux et al., 2013).

Daoud et al. (2012) theorised that changing to a forefoot strike with weak foot muscles exacerbated by running shod may cause plantar fasciitis, stress fractures or forefoot pain. Additionally, Daoud et al. (2012) suggested that Achilles tendinopathies and calf muscle strains are likely to occur in runners who transition to FFS. In support of these theories, over half of the participants in the study by Hryvniak et al. (2014) reported initial foot or Achilles pain when starting to run barefoot. Although it is likely that habitual footwear is paired with specific foot strike patterns, this is not always the case. Hatala et al. (2013) discovered a habitually barefoot population who were heel strikers. These barefoot heel strikers produced higher impact forces when heel striking, compared to when forefoot striking. Similarly, Lucas-Cuevas et al. (2016), barefoot heel striking was found to produce higher loading rates than shod heel striking. These high impact forces and loading rates are likely a result of no cushioning to absorb impact forces during barefoot running, as well as a less compliant limb (Lieberman et al., 2010). In the same sense, suddenly running barefoot will not necessarily change a heel striker to a forefoot striker. In fact, an investigation into these foot strike adaptations with footwear changes, found that runners do not always adjust their habitual foot strike patterns in different footwear conditions (Cronin & Finni, 2013; Cheung & Rainbow, 2014; Lucas-Cuevas et al., 2016). Therefore, if high GRFs and impact peaks do indeed increase the risk of RRIs, it could be theorised that without the cushioning of a shoe to enhance shock absorption (Olin & Gutierrez, 2013), barefoot heel strikers may be at the highest injury risk for impact-related RRIs.

The evidence for barefoot running as a way to decrease RRI rates is sparse and the hypothesis of increasing RRI rates being caused by running shoes is oversimplified as there are too many other variables that are possibly linked to RRI risk (Tam et al., 2014). Furthermore, modern running surfaces differ from those run on by our ancestors. With materials such as concrete, and obstacles such as glass and metal, running barefoot in the present times may result in lacerations to the feet (Squadrone & Gallozzi, 2009).

2.7.3 MINIMALIST FOOTWEAR

Minimalist shoes were created with the intention of mimicking beneficial barefoot running mechanics but with a few advantages of the standard running shoe. When compared to the conventional running shoe, minimalist running footwear often has very little or no heel elevation, is less cushioned with a thinner midsole, is lighter in weight, has less motion-control features and less heel stiffness (Lohman et al., 2011; Cauthon et al., 2013; Ryan, Elashi, Newsham-West, & Taunton, 2014). Ideally, minimalist shoes should promote forefoot or at least midfoot striking due to the lack of an elevated heel, as this heel is said to promote heel striking (Lieberman et al., 2010). As previously mentioned, forefoot striking generally produces lower loading rates and impact forces (Daoud et al., 2012). In support of this, impact forces in minimalist shoes were found to be lower than in shod running, and similar to barefoot running (Squadrone & Gallozzi, 2009). Additionally, Rice et al. (2016), found that forefoot striking in minimalist shoes produced loading rates lower than shod forefoot and heel striking. However, when habitually shod heel strikers run in minimalist shoes for the first time, it is unlikely that their footstrike patterns will change. As a result, landing on the heel in minimalist shoes with very little cushioning results in higher impact peaks and higher loading rates compared to shod heel striking (Logan et al., 2010; Willy & Davis, 2014). This may also be the reason for Giandolini et al. (2013) finding no different in loading rates between racing shoes and normal running shoes. The absence of beneficial footstrike changes may be a result of the layer of material between the foot and surface reducing sensory feedback that would be provided if the foot were completely bare (Lieberman et al., 2010). Movements during running that result in high loading rates and impact forces may be attributed to poor proprioception in runners (Kurz & Stergiou, 2002; Riskowski et al., 2005; Hesar et al., 2009). In order to correct this, it has been theorised that gait retraining should accompany footwear transitions, as this could potentially correct unfavourable changes. Although when this theory was tested, Barcellona et al. (2017), found that instructing runners to “run softly” while wearing standard running shoes resulted in similar lower limb kinematics compared to wearing minimalist footwear without instruction.

In terms of the empirical evidence of RRI occurrence in minimalist shoes, an increase in bone marrow oedema was found in more than half of a sample of runners who transitioned from conventional running shoes to Vibram FiveFingers over a period of 10 weeks (Ridge et al., 2013). Severe bone marrow oedema is classified as a stress fracture and metatarsal stress fractures have been found to occur in minimalist forefoot strikers (Cauthon et al., 2013). The risk of these bony injuries is possibly higher as a result of increased lower extremity shock from high loading rates and peak forces that occur with minimalist shoes, particularly when heel striking (Logan et al., 2010). Cauthon et al. (2013) reported on three cases where runners were injured after changing to minimalist shoes. Two patients were diagnosed with Achilles tendinopathy which could be a result of changing to a more plantarflexed landing, which requires increased duration of the calf muscle complex activation (Barcellona et al., 2017).

There is still much variation in what is considered a minimalist running shoe. Minimalist shoe studies have investigated racing flats, distance spikes, Vibram FiveFingers™, partial minimalist shoes and full minimalist shoes (Squadrone & Gallozzi, 2009; Bonacci et al., 2013; Ridge et al., 2013; Ryan et al., 2014). According to Giandolini et al. (2013), racing flats have been defined by the running footwear industry as a midpoint between the conventional cushioned running shoe, and minimalist shoes such as Vibram FiveFingers™. The racing flats used by Bonacci et al. (2013), had a slightly more elevated heel than a minimalist shoe but less than a conventional running shoe. The amount of cushioning varies throughout minimalist shoes investigated in previous studies which likely influences the differences in findings. Squadrone and Gallozzi (2009) found minimalist shoes to mimic barefoot running while Bonacci et al. (2013) found that minimalist shoes do not mimic the beneficial decreased joint torques and work produced when running barefoot. This is likely explained by the fact that the cushioning of the minimalist shoe in the study by Squadrone and Gallozzi, (2009), was half that of the minimalist shoes in the study by Bonacci et al. (2013). The data from the study by Logan et al. (2010) support the gradual transition of running in standard running shoes to minimalist shoes.

It has been found that muscle activity differs with various footstrike patterns. When heel striking, as many shod runners do, more dorsiflexion occurs before landing (Olin & Gutierrez, 2013), resulting in increased tibialis anterior activation. In contrast, barefoot and shot midfoot striking (Lucas-Cuevas et al., 2016) increases gastrocnemius lateralis activation (Giandolini et al., 2013). Muscles that are activated for longer are likely to become fatigued faster (Olin & Gutierrez, 2013), increasing the risk of RRI to those areas. Extended muscle activation is unavoidable with long-distance running, therefore regardless of the footstrike patterns, muscle fatigue is likely to occur, however extended activation in different muscle groups is likely to contribute to different types of RRIs.

2.7.4 ADDITIONAL FOOTWEAR FACTORS

An additional point to consider is that training with more than one type of shoe concurrently, has been shown to be a protective factor (Malisoux et al., 2013). As a result, it was theorised that running in more than one pair of shoes over a period of time could cause a change in the forces that are applied to the body when running, due to the difference in structures (sole hardness, sole thickness, angle of tapering) of each pair of shoes (Malisoux et al., 2013) thus giving sufficient time for tissue to adapt and strengthen. In contrast, Walter found an increased RRI risk when training in more than one pair of shoes and Wen et al. (1997) found no association between injury risk and wearing more than one pair of running shoes. However, it could be theorised that the footwear of participants in these studies were not different enough to change force application and promote the strengthening of different muscular structures.

The age of running footwear is additionally of interest in terms of RRI. Taunton et al. (2003) found that both newer and older shoes were risk factors for RRI. They suggested that this may be a result of newer shoes having better cushioning and support qualities thus acting as a protective factor against RRI, however newer shoes may also be seen as a risk factor in a cross-sectional study as injured runners may change shoes often in order to avoid further injury. In line with the theory that newer running shoes may be a protective factor, Cornwall & McPoil (2017) found that the degradation of the midsole (particularly the lateral and medial heel) cushioning occurred with increased mileage up to 640 km. The changes were significant when midsole hardness was measured with a durometer but not significant when measured by the runner, through self-perceived changes. The importance of this study lies in the fact that if a runner is not able to sense major reductions in the cushioning of the shoe, they may not adapt their running style to lessen impact forces that will increase as a result of increased midsole hardness.

Various running footwear presents different joint loads i.e. knee loading is lower but ankle loading is higher in barefoot running. Additionally, running footwear could be described as a continuum rather than separate categories as certain footwear may spill over into more than one footwear category. Fukuchi & Duarte (2008) suggested that running shoes should be designed to control movement of the rearfoot and to decrease excessive pronation through shock absorption, as these factors contribute to RRI risk. Recently, a wider range of running shoes have been developed, made to fit various foot types (Kerr et al., 2016). Although limited research has been done to test if these enhancements have any benefits, it has been suggested that a better biomechanical shoe fit such as these, may reduce injury risks (Kerr et al., 2016).

2.7.5 ORTHOTICS

Excessive or abnormal movements and forces of the lower leg are thought to contribute to injury and pain of which orthotic intervention could potentially help to control or correct. Orthotics are often used to assist in absorbing shock, controlling excessive motion and correcting biomechanical abnormalities (Nigg et al., 1999; Yeung and Yeung, 2001; Laughton et al. 2003). Different types of orthotics made with various materials are used, depending on the problem needing correction. Additionally, orthotics can be prefabricated or custom-made to fit the individual (Lucas-Cuevas et al., 2014). The use of orthotics is not uncommon among long-distance runners, for example, a third of master runners in a study by Knobloch et al. (2008) reported using orthotics.

Plantar fasciitis is a common RRI in runners (Taunton et al., 2002; Lopes et al., 2012). Runners who have suffered from plantar fasciitis often demonstrate higher vertical GRFs and flat arches, compared to injury-free runners (Pohl et al., 2009). Since orthotics should reduce impact forces during running (Laughton et al., 2003) and provide arch support, the risk of plantar fasciitis could be lowered. Additionally, Ribeiro et al. (2016) suggested that orthotics that control rearfoot valgus alignment and reduce loading could also reduce the risk of plantar fasciitis, as rearfoot valgus was found to be associated with increased plantar loads over the rearfoot in runners with plantar fasciitis. The findings from the study by Lucas-Cuevas et al. (2014) support this as they found that mean peak pressure and the duration of pressure applied to the lateral midfoot was significantly decreased with the use of orthotics (custom-made and prefabricated). In contrast, Lieberman et al. (2010) theorised that orthotics that provide arch support may result in weakened muscles thus increasing strain and leading to plantar fasciitis, however this is not supported by empirical evidence.

Patellofemoral joint loading was significantly reduced in recreational runners when running with orthotics (Sinclair et al., 2015a). Since the risk of patellofemoral injuries are increased with high patellofemoral joint loading, orthotic intervention could reduce the incidence of knee injuries in runners through reducing joint loading.

Motion-control is one of the features of most orthotics. Runners with pronation have been found to benefit from motion-control footwear and are at a higher risk of injury than those with neutral feet, if they run with normal shoes lacking motion-control features (Malisoux et al., 2016). Additionally, excessive pronation has been found to be a risk factor for Achilles tendinopathy (McCrory et al., 1999).

A systematic review by Collins, Bisset, McPoil, & Vicenzino (2007), reported that orthotics are efficient in preventing lower limb overuse injuries, however, with regards to the treatment of injuries, proof is lacking. Whether orthotics work, depends on the needs of the needs of the runner (Kerrigan et al., 2009). The use of orthotics by runners with little need for biomechanical correction or increased shock absorption may have no effect. Malisoux et al. (2016) found that motion-control shoes did not affect injury risk in runners with neutral or supinated feet, only in runners with pronation. A problem arises when orthotics have an adverse effect and increase injury risk instead of preventing injury risk. A systematic review by van der Worp et al. (2015), found moderate evidence to support that the use of orthotics increases injury risk in the leg. Similarly, Wen et al. (1997) found a higher prevalence of injuries with orthotic use, especially foot injuries.

2.8 Cross training

In the current study, cross training referred to any physical activities, excluding running, that the participant took part in, on a weekly basis. In several previous studies, less participants took part in weekly cross training activities than those who did (Satterthwaite et al., 1999; Buist et al., 2010b). Those that did cross train, took part in a wide range of activities, from ballet to cycling (Iwamoto & Takeda, 2003; Buist et al., 2010a; Buist et al., 2010b).

In terms of associations between cross training and RRI occurrence and risk, previous studies have reported varying results. Taunton et al. (2003), proposed that cross training may have positive effects on runners, as other activities may assist with rectifying strength imbalances in muscles that are secondarily used during running. A review on tendinopathy in athletes, by Reinking (2012), reported evidence for eccentric exercise successfully treating patellar tendinopathy and non-insertional Achilles tendinopathy. On the opposite side of the spectrum, cross training in runners may increase RRI risk as a result of cumulative stress from additional activities (Satterthwaite et al., 1999). Marti et al. (1988), reported that in Switzerland, skiing injuries were 6 times more frequent than running injuries, and injuries from all other sports were 2 to 2.5 times more frequent than running injuries. If a runner is then participating in these types of high injury-risk sports, an increase in injury risk is probable. In support of these theories, Buist et al. (2010a) found previous sports activity in male runners to be an RRI risk factor, and Satterthwaite et al. (1999), found that participation in other sports increased RRI risk, however a key differentiator in some studies was the type of sports and how they increased different RRI risks. Separating cross training activities into weight bearing and non-weight bearing, provides further information on how RRI risk may be affected,

Cross training activities are often categorised as weight bearing and axial loading activities, or non-weight bearing and non-axial loading activities (Iwamoto & Takeda, 2003; Taunton et al., 2003; Buist et al., 2010a; Buist et al., 2010b). Weight bearing activities include activities such as running, tennis, aerobics, basketball and ballet, to name a few (Iwamoto & Takeda, 2003; Buist et al., 2010a; Buist et al., 2010b). Non-weight bearing activities consist of activities such as cycling and swimming (Buist et al., 2010a; Buist et al., 2010b).

Non-weight bearing activities allow the impact on the musculoskeletal system to be reduced, while still facilitating fitness improvement (Taunton et al., 2003), while weight bearing activities may add additional strain to the same areas as running. Tibial stress fractures are a common injury in athletes who participate in weight bearing sports (Iwamoto & Takeda, 2003). On the other hand, weight bearing activities could have more positive effects than non-weight bearing activities. Buist et al. (2010b) proposed that non-weight bearing sports may increase respiratory fitness levels which could cause a runner to push their musculoskeletal system harder during running. However, because the body may have not adapted to the impact forces as well as the runners who participate in other weight bearing activities; the swimmers and cyclists may be at an increased risk for RRI when running. Buist et al. (2010a) found female recreational runners who participated in non-weight bearing activities, were at a higher risk for RRI, than those participating in weight bearing activities. Similarly, Buist et al. (2010b) discovered that male novice runners who participated in non-weight bearing sports, were at an increased risk for RRI, compared to those who took part in weight bearing activities. With these findings in mind, it is likely that different types of cross training are associated with different types of RRIs. Satterthwaite et al. (1999), found that runners who participate in cycling, a non-weight bearing activity, were more prone to front thigh RRIs, while runners who took part in aerobics, a weight bearing activity, were at a higher risk of hamstring RRIs.

It is evident that the literature on cross training and running, and the subsequent risk of RRI, is unclear. However, it is apparent that the nature of the cross-training activities is of importance when investigating the risk of RRI in long-distance runners.

2.8 Conclusion

The review of the existing literature shows the contention surrounding possible running related injury contributors and risk factors, as well as the areas where more research is needed, especially surrounding South African long-distance runners. A basis of understanding of the theories and findings relating to RRIs, is essential to formulate a study from which the gaps in the literature can be filled, and future studies can build on. This way, the RRI research community can move forward, assisting long-distance runners, physicians and coaches, to take a preventative approach to reduce running injuries.

CHAPTER III

METHODOLOGY

3.1 Introduction

As running is a large contributor to sports injuries (Rothschild, 2012), it is important to investigate the many factors that may increase the risk of these injuries. Running research has presented a vast amount of literature relating to injury, however the South African population of long-distance runners and the subsequent injury risk, has been greatly understudied (Puckree et al., 2007; Ellapen et al., 2013). In addition to the understudied South African context, the potential RRI associations have not been studied to the full potential. Out of the hundreds of RRI studies, only a few studies have investigated several potential risk factors (Meeuwisse, 1994; McCrory et al., 1999; Satterthwaite et al., 1999; Taunton et al., 2002; Taunton et al., 2003; Buist et al., 2008; Knobloch et al., 2008; van Middelkoop et al., 2008b; Buist et al., 2010; Reinking et al., 2013), as opposed to focusing on one or two, however none of these studies have been done on the South African population.

The following chapter deconstructs the methods used in the current study and describes each aspect that forms part of the methodology.

3.2 South African context

The study was specifically designed for the South African population as it is unique in that the population is ethnically diverse, susceptible to non-communicable diseases (Mayosi et al., 2009) and high poverty rates (Bhorat, 2012). These distinctive traits that characterise this population, influenced the design of the current study. Furthermore, very few studies have investigated running related injuries in South African long-distance runners and the studies that had, had focused on sub populations within SA as opposed to the population as a whole (Puckree et al., 2007; Ellapen et al., 2013).

The population of SA is made up of 4 main racial groups according to the 2011 Census of South Africa (Stats SA, 2011). Black Africans make up 79.2 % of the South African population, coloured people make up 8.9 %, Caucasian people make up 8.9 %, Indian and Asian people make up 2.5 % together and "other" races make up 0.5 % of the SA population (Stats SA, 2011). SA has one of the highest numbers of official languages, originating from diverse ancestral origins, further demonstrating the uniqueness of the South African population. Table III shows the 11 official languages of SA and the associated percentage of home language speakers, also including other unspecified languages and sign language, from the 2001 Census (Stats SA, 2001).

Table III. Official languages of SA and the associated percentage of speakers

Languages	**Percentage of speakers (home language)**
Zulu	22.7 %
Xhosa	16 %
Afrikaans	13.5 %
English	9.6 %
Northern Sotho/Sepedi	9.1 %
Setswana	8 %
Southern Sotho/Sesotho	7.6 %
Tsonga	4.5 %
Swati	2.5 %
Venda	2.4 %
Ndebele	2.1 %
Other	1.6 %
Sign language	0.5 %

3.3 Participant selection and recruitment

3.3.1 INCLUSION CRITERIA

The sample that was selected, aimed to represent the population of South African long-distance runners. The minimum sample size needed was identified as 200 participants, in order for any small to moderate associations between risk factors and injuries to be identified (Bahr & Holme, 2003). The participants that made up this sample had to fit the criteria of a long-distance runner in order to be included in the current study, however this definition differs between studies. In previous studies, weekly distance run and how long the runner has been running for, has been used as inclusion criteria for long-distance runners. Hreljac (2005) defined a long-distance runner as a person who has been running 20-30 km per week for at least one year. Similarly, Lieberman et al. (2010) used participants that ran a minimum of 20 km per week however, Lun et al. (2004) recruited recreational runners who ran no more than 20 km per week. Crowell et al. (2010) only included participants who ran at least 32 km per week for the past 3 months. With the above-mentioned criteria, the current study included participants that ran a minimum of 20 km per week for the past 6 months. This was done as running experience was one of the factors that was tested, therefore runners with little experience had to be included however still needed to be running for a long enough period to be considered long-distance runners. The current study included runners regardless of whether or not they had been previously injured, to allow investigation of the factors that may influence the reasons for some runners being prone to injury while others are not. The injured participants were included, provided that these participants fitted the inclusion criteria for the study, prior to the injury. This broadens the range of participants that could have been recruited as some participants may have been injured around the time of receiving the questionnaire.

3.3.2 EXCLUSION CRITERIA

Runners who have not run in over a year were excluded due to recall bias (Ristolainen et al., 2010; van Poppel et al., 2016) as running injuries and training habits may be more difficult for these participants to recall and therefore the answers to the questionnaire may not be accurate. Participants had to be South African citizens as the current study aimed to identify how the South African population differs to previously studied populations of long-distance runners.

3.3.3 RECRUITMENT

There are several ways of recruiting long-distance runners as participants, which include posting links to the questionnaire on running websites, placing an advertisement in a running club newsletter or local media (Knobloch et al., 2008; Buist et al., 2010), handing out questionnaires at popular races or having the questionnaire added to pre-race pack (Reinking et al., 2013). The limitation of this last method when studying injury, is that runners who are currently injured are not likely to be participating in races, therefore these runners would be unintentionally excluded from the study.

Postal questionnaires are another method of recruiting participants as done in a study by Nicholl et al. (1995) which had a 68% return rate however, this was in 1995 and in the current times, email is used more often, is faster and more reliable (Chen et al. 2010). Thus the current study made use of email and the internet to reach as many potential participants as possible as done in previous studies (Hespanhol et al., 2012, Reinking et al., 2013; van Poppel et al., 2014; Zwingenberger et al., 2014). Since a runner has to be registered with a running club to compete in the Comrades which holds the record for the greatest number of runners in the world in 2010 (Guinness World Records, 2015), contacting running clubs via email yielded a large number of potential participants for the current study. The website "Runner's Guide" provided a list of many of the running clubs in SA as well as the email addresses of these clubs. The names and contact details of these clubs can be found in the appendices. In addition to this, participants were recruited by word of mouth as done by Williams et al. (2001) as well as on the social networking site, Facebook® where a participant recruitment picture was posted in running groups (see Appendices). Moreover, a half marathon in the Eastern Cape was attended in order to recruit participants.

3.4 Experimental design

The current study employed a cross-sectional, retrospective approach, using an online questionnaire designed specifically for the South African long-distance running population. Previous sport related injury studies have used retrospective questionnaires with cross-sectional study designs (Lopes et al., 2011; Reinking et al., 2013; Zwingenberger et al., 2014). The advantages of using a cross-sectional, retrospective design include the ability to investigate many factors, and large sample sizes to be studied (Bahr & Holme, 2003; Lopes et al., 2011; Hespanhol Junior et al., 2012). Conducting a retrospective questionnaire has a higher chance of recruiting many participants than intervention or cohort studies, as this method is not limited by area. An online questionnaire allows access to a large range of prospective participants all over SA as it can be quickly and easily accessed via the internet (Gunn, 2002). Furthermore, it is a form of self-report (Wen et al., 1997; Lopes et al., 2011) which assists in reducing investigator bias (Clarsen et al., 2013). Due to the large number of factors that were investigated in the current study, and the need for a large sample size, a cross-sectional design using a retrospective questionnaire was deemed as the most efficient and effective method of collecting the relevant data. The disadvantage of a retrospective study is the inability to identify causal relationships, however as the current study is aimed at being more explorative in nature, the disadvantage is outweighed by the advantages.

Several websites were available to facilitate the development of a web-based questionnaire, such as Google Forms, SurveyMonkey®, and FluidSurveys™. For the current research questionnaire, Google Forms was selected as this resource is free and allowed for many questions to be posted, whereas other websites allowed a limited amount of questions and were not free. Additionally, Google Forms allowed for various question formats such as multiple choice, long questions and short questions. Once the questionnaire had been completed, Google Forms loaded the results onto a spreadsheet, which was useful for data reduction. Another advantage of using Google Forms is that it provided a "logic threading" feature which allowed the subsequent question to change, depending on the answer that had been previously chosen, provided this previous question was multiple choice.

3.4.1 QUESTIONNAIRE STRUCTURE AND CONTENT

The current study examined factors relating to the runner, that have been investigated in previous studies (see Chapter II) and shown to be associated with RRI risk and occurrence. Studying these factors further, may help to determine any associations that may exist between specific factors and developing an RRI (Williams et al., 2001; van Ginckel et al., 2009; Daoud et al., 2012) thus providing information to potentially reduce RRI risk and prevalence. These factors have also been understudied in the South African long-distance running population, making them relevant to the current study. Because RRI risk and occurrence is multifaceted, it is imperative to consider more than one area of interest. In order to effectively determine possible injury associations, the potential risk factors investigated in the current study were organised into five different sections: personal characteristics and demographics of the participant, training characteristics, running experience, footwear, and cross training. This division facilitates an understanding of where the majority of associations may lie. Additionally, characteristics relating to RRI formed a separate section.

The details of the researched factors are presented in the review of literature, for further details please refer to Chapter I and II. These specific factors were chosen as they were able to be self-reported and did not require direct measurement by an investigator. In order to ensure that the methods can be easily followed, the questionnaire used for the study has been placed in the appendix (see appendix A). The design of the questionnaire ensured that the questions were as direct and unambiguous as possible and that each question was worded in a neutral way and did not prompt the participant for a specific answer. The questionnaire consisted of open-ended questions and close-ended questions with a selection of answers informed by previous studies (See table III) for ease of data collection (Gunn, 2002). Several questions were open-ended in order not to limit the participants' answers and to avoid the participants choosing an answer that was not a true reflection of their answer, as a result of their option not being listed. Furthermore, at the end of each question, a comment box was offered for any further notes that the participant may want to add, as done in the study by Hespanhol Junior et al. (2013). This was done to ensure that information that might be useful for the study was not overlooked.

The following section highlights the literature used to determine the specific questions that were included in the questionnaire. The key studies that informed the design of the current study were van Middelkoop et al. (2008), Lopes et al. (2011), Hespanhol Junior et al. (2012), Clarsen et al. (2013), Reinking et al. (2013) and Zwingenberger et al. (2014). Questions were formulated based on the areas of research that were lacking or contending in the literature and areas that required research within the South African population.

Table IV indicates which questions were newly formulated and which were taken from previous questionnaires based on sports injuries. After the pilot questionnaire, the final questionnaire was adjusted accordingly and sent out to participants.

Table IV. Characteristics of questions in questionnaire

Personal Characteristics and Demographics			
Question	**Based on previous literature ?**	**Reference**	**Open- or close-ended**
Age	**Yes**	Fallon (1996), Fredericson et al. (2000), Williams et al. (2001), Lun et al. (2004), Buist et al. (2008), Knobloch et al. (2008), Middelkoop et al. (2008a), Azevedo et al. (2009), Buist et al. (2010), Lopes et al. (2011), Abate et al. (2012), Bennett et al. (2012), Daoud et al. (2012), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), Reinking et al. (2013), van Poppel et al. (2014),	Open
Sex	**Yes**	Fredericson et al. (2000), Hreljac et al. (2000), Williams et al. (2001), Lun et al. (2004), Buist et al. (2008), Knobloch et al. (2008), van Middelkoop et al. (2008a), Azevedo et al. (2009), Buist et al. (2010), Lopes et al. (2011), Bennett et al. (2012), Daoud et al. (2012), Hespanhol Junior et al. (2013), Reinking et al. (2013), van Poppel et al. (2014).	Closed
Stature, mass.	**Yes**	Fredericson et al. (2000), Hreljac et al. (2000), Williams et al. (2001), Lun et al. (2004), Järvinen et al. (2005), Buist et al. (2008), Knobloch et al. (2008), Middelkoop et al. (2008a), Azevedo et al. (2009), Buist et al. (2010), Ristolainen et al. (2010), Lopes et al. (2011), Abate et al. (2012), Daoud et al. (2012), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), van Poppel et al. (2014).	Open
Ethnicity	**Yes**	Reinking et al. (2013)	Closed
Ethnicity of parents	**No**	-	Closed

Country of origin of parents	**No**	-	Open
Home language	**Yes**	McKune et al. (2009).	Closed
Home language of parents	**Yes**	McKune et al. (2009).	Closed
Monthly income	**Yes**	Nicholl et al. (1995), van Middelkoop et al. (2008a), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013).	Closed
Training characteristics			
Question	**Based on previous literature?**	**Reference**	**Open- or close-ended**
Weekly training frequency	**Yes**	Lun et al. (2004), Buist et al. (2008), Knobloch et al. (2008), Middelkoop et al. (2008a), Ristolainen et al. (2010), Lopes et al. (2011), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), van Poppel et al. (2014).	Closed
Weekly training distance	**Yes**	Fallon (1996), Hreljac et al. (2000), Williams et al. (2001), Buist et al. (2008), Knobloch et al. (2008), Middelkoop et al. (2008a), Lopes et al. (2011), Abate et al. (2012), Bennett et al. (2012), Daoud et al. (2012), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), Reinking et al. (2013), van Poppel et al. (2014).	Closed
Weekly training duration	**Yes**	Middelkoop et al. (2008a), Ristolainen et al. (2010), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), van Poppel et al. (2014).	Closed
Number of training months per year	**Yes**	Malisoux et al. (2014).	Open

Running terrain	**Yes**	Hreljac et al. (2000), Knobloch et al. (2008), Middelkoop et al. (2008a), Lopes et al. (2011), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), Reinking et al. (2013).	Closed
Changes in training program over past year	**Yes**	Hreljac et al. (2000)	Closed
Running experience			
Question	**Based on previous literature?**	**Reference**	**Open- or close-ended**
Running experience (years spent running)	**Yes**	Fallon (1996), Lun et al. (2004), Buist et al. (2008), Knobloch et al. (2008), Middelkoop et al. (2008a), Buist et al. (2010), Lopes et al. (2011), Abate et al. (2012), Hespanhol Junior et al. (2012), Hespanhol Junior et al. (2013), van Poppel et al. (2014).	Closed
Preferred race distances	**Yes**	Knobloch et al. (2008), Hespanhol et al. (2012).	Closed
Number of competitions of various race distances	**Yes**	Knobloch et al. (2008), Middelkoop et al. (2008a).	Closed
Race seeding	**No**	-	Closed
Sponsored or professional athlete	**No**		Closed

Currently training for a race?	**Yes**	van Poppel et al., (2016).	Closed
Running footwear			
Question	**Based on previous literature?**	**Reference**	**Open- or close-ended**
Running footwear	**Yes**	Hreljac et al. (2000), Lun et al. (2004), Knobloch et al. (2008), Middelkoop et al. (2008a), Hespanhol Junior et al. (2012).	Closed
Foot orthotics or insoles	**Yes**	Lun et al. (2004), Knobloch et al. (2008), Bennett et al. (2012), Hespanhol Junior et al. (2012), Reinking et al. (2013),	Closed
Cross-training			
Question	**Based on previous literature?**	**Reference**	**Open- or close-ended**
Participation in other sports (Cross training)	**Yes**	Hreljac et al. (2000), Buist et al. (2008), Knobloch et al. (2008), Middelkoop et al. (2008a), Buist et al. (2010), Hespanhol Junior et al. (2012), Reinking et al. (2013),	Closed
Running related injury characteristics			
Question	**Based on previous literature?**	**Reference**	**Open- or close-ended**

Running related injury history	**Yes**	Fallon (1996), Fredericson et al. (2000), Lun et al. (2004), Buist et al. (2008), Knobloch et al. (2008), Buist et al. (2010), Ristolainen et al. (2010), Bennett et al. (2012), Hespanhol et al. (2012), Hespanhol Junior et al. (2013), Reinking et al. (2013).	Open
Location, nature, mechanism (overuse or acute) of previous injury	**Yes**	Williams et al. (2001), Gerlach et al. (2005), Knobloch et al. (2008), Ristolainen et al. (2010), Bennett et al. (2012), Ellapen et al. (2013), Hespanhol Junior et al. (2013), Reinking et al. (2013).	Open
Duration, full recovery (before training), professional diagnosis, surgery of injury	**Yes**	Gerlach et al. (2005)	Closed

3.4.1.1 Personal characteristics and demographics

As highlighted in the review of literature; age, sex, stature and mass, were the key personal characteristic risk factors of running related injuries in previous research and were asked in the standard format as previous studies have done (

Table IV). Previous studies have reported the importance of sex and age on the running related injury risk of athletes (

Table IV), however most of the literature available is in disagreement of exactly how these factors influence injury risk. Thus, the interaction between the age and sex of a runner and this effect on injury risk has been investigated in this study. Stature and mass were additionally deemed as important as these factors could be risk factors for injury according to previous studies (

Table IV). Stature and mass were used to calculate the Body Mass Index (BMI) of the participants. Being overweight has been found to increase the likelihood of some sports induced injuries (Järvinen et al., 2005), and although BMI is not the most accurate indicator of obesity as it does not take into consideration body composition, it is a viable tool in questionnaires.

A few previous studies done on sports injuries have asked participants about their ethnicity (Reinking et al., 2013). Ethnicity has been shown to influence muscle composition (Ama et al., 1986), athletic performance (Kohn et al., 2007; Deason et al., 2012) and injury risk (Kong & Heer, 2008). Although the focus of much research has compared African to European or Caucasian athletes (Bosch et al., 1990; Larsen, 2003; Larsen et al., 2004; McKune et al., 2009), it is important to recognise the diversity that exists within the African continent (Tishkoff & Williams, 2002). It has been previously found that some athletes of the same ethnicity but of different geographical origin are genetically predisposed to excel at different sports (Larsen, 2003; Tucker et al., 2015) and have varying injury risks (Woods et al., 2004; Kong & Heer, 2008). For example, African athletes from West Africa (or at least West African descent) are biomechanically, anthropometrically, and physiologically very different to those from East Africa. This is particularly evident in the athletic events that these athletes have excelled in, with West African success in sprint events and East African success in endurance events (Tucker et al., 2013). Similarly, it cannot be assumed that athletes that originate from Southern Africa are going to be similar to the athletes from other parts of Africa. Consequently, it is imperative that the science involved in trying to understand performance is not reduced to ethnicity alone, but rather that the historical geographical origin or location of an athlete’s ancestors would appear to infer certain genetic traits for performance in these athletes (Deason et al., 2012). As such, a key focus of the current research was to establish whether associations exist between the ethnic origin of participants, and RRI characteristics. It was deemed an important component of the current study, especially considering the ethnic diversity that characterises SA (Stats SA, 2010). However, participants cannot be categorised by ethnicity alone as there is often as much, if not more, genetic variation within an ethnic group, as between ethnic groups (Tishkoff & Williams, 2002; Yudell, Roberts, Desalle, & Tishkoff, 2016). The current study cannot directly determine the genetics of the participants however, to ensure that the questionnaire provided accurate data on the ethnic background of the participants, the ethnicities of the participants' parents were asked, in addition to the home language and historical geographical origin of the participants and their parents (Kohn et al., 2007; McKune et al., 2009). Although the parental origin may not completely describe the ancestry and therefore genetic origin of the participant, it can be cumbersome to go as far back as the participants' grandparents or further into the ancestry. Additionally, the participant may not have access to this information. Home language and historical geographical origin have not been considered in previous studies on running injuries but were further determined to be of interest within the South African context.

With regards to socioeconomic background, according to Stats SA (Lehohla, 2015), the South African poverty line has been defined as living on less than R779 per month in 2015 and more than half of SA was living below this poverty line. Therefore, there may potentially be long-distance runners in SA that fall under this poverty line. Post-apartheid, SA's income inequality has increased therefore creating a drastic difference between the largest and smallest income brackets, as well as between the racial groups (Liebbrant et al., 2012). This socioeconomic diversity is important to address as it affects the standard of living of the South African population with disease being prevalent in the poorer areas (Mayosi et al., 2009). The presence of disease results in compromised health status (Bourne et al., 2002), possibly increasing the susceptibility to injuries. Previous studies investigating exercise and sport related injuries (Nicholl et al., 1995; Hespanhol Junior et al., 2013) deemed it important to inquire about the employment and education of the participants. Refer to Chapter II for further information on socioeconomic status and running related injury risk.

3.4.1.2 Training characteristics

Information regarding the training characteristics of a runner is imperative to any injury related study, as training characteristics largely influence the risk of a running related injury as found in previous studies (

Table IV). Therefore, in the current study, questions pertaining to training characteristics such as frequency, distance, duration, and terrain were asked. Furthermore, these training characteristics of South African long-distance runners are unknown, as well as whether associations exist between training characteristics and injury risks, as in previously studied populations (van Poppel et al., 2016).

3.4.1.3 Running experience

The years of running experience vary between studies. Novice runners, who can be defined as runners having less than 3 years of experience (Reinking et al., 2013), have been found in most studies to be more likely to develop injuries than experienced runners (Taunton et al., 2002; Fredericson & Misra, 2007; Reinking et al., 2013), however this may be age dependent (van Gent et al., 2007; Buist et al., 2008) or a result of the healthy runner selection bias (Wen, 2007 as cited by Buist et al., 2008) in which runners who do not become injured, continue running. To ensure that the effects of both age and running experience on injury risk were equally accounted for, the questionnaire included both factors. Within the South African population of long-distance runners, the effect of running experience on injury risk is unknown and may differ from previous literature. For these reasons, questions relating to running experience were presented in the questionnaire. Some of the questions in this section were informed by previous studies (Wen et al., 1997; Lopes et al., 2011; Reinking et al., 2013).

In terms of the level of competitiveness, Zwingenberger et al. (2014) stated that it is possible that professional athletes have more weekly training hours which could influence RRI characteristics, therefore questions pertaining the current race seeding were asked, and whether the runner was a professional or sponsored runner. Additionally, questions on current training for races were asked, as it is likely that running related injury risk varies in relation to whether or not the participant is currently training for a race or not (van Poppel et al., 2014). The number of races of specific distances, done in the past year, was asked, in addition to the preferred race distances of the participant as half marathon runners and ultramarathon runners, for example, are likely to have different associations with RRI characteristics.

3.4.1.4 Footwear

In the last few years, barefoot and minimalist running has increased in popularity (Lieberman, 2012) and is therefore an area that should not be ignored. The literature supports barefoot (Divert et al., 2005; Hanson et al., 2010; Lieberman, 2012; Hvryniak et al., 2014) and shod (Franz et al., 2012; Olin and Gutierrez, 2013; Willson et al., 2013) running however, both footwear conditions have been associated with running related injuries (Järvinen et al., 2005). For this reason, it is important to investigate the relationship between runners' running shoe choice and the running injury history.

No studies on running footwear and injury risk have been done within the South African population. It is therefore unknown how running footwear may contribute to injury in this specific population. The specific running footwear referred to in the questionnaire was chosen as many studies on running footwear have been done on or included the following footwear; normal running shoes (Divert et al., 2005; Perl et al., 2012; Bonacci et al., 2013; Cauthon et al., 2013; Shih et al., 2013), minimalist shoes (Perl et al., 2012; Bonacci et al., 2013; Cauthon et al., 2013), barefoot running (Divert et al., 2005; Bonacci et al., 2013; Shih et al., 2013) and racing flats (Bonacci et al., 2013). Socks were included as a footwear choice in the questionnaire and although socks are not often used to run in, if any runners do run in socks, it should be noted as although they provide little support such as barefoot running, socks would reduce sensory feedback as the foot is not in direct contact with the ground (Lieberman, 2012).

The participants were questioned on whether there was a recent change from one type of running footwear to another, as runners have been found to be at a higher risk of injury if they have recently changed to barefoot running from shod running (Cheung & Rainbow, 2014) therefore it is important to find out if this is the case with a change to other footwear and how the South African population is affected.

3.4.1.5 Cross training

Previous studies have shown that participating in other sport lessens the likelihood of injury as a result of strengthening other muscle groups (Malisoux et al. 2013). However, a study done on a sub-population within SA found contrasting results (Ellapen et al., 2013) which may be due to a different population being studied to those studies previously done, thus demonstrates a need for further research into the South African population.

Enquiring about participation in other sports or exercise, was based on a section in a study by Nicholl et al. (1995) and on a study by Reinking et al. (2013). As some sports often have high injury rates such as soccer and rugby (Nicholl et al., 1995), participating in other sports such as these, may then increase the risk of developing an injury in another sport such as running or even exacerbate current injuries. Therefore, the questionnaire of the current study asked participants to specify which type of activities they participate in.

3.4.1.6 RRI characteristics

RRI definitions have varied across studies. According to Buist et al. (2008), an RRI is musculoskeletal pain or discomfort in the lower limbs or back caused by running, which results in not being able to run for at least one day. Pain occurring while running, directly after a run, or pain resulting in the runner having to decrease running duration or stop completely, would additionally be considered a running related injury (Taunton et al., 2002). The Injury Surveillance System (Dick et al., 2007) defined a reportable injury as one that was a result of training, needed medical attention or caused the athlete to lose one day of training. These definitions could be considered time-loss definitions which are the most commonly used method of describing an injury as it describes the extent of the injury and how it affects the athletes training (Clarsen et al., 2013). However, the current study did not use a time-loss definition for injury as it is believed that some runners would run through injuries and pain, therefore these injuries would be overlooked if the time-loss injury definition was used. More than three times the amount of non-time loss RRIs occurred in collegiate cross-country runners, compared to time-loss injuries (Kerr et al., 2016), emphasising the importance of not limiting RRI definitions to time-loss definitions. To ensure that the participants reported on any pain to reduce the chance of missing any injuries, both of the words “pain” and “injury” were used. This allowed all injuries or pain to be reported, whether or not training was affected.

The participants were asked to define each running related injury using injury descriptions from previous studies (Wen et al., 1997; Clarsen et al., 2013; Ellapen et al., 2013; Zwingenberger et al., 2014). Information such as the duration, location, and nature (feeling) of the injury and whether the injury developed gradually or suddenly (overuse or acute) was asked. Participants were required to report on any injury or pain within the last 12 months (Gerlach et al., 2005). Enquiring about any injuries prior to 12 months may have yielded incorrect information due to difficulty in remembering the details of each injury.

Recurrence of an RRI was asked in the questionnaire as having had a previous injury increases the risk of developing additional injuries which was demonstrated by the findings in previous studies (refer to

Table IV). Despite the evidence, it is unknown whether the South African population reflects the same results as previous studies.

3.5 Data collection

3.5.1 PILOT QUESTIONNAIRE

Two running clubs were chosen to receive the pilot questionnaire via email before being sent to running clubs all over the country. This was done to ensure that the questions were comprehensible, and the participants' answers would provide the necessary information needed for the current study. In a similar study by Reinking et al. (2013), five runners were sent the initial questionnaire to assess usability and adapted accordingly, before the final questionnaire was sent out. The pilot questionnaire was adapted by assessing the answers of the pilot questionnaire group and adapting the questions accordingly, to ensure that all questions were easy to understand. The following aspects were updated after the pre-questionnaire phase:

- The duration of orthotic use was changed to a close-ended question
- The descriptions of each injury were separated into different questions instead of describing the entire injury in one answer.

Additionally, sending out an initial questionnaire assisted in testing the questionnaire response rate of participants.

3.5.2 FINAL QUESTIONNAIRE

Of the 1811 running clubs listed on the Runners' Guide website (www.runnersguide.co.za), 57 were excluded due to lack of contact details. Contact details of the remaining 1757 running clubs around SA were obtained. Each club was contacted via email and Facebook®, sent the letter of information and the link to the questionnaire. The aims and purpose of the study were explained in detail to all of the participants in the letter of information. This is necessary for ethical purposes. In addition, it increases the validity of the test as the participants are more informed (Balady et al., 2000). The questionnaire was administered once to each participant, as opposed to several times over a specific period of time, as it is easier to source information from a participant once than it is to do so several times, due to participant dropouts as seen in previous studies (Zwingenberger et al., 2014; Hespanhol Junior et al., 2013). Dropouts are more likely to occur with a follow-up questionnaire, as participants may lose interest in the study (Knobloch et al., 2008).

3.6 Data reduction

The following section explains the methods of reducing the raw data obtained from the online questionnaire. The data that was collected from the questionnaire, was exported into a Microsoft Excel spreadsheet. All answers were checked for errors or inconsistency and excluded as a result. Continuous variables such as age were arranged into categorical variables in order to statistically test for significant associations between these continuous variables and other variables, for example age and injury (Bahr & Holme, 2003). Similar answers from open-ended questions were pooled together for the purpose of statistics and ease of analysis. If there were too few units of analysis (participants or injuries) (n<5) in a category under a variable, the results from the statistical analyses have to be interpreted with caution. In order to minimise any doubt regarding these results, data were pooled where possible. Variables such as province and running terrain could not be pooled as categories were not similar in nature or it was of statistical importance that the categories were analysed separately.

Non-numerical variables that were pooled consisted of running terrain, running footwear type, reasons for adapting footwear types, reasons for using orthotics, cross training activities, anatomical location of running related injuries, and nature of running related injuries. Details of the pooled data can be found in the appendices.

Cross training activities were separated into two categories: weight-bearing and non weight-bearing. These cross-training activities were arranged as seen in Table V

Table V. Weight-bearing and non weight-bearing cross training activities

Weight-bearing activities	**Non weight-bearing activities**
Aerobics	Canoeing

Basketball	Cycling
Athletics	Horse riding
Badminton	Paddling
Bowls	Rowing
Boxing	Swimming
Climbing	
Cricket	
Crossfit	
Dancing	
Field hockey	
Golf	
Gymnastics	
Hiking	
Martial arts	
Netball	
Pilates	
Resistance training (lifting weights and body weight exercises)	
Rugby	
Sailing	
Soccer	
Squash	
Surfing	

Tennis	
Volleyball	
Walking	
Yoga	
Other	

Specific questions that resulted in too many unusable answers were removed during data reduction. These questions included the duration of using one specific footwear type, the seeding for races as there is no seeding for trail races, the changes made to training in the past 12 months as the answers were too broad to be pooled, and lastly, what was changed about the footwear type and why, as many of the answers appeared as if the participants misunderstood the question.

3.7 Data analyses

The data were analysed in two ways, as descriptive data and as inferential data. Some data were used only to create the descriptive profile as these data were difficult to measure statistically. The unit of analysis for each question, was most commonly the participant or the RRI. The following section explains the methods used to analyse the descriptive data and the inferential data.

3.7.1 DESCRIPTIVE DATA

The descriptive data was used to create a profile of the South African long-distance running population. Percentages were calculated for the answers to each question. The most common answers assisted in providing insight into the most common characteristics of the South African long-distance running population. Questions with more than two answers were displayed graphically, using mostly bar graphs, while questions with only two answers, were displayed in a table.

3.7.2 INFERENTIAL STATISTICS

Inferential statistics were used to test the hypotheses presented in Chapter I, by testing for significant associations between the key runner characteristics, and RRI characteristics. Hypotheses were classified as supported, partially supported or not supported, depending on the number of sub-hypotheses that are supported under that category. The sub-hypotheses were supported if a significant association was found between the variable and an RRI characteristic. After data reduction was completed, Statistica™ 7 was used for statistical analyses. Chi square tests were used to determine the probability of finding an association between two categorical variables with more than two categories (Bahr & Holme, 2003). Two-tailed Fisher exact tests were used when variables had only two categories. The level of significance used was 0.05. Contingency tables of the significantly associated variables were then examined in order to further assess the association.

Table VI. Simplified matrix of variables that were tested for significant associations

	RRI prevalence and incidence	Anatomical location of RRI	Acute or overuse RRI	Duration of RRI	Recovery status of RRI	Recurrent RRI	Medical aspects of RRI
Personal characteristics and demographics	X	X	X	X	X	X	X
Training characteristics	X	X	X	X	X	X	X
Footwear	X	X	X	X	X	X	X
Running experience	X	X	X	X	X	X	X
Cross training	X	X	X	X	X	X	X

3.7 Ethical considerations

Ethical approval from the Rhodes University Research Ethics Committee was obtained prior to the commencement of the testing period. The experiment was explained through writing to participants as well as the risks and benefits associated with the protocols. Participants were additionally notified that they were not obliged to continue with the questionnaire once having started and could exclude themselves if they so wished. Once the participant had decided whether or not to participate, a letter of consent was signed by these participants.

CHAPTER IV

RESULTS

4.1 Introduction

This results chapter aims to combine the data found from the current study into a coherent synthesis of the findings. To facilitate this, the chapter is divided into two main sections: firstly, descriptive results of characteristics of the sample, and secondly, inferential results detailing the associations between these characteristics and RRIs. All data are based on the 12-month period preceding the participants' completion of the questionnaire unless otherwise stated.

4.2 Responses

The questionnaire was electronically sent out to 1757 running clubs all over SA. 422 runners responded to the questionnaire. Nine incomplete questionnaires and 35 questionnaires with data interpretation difficulties had to be excluded. The final sample consisted of 378 participants.

4.3 Descriptive results

The section on descriptive results is further divided into basic participant characteristics and demographics, training characteristics, running experience, running footwear, cross training and running related injuries. The interpretation of figures is as follows: The legends on the right of the figures indicate which bar corresponds to each category within a variable, by using identical colours or shades. The numbers above each bar represent the percentage of items (participants, injuries, races) in each category.

4.3.1 PERSONAL CHARACTERISTICS AND DEMOGRAPHICS

The following information reports on the sex, age, stature, mass, body mass index (BMI) and demographics of the participants in the current study. The following table, details information on the female runners, male runners, and total sample of the study.

Table VII. Participant characteristics (Mean values with standard deviation in brackets and CV as Coefficient of Variation).

	Sex		
	Female (n=153)	Male (n=225)	Total sample (n=378)
Age* (years)	38.54 (11.52) CV: 30%	43.07 (12.62) CV: 29%	41.2 (12.37) CV: 30%
Stature* (m)	1.66 (0.07) CV: 4%	1.78 (0.08) CV: 5%	1.73 (0.1) CV: 6%
Mass* (kg)	61.54 (12.74) CV: 21%	77.69 (11.24) CV: 15%	71.15 (14.27) CV: 20%
BMI* (kg.m^{-2})	22.49 (5.18) CV: 23%	24.62 (3.93) CV: 16%	23.76 (4.59) CV: 19%
BMI category	Normal	Normal	Normal

* Indicates significant difference (p<0.05) between male and female participants

The sample of the current study consisted of 72 more male than female runners (Table VII). The male participants were significantly older, taller and had significantly higher body mass than the female participants. Additionally, the male participants had significantly higher BMI than the female participants, however, both sexes were classified as normal on the BMI scale (World Health Organisation, 2016).

Males were, on average, four and a half years older than the average female participant. The mean age of the sample was 41.2 years of age with a standard deviation of 12.37 years (CV: 30%). With coefficients of variation of 30% and 29% for female and male participants respectively, the variability amongst participant ages was high in both sexes.

In contrast, both male and female groups demonstrated moderately homogeneous samples in terms of stature, which is indicated by the coefficient of variation of 4% for the female group and 5% for the male group. The mean stature of all participants was 1.73 m with a standard deviation of 0.1 m. Female participants were, on average, 0.12 m shorter than their male counterparts.

The mean mass combined for both sexes was 71.15 kg with a standard deviation of 14.27 kg and a CV of 20%, indicating a high variability of mass throughout the sample. The female sample was a more heterogeneous group with a CV of 21% in terms of mass, when compared to the male group with a CV of 15%.

The average BMI differed by roughly 2 kg.m^{-2} between male and female participants with the average male participant displaying a higher BMI than the average female participant. The coefficient of variation for BMI was 23% for females and 16% for males, indicating a higher variability among female participants than males. The total sample had a mean BMI of 23.76 kg.m^{-2} with a standard deviation of 4.59 kg.m^{-2} and a coefficient of variation of 19%, indicating high variation throughout the sample.

Participant BMI has been categorised into underweight (<18.50), normal (18.50 – 24.99), overweight (25.00 – 29.99) and obese (≥30.00) as seen in figure …

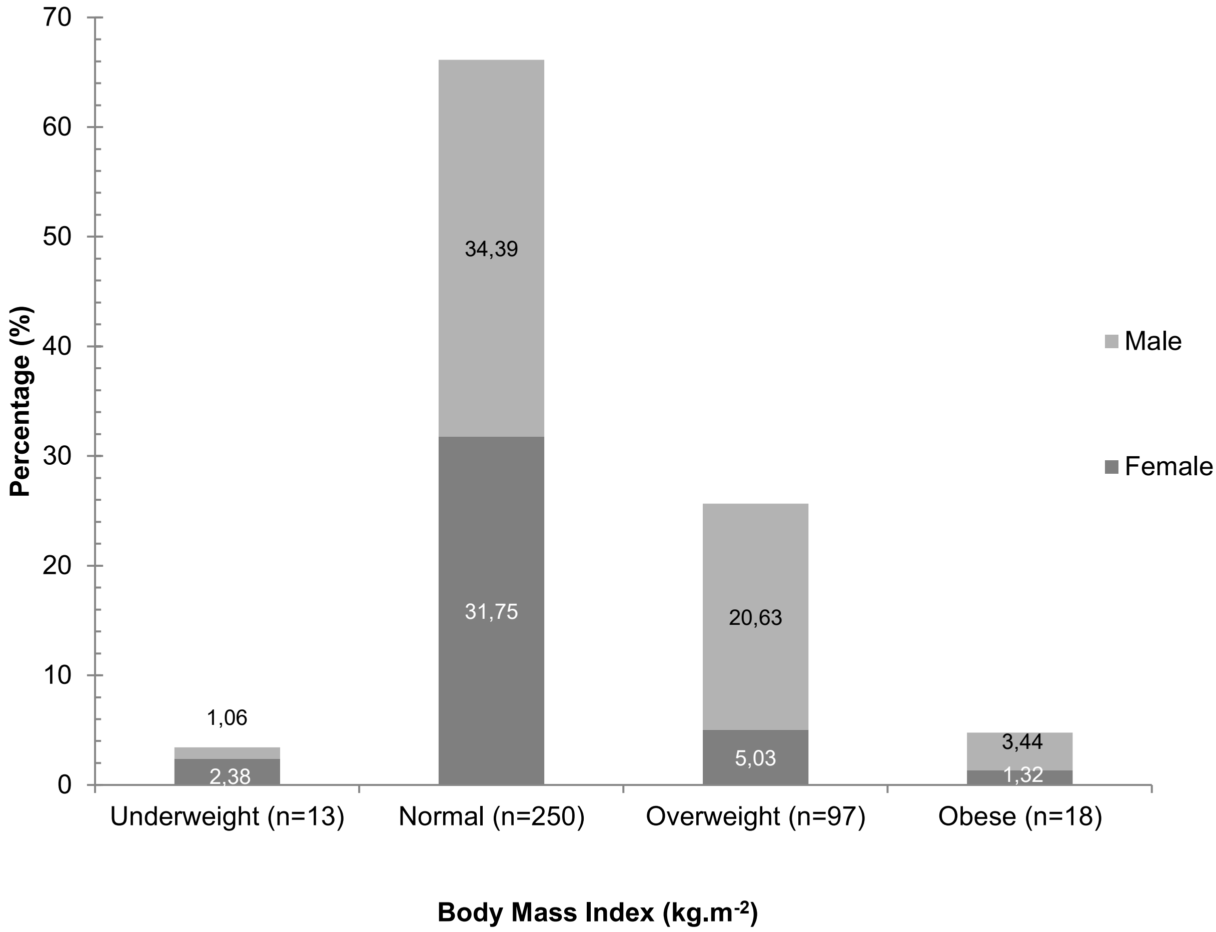

Figure 6. Percentage of male and female participants of each BMI category

The percentage of participants with “Normal” BMIs, were almost equal for males and females. However, the other BMI categories display a different pattern. More female participants were considered “Underweight” while more male participants were grouped into the “Obese” category; however, the differences were only small between the sexes in these categories. The “Overweight” category presents the largest discrepancy between sexes; there were approximately 4 males to every 1 female participant in this BMI group. Overall, the largest number of participants had “Normal” BMIs while the “Underweight” group consisted of the least participants.

In terms of demographics, the following paragraphs provide information relating to the province, ethnicity, home language and monthly income of the participants. Due to inconclusive data relating to home language and to the parents of participants, these data have been excluded from this section and can be found in the appendix. In terms of home language, the fact that the questionnaire was in English may have skewed the data and created a bias. With regards to researching the parents of the participant, the nature of the questionnaire allowed only for self-report and the purpose of the questions relating to parents was to gain insight into genetic lineage. However, as an afterthought, it was deemed as a less important factor to investigate.

The following figure displays the percentage of participants residing in each province in SA.

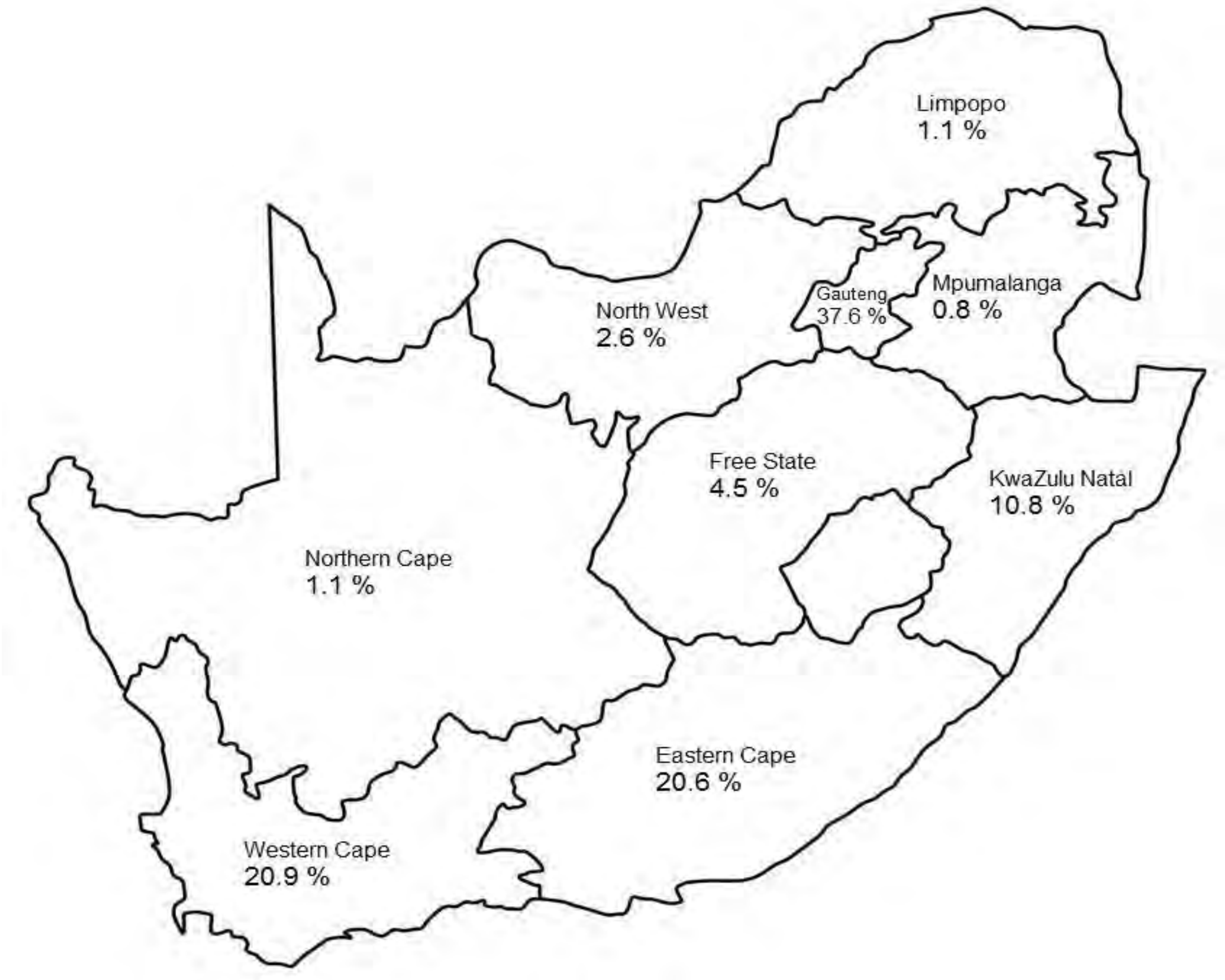

Figure 7. Percentage of participants living in each province of SA

Figure 7. Percentage of participants living in each province of SA indicates that just over a third of the participants were living in Gauteng (37.6%), followed by 20.9% and 20.6% of participants living in the Western Cape and Eastern Cape respectively. A

further 10.8% of the sample were from KwaZulu-Natal inferring that 89.9% of the participants were living in the four aforementioned provinces. The remaining five provinces therefore only comprised of approximately 10% of the sample with 4.5% of these coming from the Free State and only 0.8 (n=3) from Mpumalanga.

In terms of the ethnicity of participants, the subsequent figure displays the percentages of the various ethnicities that made up the sample of the current study.

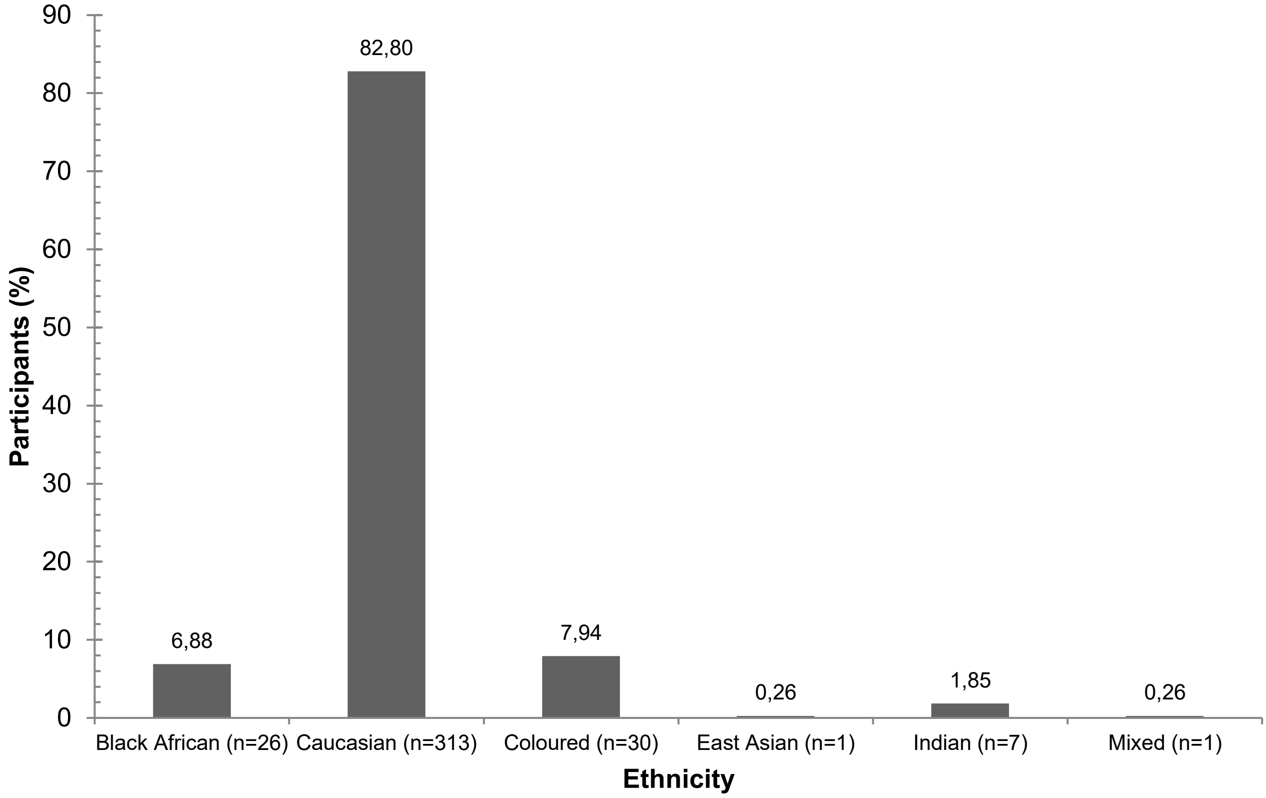

Figure 8. Ethnicity of participants

The largest proportion of the participants was classified as Caucasian, while Black African and Coloured participants constituted a further 6.88% and 7.94% of the sample respectively. Indian participants made up 1.85% of the sample while East Asian and Mixed participants both formed 0.26% of the sample.

In the current study, the monthly household income of the participants represented a crude indication of socio-economic background of the sample, which is displayed in the subsequent table.

Table VIII. Percentage of participants in various household monthly income brackets

Class	**Monthly income bracket**	**%**
Low	R 5 000 or less	3.46
Low emerging middle	R 5 000 – R 10 000	8.24
Emerging middle	R 10 000 – R 15 000	9.84
Lower middle	R 15 000 – R 30 000	29.00
Upper middle	More than R 30 000	49.46

The monthly household income of the participants in the current study were diverse, as there were participants from every income bracket listed in the questionnaire, however, a large disparity was evident. Half of the participants were from households that earned R 30 000 or more on a monthly basis, while there were only 3.46% that were classified as being from the low socioeconomic bracket. This being said, the upper middle-income bracket may have had more participants as the end range of this income bracket was not defined in the questionnaire.

4.3.2 TRAINING CHARACTERISTICS

The following results on training characteristics comprise of participant data relating to the frequency, duration and distance run per week. Additionally, running club involvement, the number of training months per year, running terrain and changes made to running training, were included in the subsequent section.

4.3.2.1 Weekly running frequency, duration and distance

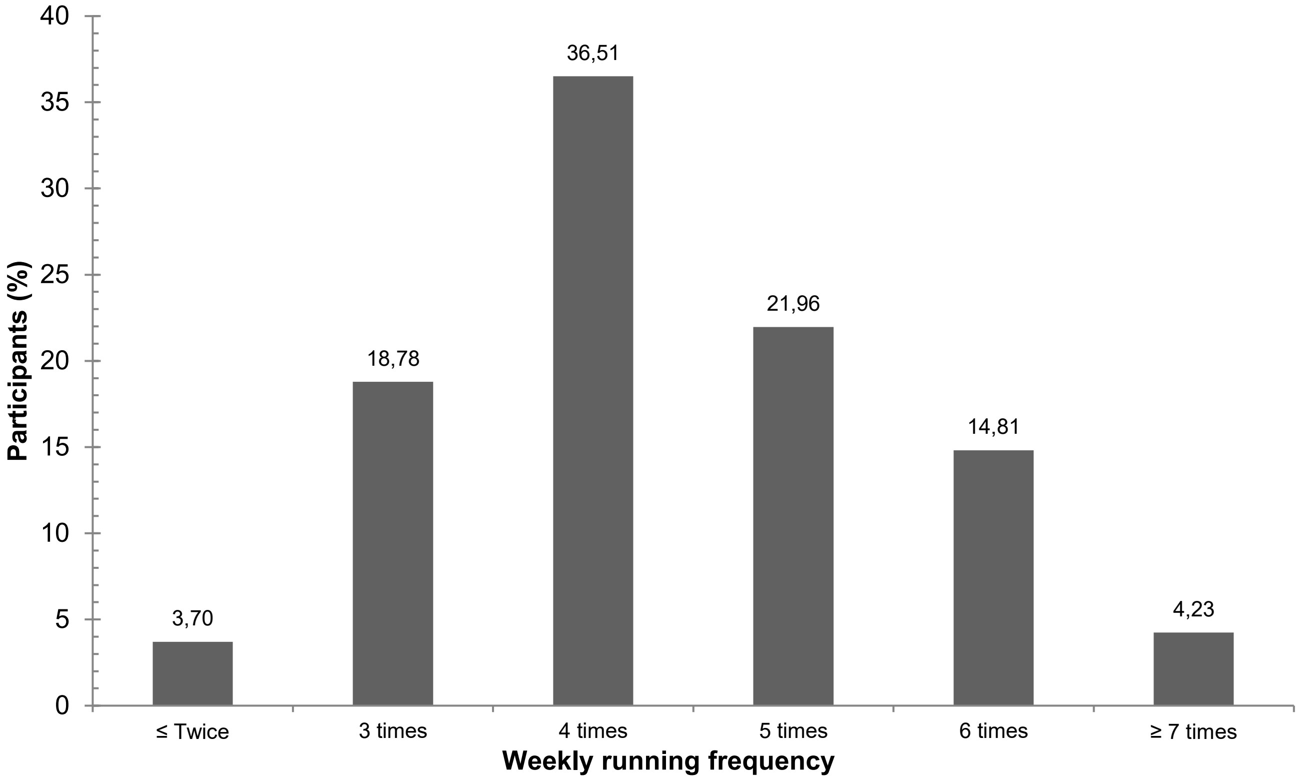

Figure 9. Weekly running frequency of participants

The most common weekly running frequency was four times (36.51%) while the least common was running twice or less per week (3.70%). Figure 9 indicates that over 3 quarters (77.51%) of the participants spend more days running than days not running, in a week.

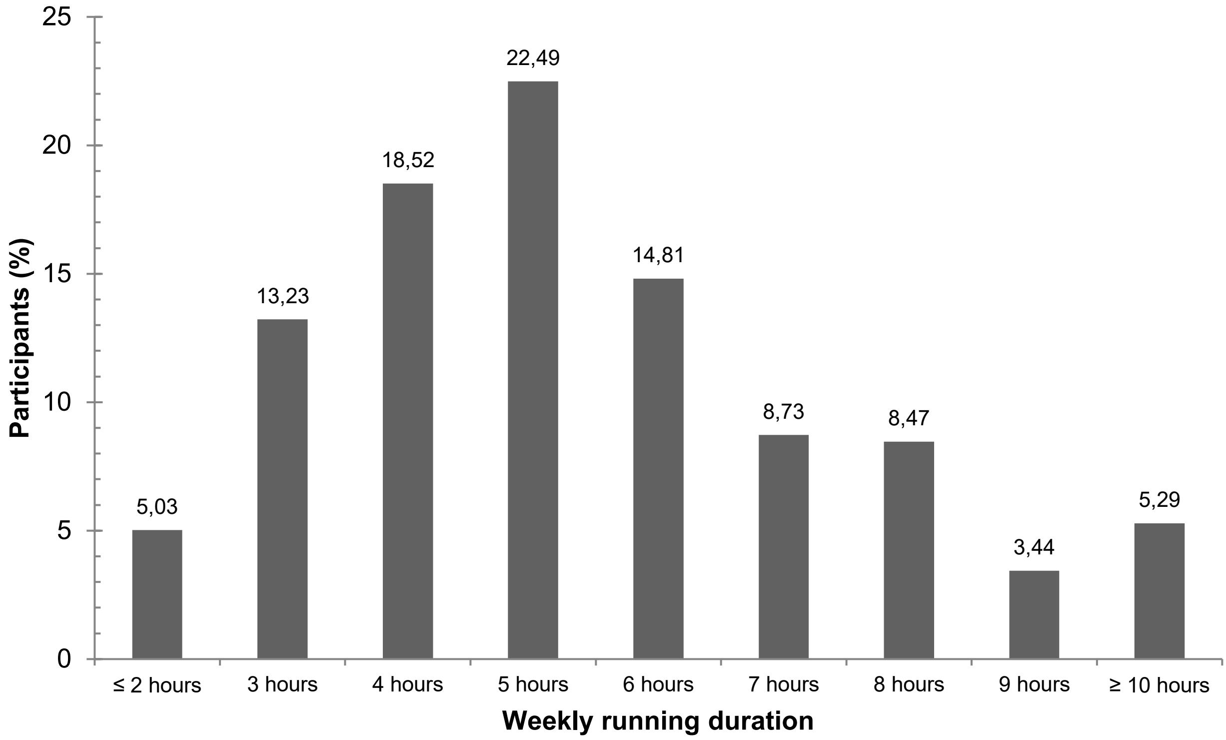

Figure 10. Hours spent running per week

The highest percentage of participants spent 5 hours a week, running. Only a few participants accumulated nine or more running hours during the week, and even less participants (5.03%) ran less than two hours per week.

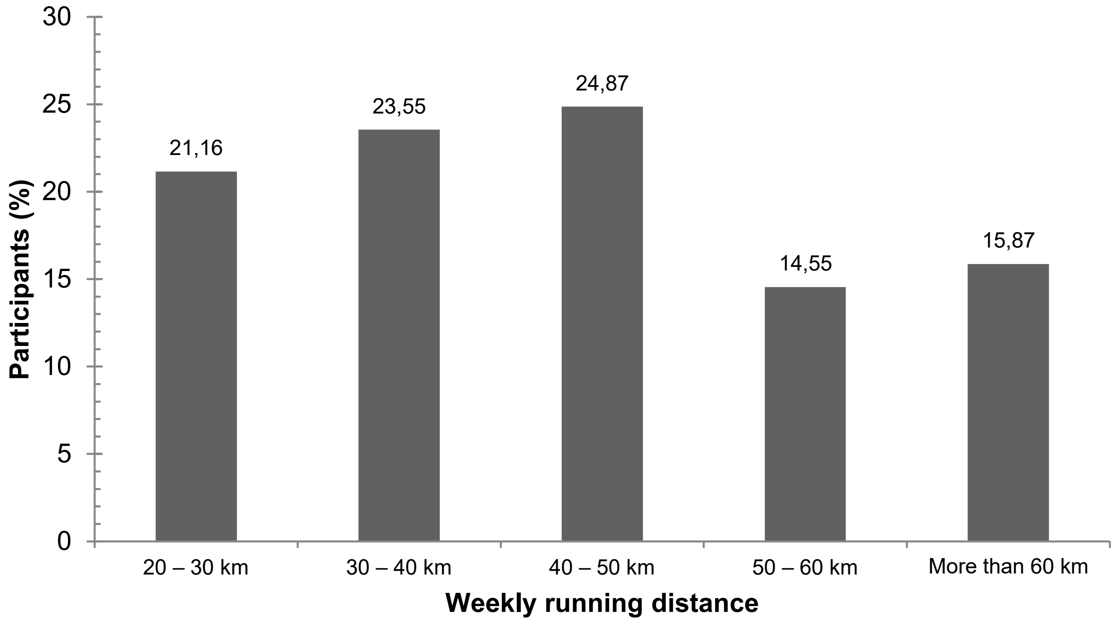

Figure 11. Weekly running distance of participants

It is interesting to note that the sample presented a wide range of weekly running distances, with almost equal numbers of runners in the first three distance categories. More than two thirds (69.58%) of the participants preferred to run weekly distances of 50 km or less, whereas running more than 50 km a week was only practised among 30.42% of participants.

4.3.2.2 Training months per year

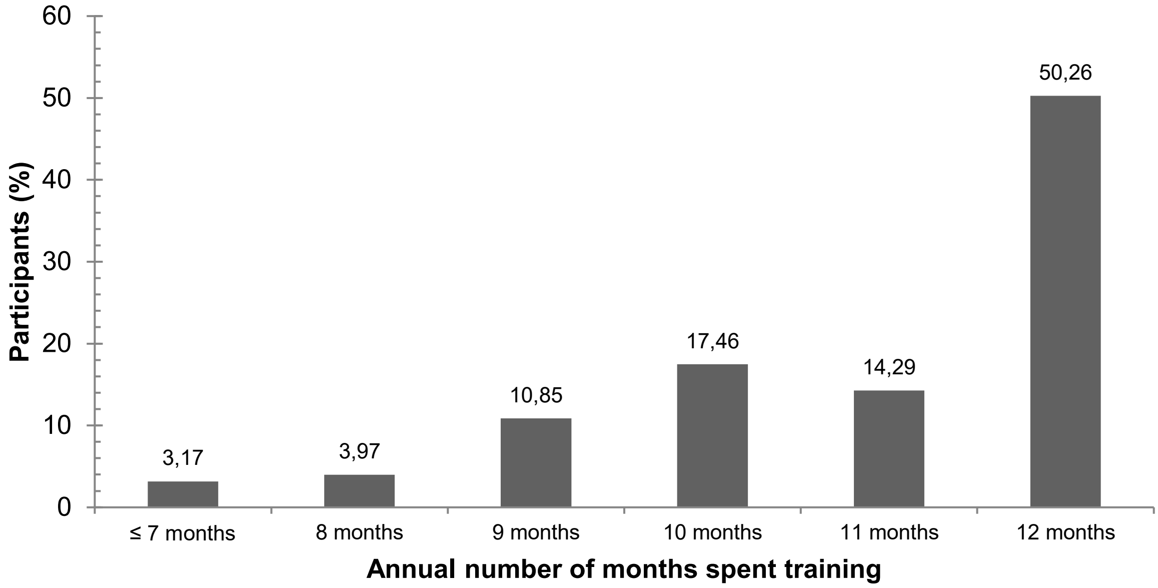

Figure 12. Participants training for various numbers of months per year

Half of the participants in the study indicated that they ran all year round with a further 42% of the sample running between 9 and 11 months of the year. Only approximately 7% of the sample ran for 8 or less months of the year, indicating that the majority of the sample tended to utilize most of the months of year for running training.

4.3.2.3 Running terrain

Various types of running terrains reported by the current sample included cement, cross country/trail, grass, road/tar/asphalt, sand, track/tartan, and treadmill. Participants were asked to select all of the terrains that they included in their training regime. Most participants ran on two different terrains (37.04%), closely followed by one type of terrain (34.39%). One fifth of participants included three different terrains in their training regime but more than three terrains was uncommon. The popularity of each terrain can be seen in Figure 13. As the participants could select more than one terrain on which they frequently train, a total of 764 terrain selections were recorded. The number of times these terrains were selected is indicated next to the terrain type in Figure 13.

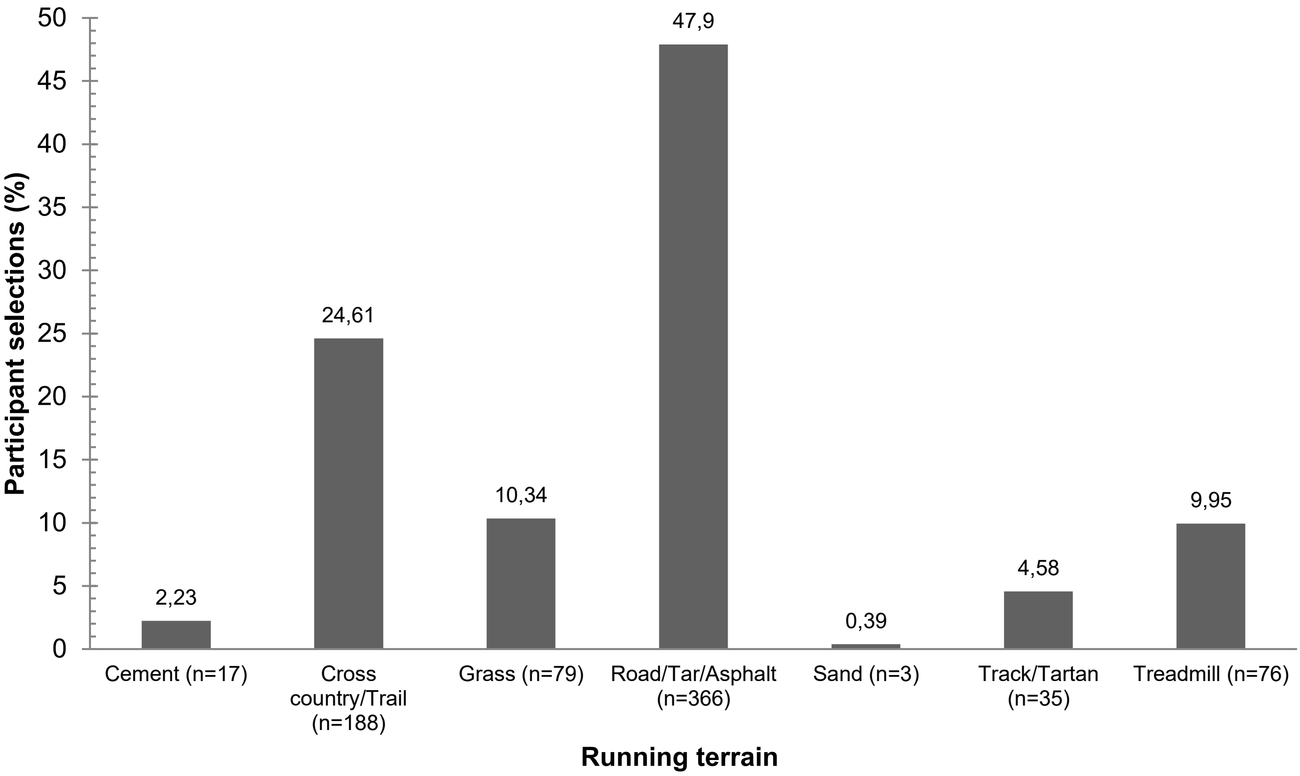

Figure 13. Participant selections of each different terrain

Road/tar/asphalt was undoubtedly the most popular terrain choice among participants, with almost half of the sample including this terrain in their running programs. With a quarter of the selections, cross country/trail was the second most frequently reported running terrain. Grass and treadmill running were of equal popularity however each only made up one tenth of the terrains listed. The remaining terrains combined, made up a small portion of the sample choices (7.20%), with sand being the least common training terrain.

4.3.2.4 Additional training characteristics

Table IX. Binary questions relating to training characteristics

	Yes	No
Changed aspects of training in the past 12 months?	47.40%	52.60%
Training for a long-distance race?	76.20%	23.80%
Part of a running club?	86.24%	13.76%

Over the past year, approximately half of the participants had changed aspects of their training. This is an important finding in terms of whether or not these participants presented more injuries. When asked if they were currently training for a long-distance race, more than three quarters of the sample answered yes. It appears that most of the sample favoured organised running groups as 86.24% reported to be part of a running club.

4.3.3. RUNNING EXPERIENCE

Running experience refers to the number of years that a participant has been taking part in long-distance running, as well as the races that the participant runs and their level of professionalism and competitiveness.

4.3.3.1 Years of running experience

Years of running experience was presented in categories in the questionnaire, as seen in the following figure.

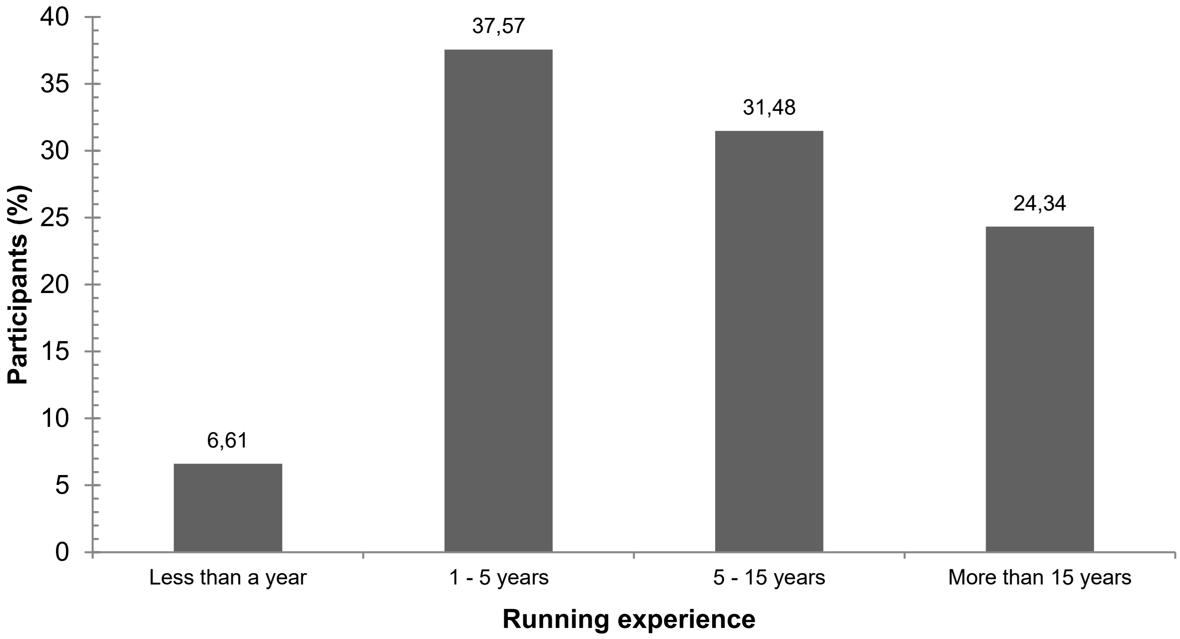

Figure 14. Participants with varying years of running experience

The sample presented a wide range of running experience levels, from less than one year to more than 15 years of running experience. This presents a cross section of novice as well as more experienced runners. This being said, from Figure 14, it can be seen that very few participants had less than one year of experience, however, there were more participants with less running experience than those with five or more years of experience.

4.3.3.2 Race distances

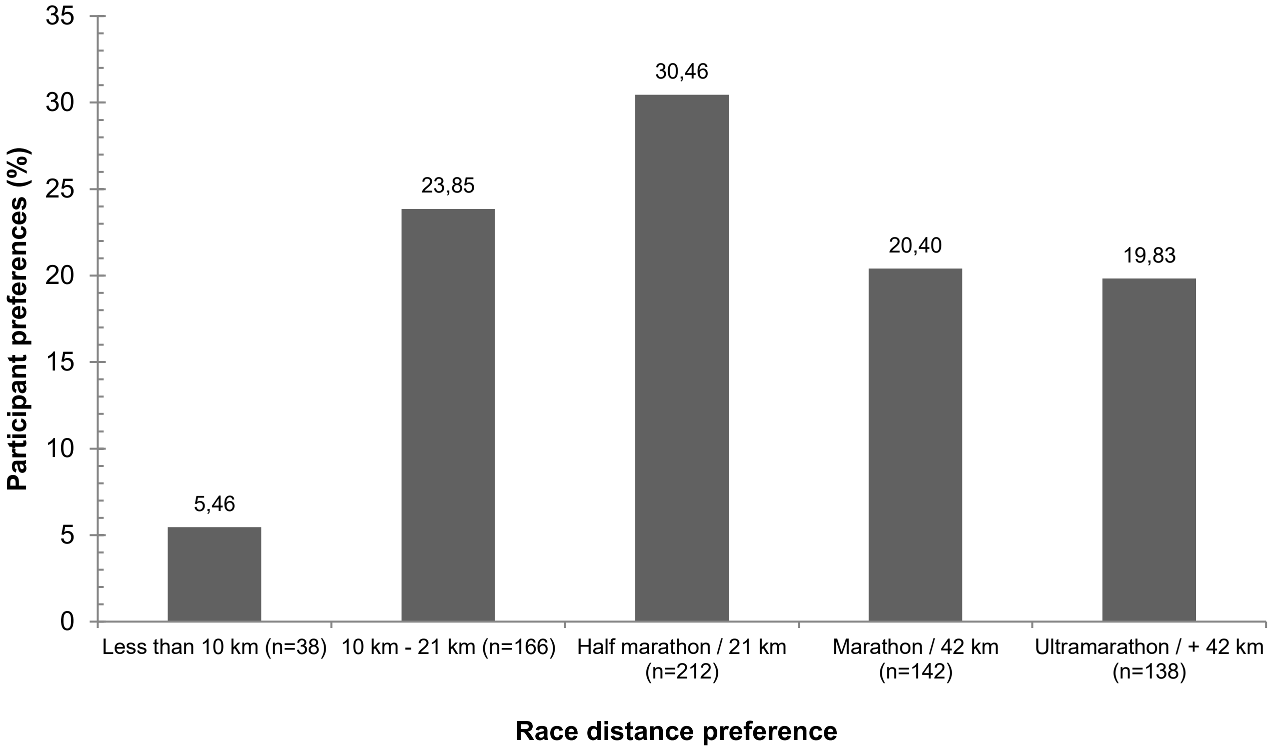

Figure 15. Participant preferences of various race distances

Of the 378 participants, 696 preferences on running distances were reported, as each participant could select more than one preferred race distance. On average, each participant selected two running distance preferences. Race distances of 10 km to distances of more than 42 km were popular preferences among participants, with half marathons being favoured the most. Races of less than 10 km were uncommon preferences of the runners in the current sample with only 5.46% of the total preferences.

Table X. Frequencies of number of races of specific distances run in the past 12 months

	Approximately 21 km	**Approximately 42 km**	**More than 42 km**
0 races	20 (5.92%)	137 (36.24%)	224 (59.26%)
1 race	27 (7.14%)	49 (12.96%)	116 (30.69%)
2 races	40 (10.58%)	39 (10.32%)	18 (4.76%)
3 races	58 (15.34%)	47 (12.43%)	13 (3.44%)
4 races	44 (11.64%)	34 (8.99)	2 (0.53%)
5 races	33 (8.73%)	19 (5.03%)	0
More than 5 races	156 (41.27%)	53 (14.02%)	5 (1.32%)
TOTAL	378	378	378

With an increase in race distance, the number of races run in a year, appears to lessen. Almost all participants (94.08%) ran at least one half marathon in the last 12 months while 63.76% ran at least one race of approximately 42 km and 40.74% ran one or more races of + 42 km. The most popular races were 21 km races, with the largest percentage (41.27%) of participants running 5 or more races in a year. With regards to participants who ran 42 km races, there was a relatively even distribution of participants among the numbers of 42 km races run. More participants did not run any ultramarathons in a year (59.26%) than those who ran one or more (40.74%). Out of those 40.74% who did run races of more than 42 km, most participants (30.60%) ran only one in a year. From the wide range of race distances and numbers of each races run, this table demonstrates the diversity of the runners of the current study.

4.3.3.3 Professional level of participants

In terms of the professional level of the sample, participants were asked if they were sponsored or professional runners. Only 12 (3.17%) participants indicated that they were, while the majority (96.83%) were not sponsored or professional runners.

4.3.4 RUNNING FOOTWEAR

Running footwear relates to the shoes (or lack thereof) that the participant uses when running long-distances. The following section reports on the footwear type predominantly used when running, the number of different types of footwear a participant uses and the total number of pairs of running footwear used. Additionally, whether participants made changes to their footwear type and the reasons for this are found in this section, as well as information regarding the use of orthotics.

4.3.4.1 Running footwear type

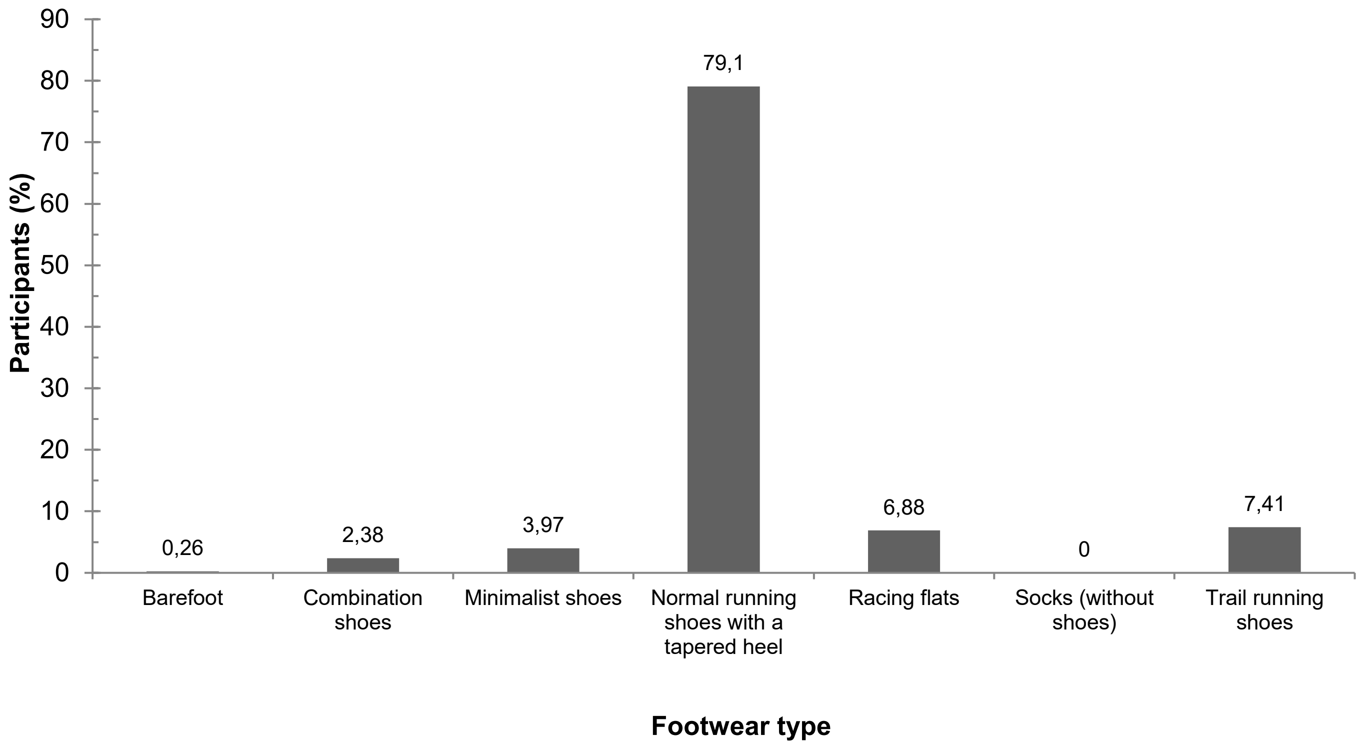

Figure 16. Various running footwear types of participants

The questionnaire allowed for participants to select only one footwear type that they predominantly run in. For descriptions on each footwear type, see Chapter III. More than 3 in 4 participants (79.1%) ran in normal running shoes with a tapered heel; by far the most utilised running footwear in the current study. The remaining categories were much less popular, with each category being used by less than 10% of the participants. Only one participant ran barefoot (0.26%) and none ran in socks alone.

The questionnaire asked participants whether they had made any changes to their footwear type in the past year. Less than a quarter of participants (21.42%; n=81) reported to have changed their predominant running footwear type in the 12 months preceding the questionnaire.

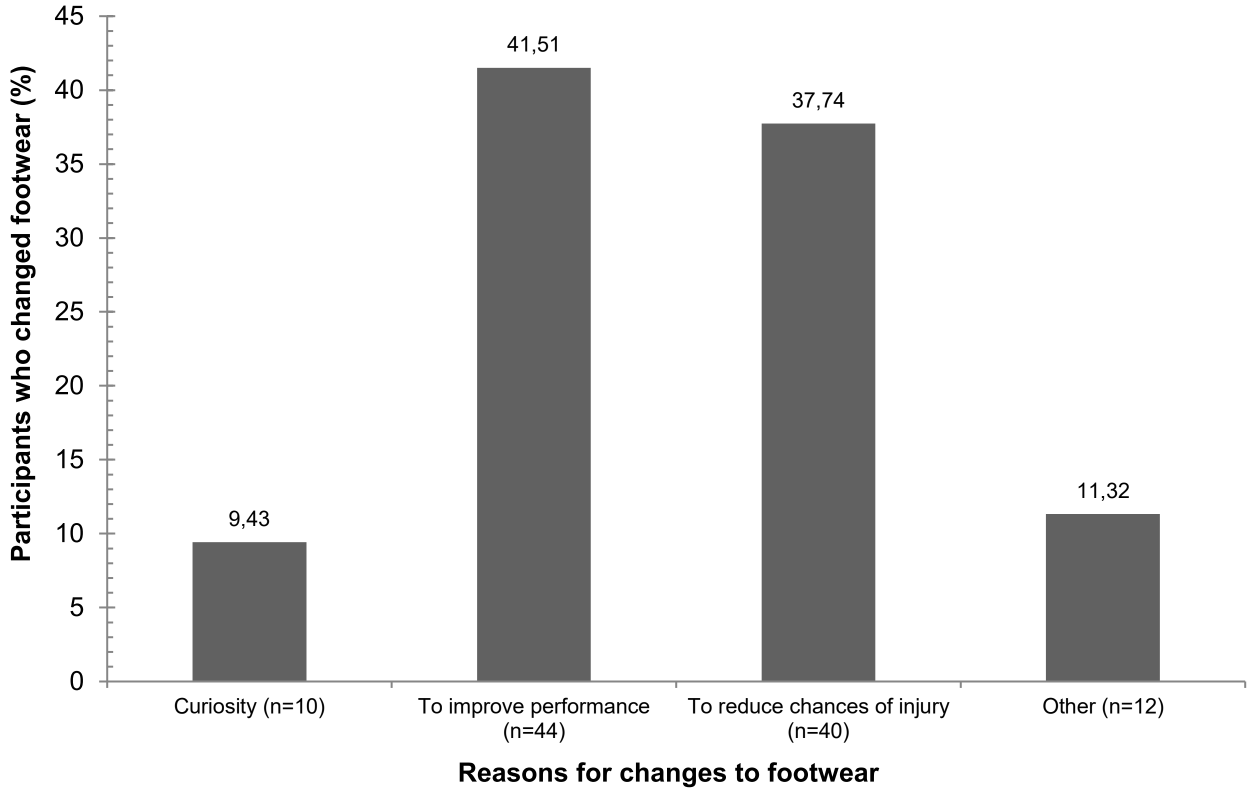

Figure 17. Reasons for changing running footwear type

Participants could list more than one reason for changing their footwear type therefore from the 81 participants who did change their footwear type, there were a total of 106 reasons as to why this was done. Reasons for changing the running footwear type were mostly to reduce the chance of injury occurring, or to improve performance. Changing footwear types as a result of curiosity made up a very small percentage (9.43%) of the reasons for changing footwear. The “Other” reasons made up 11.32% of the reasons for changing running footwear which were a combination of various reasons described by participants, which are detailed in Chapter III.

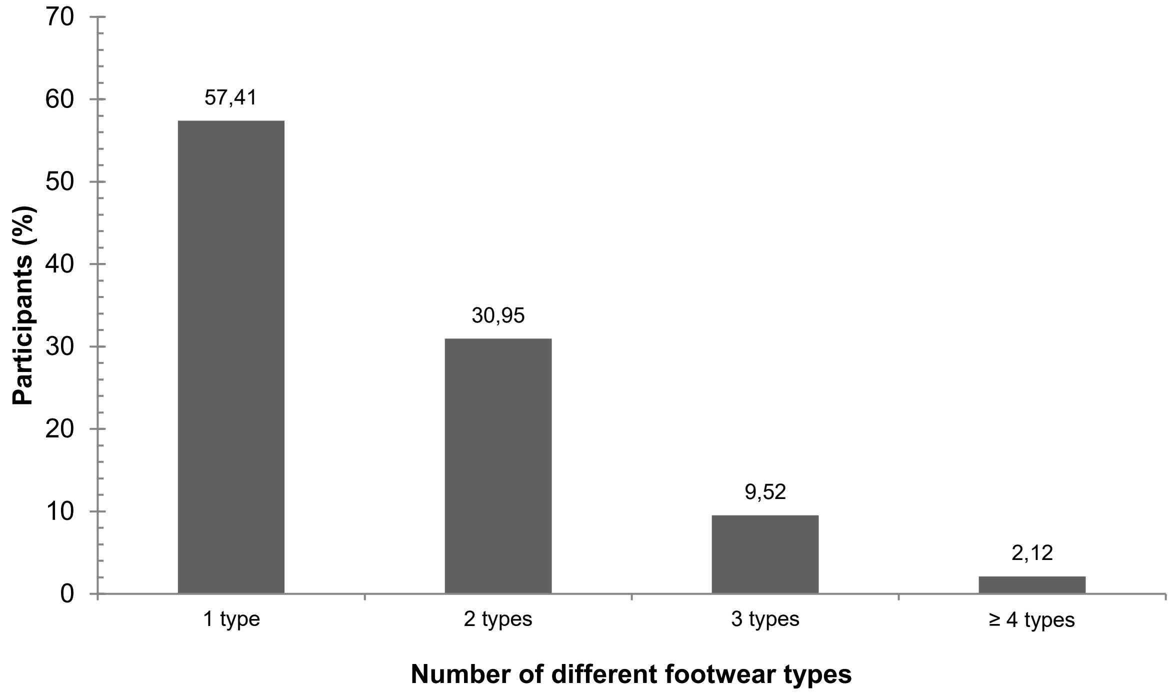

Figure 18. Participants using different footwear types

There are various types of running footwear used by runners, with some opting to train in more than one different type of footwear. Figure 18 indicates that just over half (57.41%) of the participants ran in only 1 type of running footwear. The sample preferred running in less different types of footwear with 88.36% running in 2 or less various footwear types, and the remaining 11.64% running in 3 or more types.

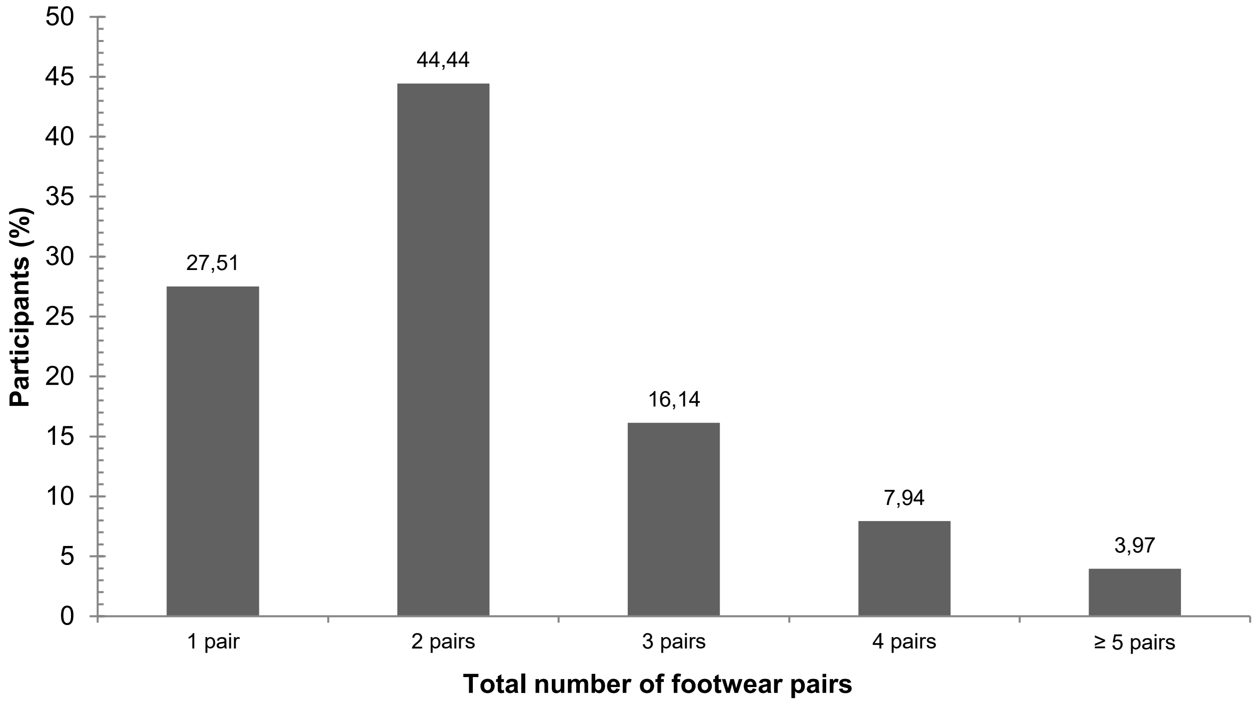

Figure 19. Participants with different numbers of footwear pairs

Apart from running in different footwear types, runners may train in more than one pair of running shoes. Note that these can be the same type of footwear. 44% (n=168) used a total of two pairs at any given time while a further 27.5% used only one pair. As the number of pairs increased above two, the percentage of runners using them decreased from 16% at 3 pairs, to less than 4% using 5 or more pairs. 71.95% used two pairs of running footwear or less, demonstrating the preference of the sample as having less pairs of footwear as opposed to more.

4.3.4.2 Orthotics

The use of orthotics in combination with running footwear was an unpopular practice in the current sample, with only a fifth (19.58%) of participants using orthotics when running. The remaining 80.42% indicated that they did not make use of orthotics when running.

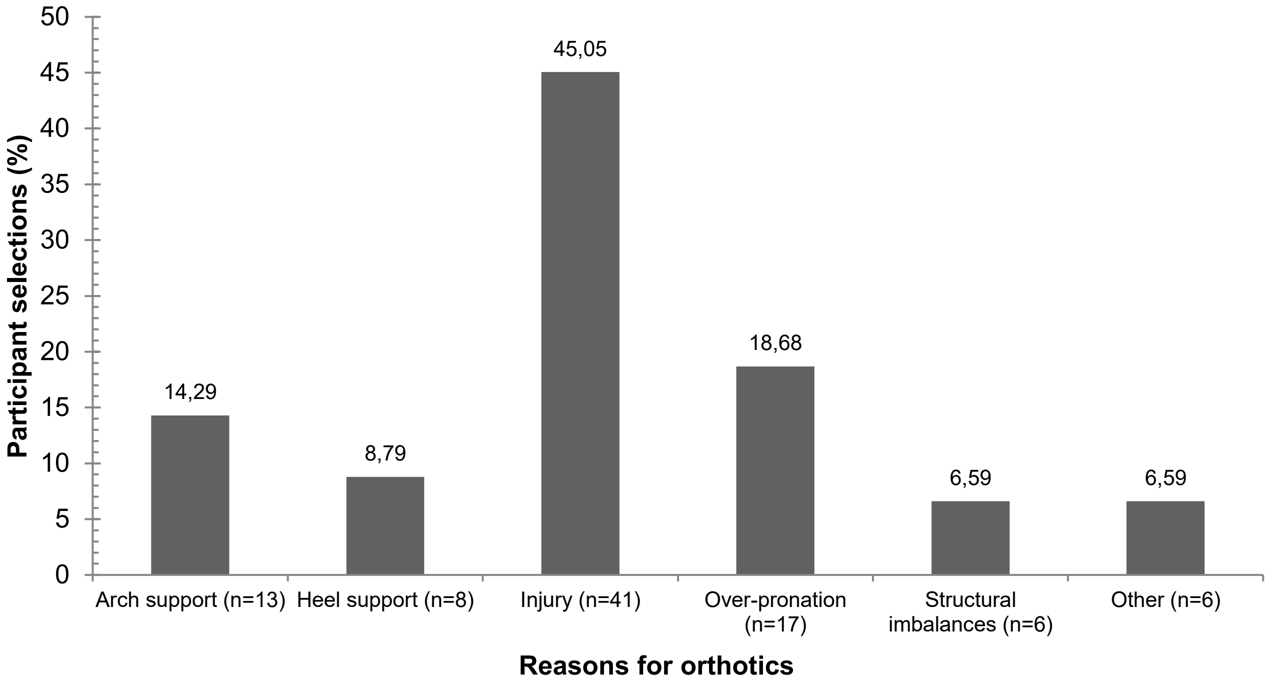

Figure 20. Various reasons for orthotics in running footwear

As previously mentioned, 19.58% (n=74) of the participants wore orthotics. Participants were allowed to list several reasons for using orthotics, resulting in a total of 91 responses. Injury was, by far, the most popular reason for using orthotics when running (45.05%). Almost a quarter (23.08%) of the total number of reasons for orthotics use was indicated as support (heel and arch support). Over-pronation was reported in almost 1 in 5 orthotic-wearing participants (18.68%) using orthotics for this reason. The two least prevalent categories were structural imbalances and other reasons which were detailed in Chapter III.

4.3.5 CROSS TRAINING

In the current study, cross training referred to any other sports or athletic related activity, apart from long-distance running, that is performed on a weekly basis. Two out of three (66.40%) participants took part in weekly cross training activities while one third participated in only long-distance running. This being said, the weekly frequency of cross training activities differed between participants as seen in the figure below. In total, participants took part in 557 cross training activities. Out of the cross training participants, three times more participants took part in weight-bearing activities than those who did no weight-bearing activities.

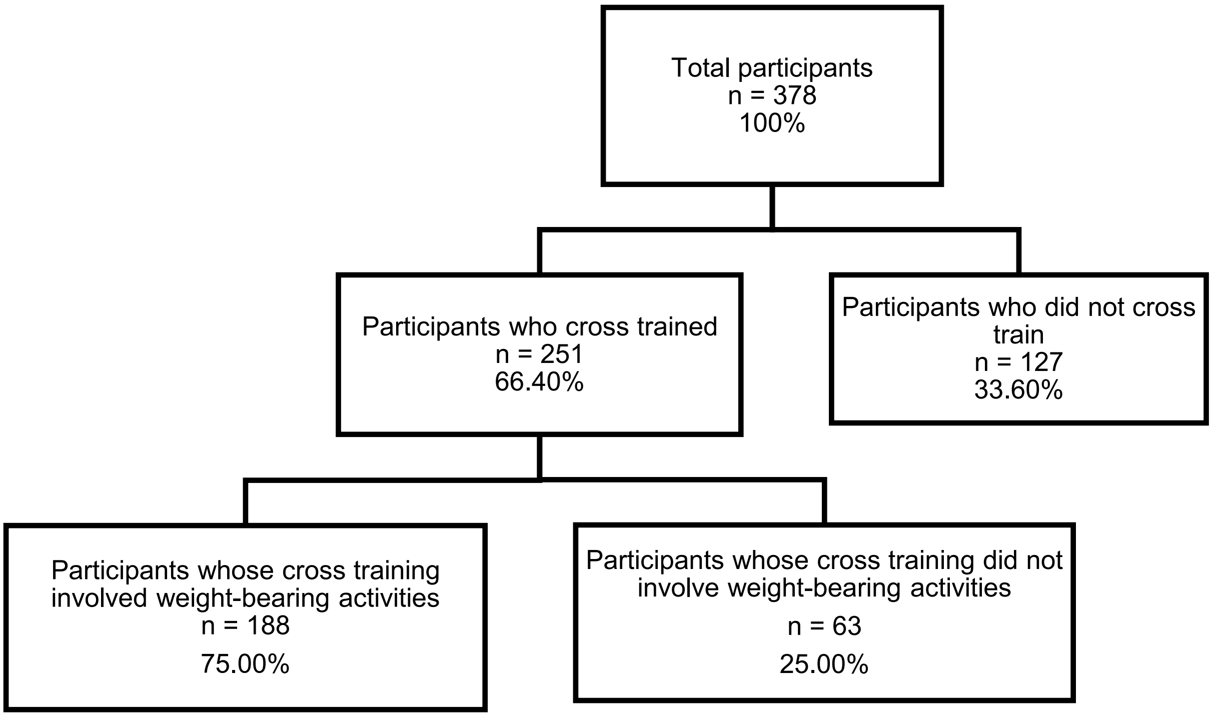

Figure 21. Organisational chart showing the divisions of participants who took part in cross training

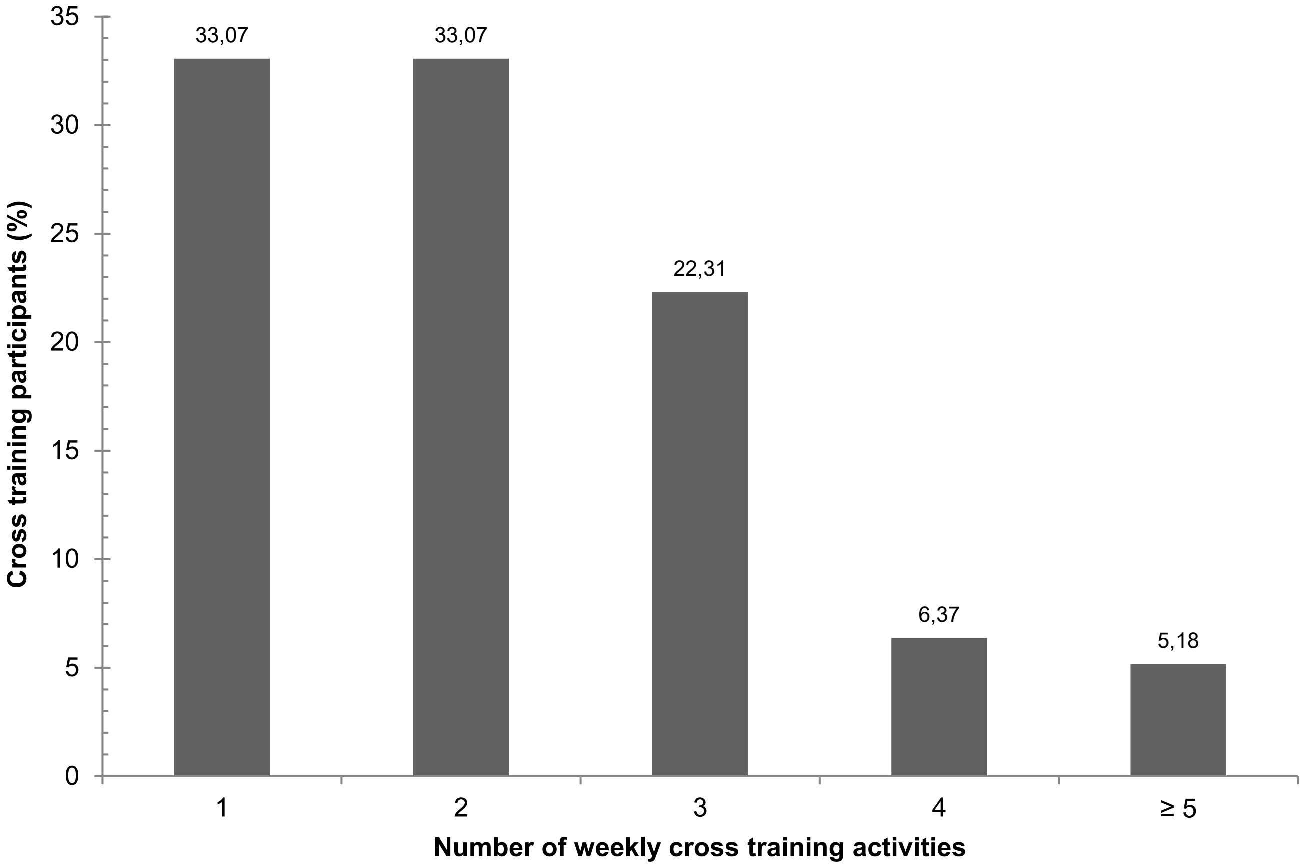

Figure 22. Cross training participants partaking in various numbers of weekly cross training activities

Out of the 251 participants who took part in cross training, most participated in either one or two different cross training activities on a weekly basis, with just under a quarter of the sample participating in three different cross training activities per week. Very few cross training participants (11.55%) were involved in four or more cross training activities on a weekly basis.

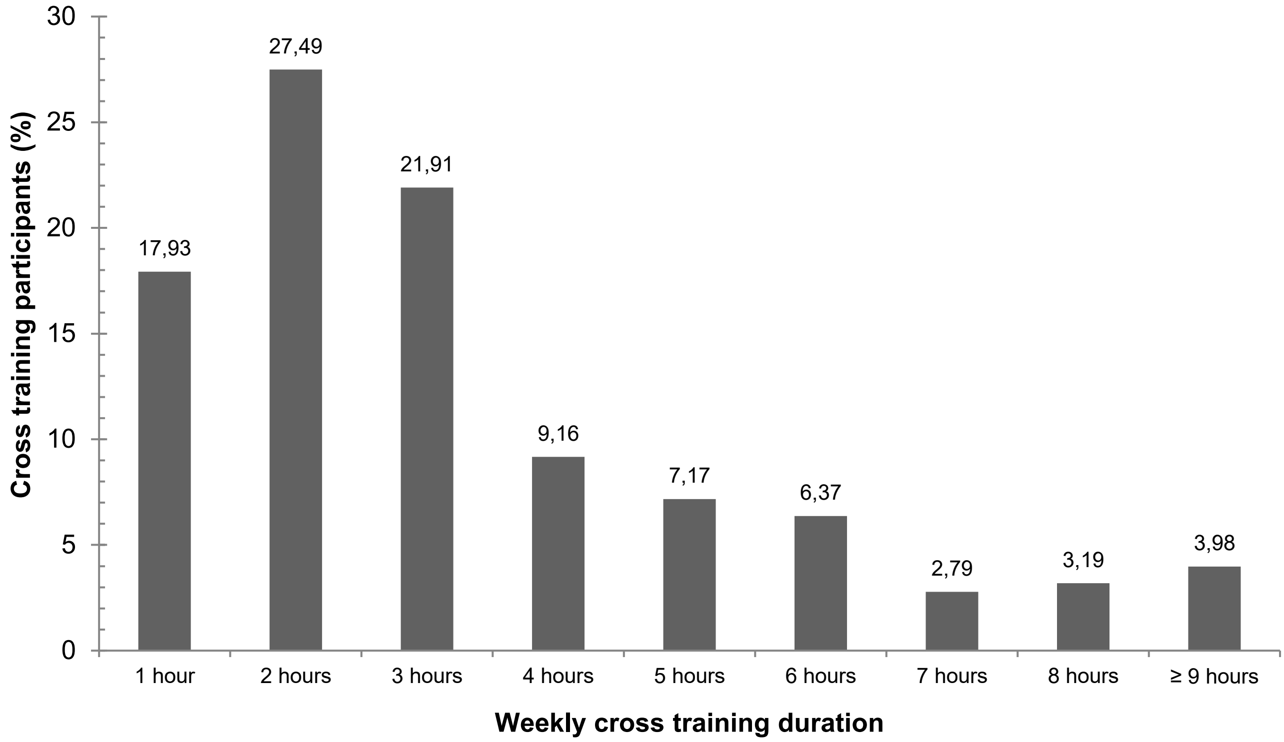

Figure 23. Cross training participants and the time spent cross training per week.

The majority of cross training participants spent more time running, than cross training. Most participants ran for five hours per week while the most prevalent number of hours spent cross training was 2 hours per week (27.49%). Two thirds (67.33%) of the cross training participants spent 1 to 3 hours per week cross training. The remaining third accounted for participants who cross trained for 4 or more hours per week.

4.3.6. RUNNING RELATED INJURY AND PAIN

Participants were asked to list the number of running related injuries (RRIs) that they had developed over the most recent period of 12 months. Following this, the description of four of these RRIs were requested, including anatomical location, nature, whether the injury was acute or overuse, duration, if the injury recovered fully before resuming training, if the injury was recurrent, professional diagnosis and if surgery was required. Since only four RRIs could be described in detail in the questionnaire, but more could be listed, the number of listed RRIs was different to the number of described RRIs. The total number of RRIs listed was 471 while 467 injuries were described. The results pertaining to these descriptions are shown below.

It must be noted that when describing injuries, participants did not always disclose all of the required details which is likely due to a flaw in the questionnaire layout (see limitations, page 191). However, the data that were available for each described injury were used regardless of whether the descriptions were complete. Therefore, the total sample sizes (n=x) vary throughout this section.

4.3.6.1. RRI incidence and prevalence

RRIs appeared to be highly prevalent in the sample of the current study. 3 in 4 participants (74.07%; n=280) had suffered from an RRI in the past 12 months, meaning that three times more runners had been injured from running, over a period of a year, than those that had not been injured. Over a third (38.36%) of the participants was suffering from an RRI at the time of the questionnaire; thus, one in three runners are likely to be injured at any given time.

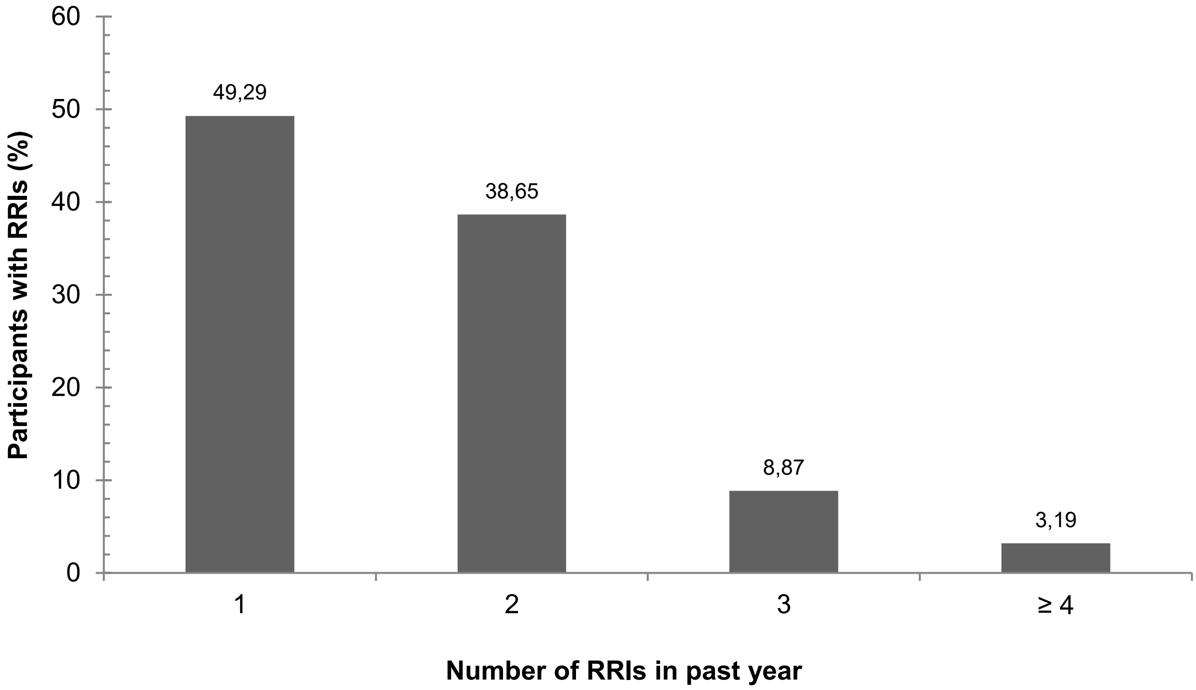

Figure 24. Injuries per participant over a period of 12 months.

Participants were required to report the total number of RRIs developed in the 12 months preceding the questionnaire. Of a total of 280 participants who had developed an RRI in the past year, 88% had 1 or 2 RRIs, with half of the injured sample suffering from only 1 RRI. It was uncommon to have had 3 or more injuries within 12 months as only 12% of the injured participants suffered from more than 2 RRIs.

4.3.6.2 Anatomical location

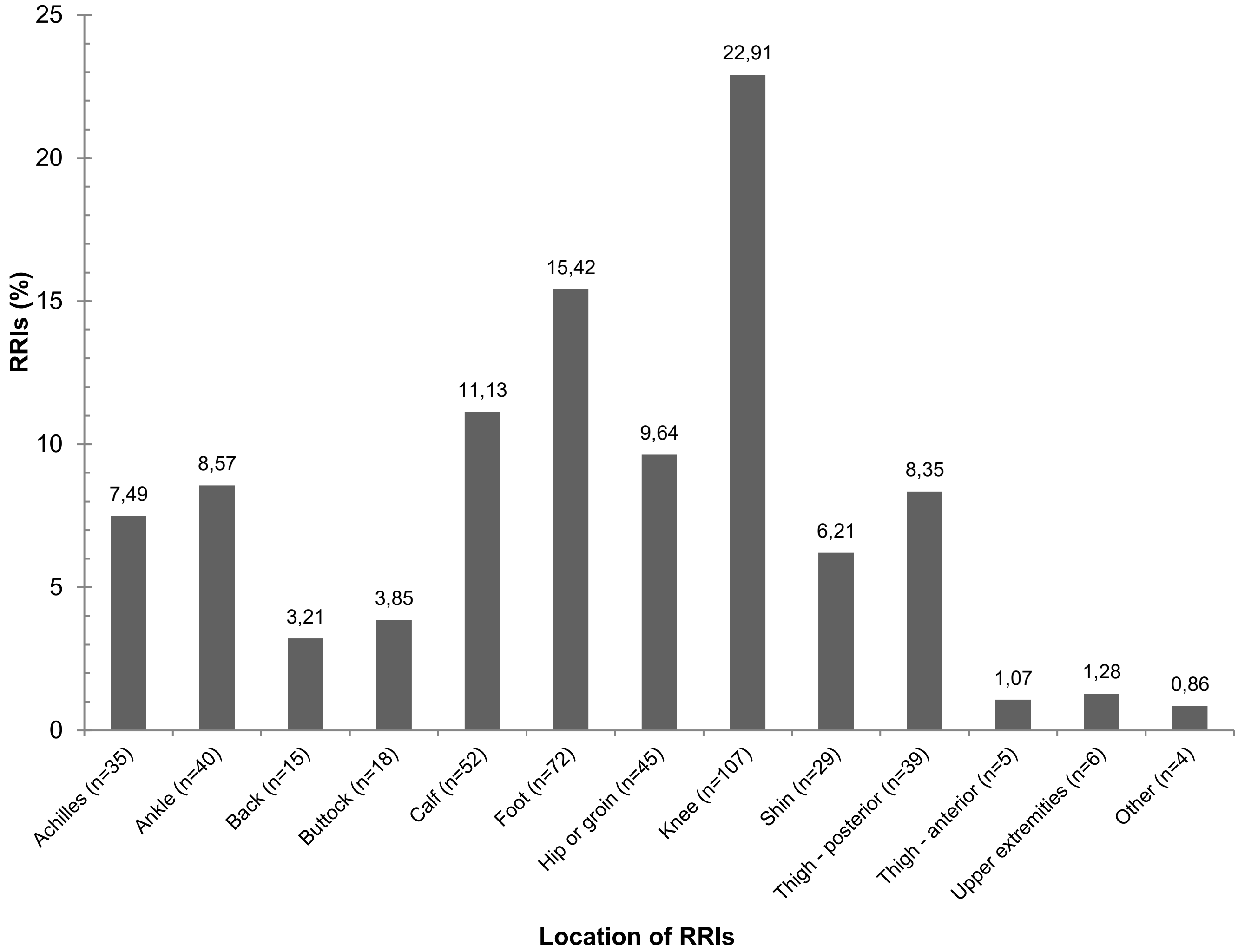

Figure 25. RRIs in various anatomical locations

The total number of injury locations described was 467, of which 98.71% of these injuries consisted of lower limb RRIs including those listed under “Other”, as these injuries were all to the lower limbs. “Upper extremities” referred to the head, neck and shoulders, and comprised of 1.28% of the described RRIs. The knee was the most common site of running related injuries, with almost a quarter (22.91%) of RRIs occurring in this location. The second most prevalent injury occurred at the foot (15.42%) followed by the calf (11.13%). “Other” injury locations made up 0.86% of the described injuries, the lowest number of injuries (n=4). Injuries below the knee, excluding the knee, were locations of almost half (48.82%) of the RRIs. Injuries to the upper leg, from the knee to the hip or groin, including both, occurred in 45.82% of the injury cases. Injuries to the lower leg and upper leg were therefore of similar prevalence.

4.3.6.3 Nature of RRI

The nature of the RRI refers to the sensation of the injury or pain.

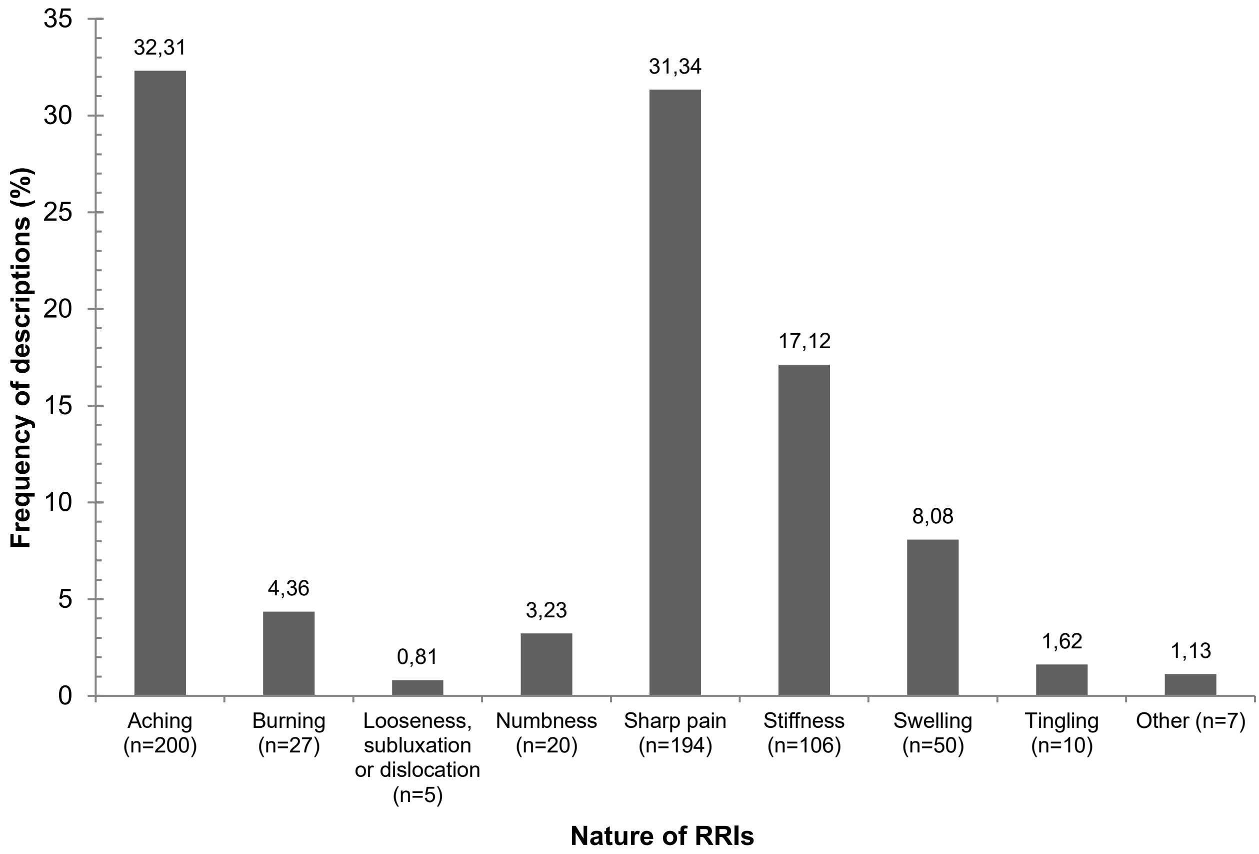

Figure 26. Various descriptions (natures) of RRIs

The nature of the injuries was indicated in 419 RRIs. Participants were allowed to describe their injuries using multiple terms. 619 terms were used to describe 419 injuries (48 injuries did not have an indicated nature). Aching (32.31%) and sharp pain (31.34%) were used to describe injuries most often, with each making up a third of injury descriptions. Stiffness was experienced in 17.12% of the RRIs. The other descriptions were much less prevalent, each making up less than 9% of the injury descriptions. Details of “Other” injury descriptions (1.13%) can be found in Chapter III.

4.3.6.4 Overuse or acute RRI

Table XI. Overuse and acute RRIs

Overuse or acute	**n =**	**%**
Overuse (Gradual)	286	68.1
Acute (Immediate)	134	31.9
TOTAL	420	100

Out of the 467 injuries that were described, whether the injury was overuse or acute was reported in 420 of those described injuries. Of these 420 RRIs, 68.1% (286) were overuse (gradual) injuries while 31.9% (134) were acute (immediate) injuries. Overuse injuries occurred almost twice as many times as acute RRIs.

4.3.6.5. RRI duration

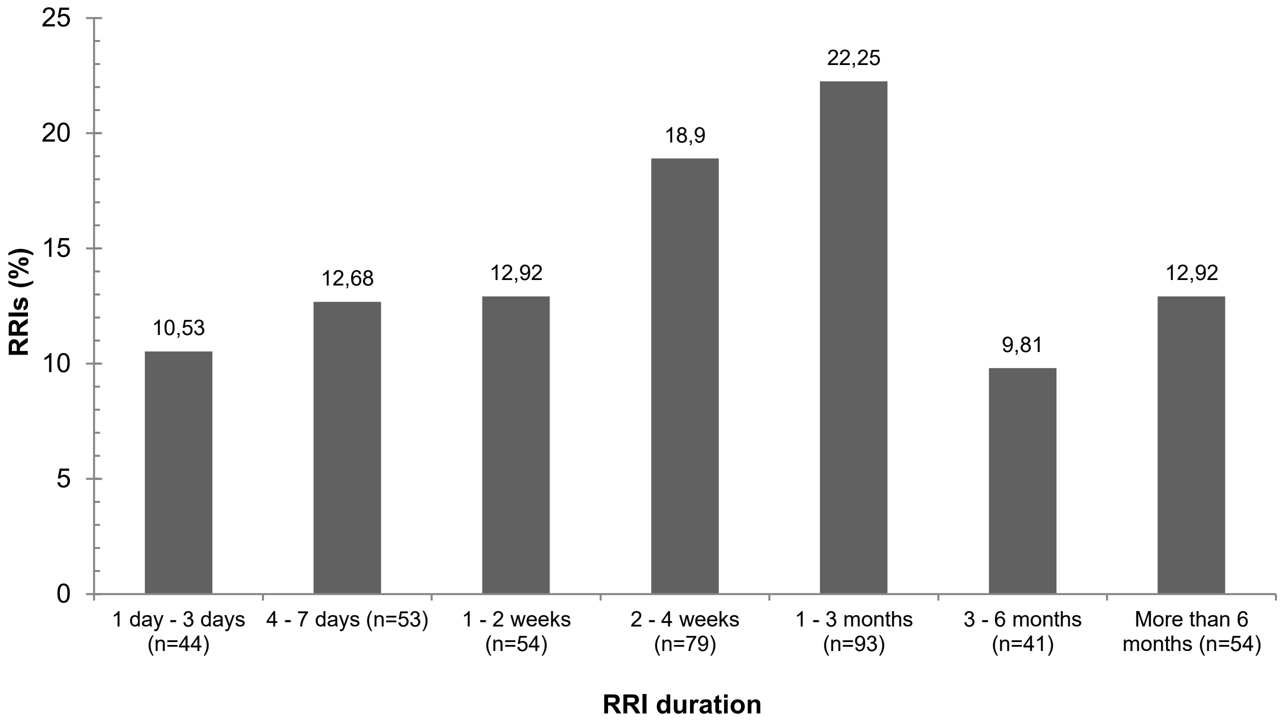

Figure 27. RRIs of various durations

418 injury descriptions included the duration of the injury. Figure 27 presents a variety of durations of RRIs, with the most common and least common category differing by only 13% indicating a large range of injury durations in the current study. Most injuries lasted for 1 – 3 months (22.25%) closely followed by 2-4 weeks which represented 18.9% of responses. However the data also indicate that the runners in the current study were not restricted to RRIs of specific durations.

4.3.6.6. Recovery status of RRI

Table XII. Recovery status of running related injuries in relation to training

Did the injury recover before resuming training?	n =	%
Yes	165	39.47
No	162	38.76
Still recovering	91	21.77

TOTAL	418	100

The recovery status of RRIs was reported in 418 cases of RRIs. Over a third of these RRIs (39.47%) were not fully recovered before resuming training. There was a small difference of only 0.71% between injuries that had fully recovered before training resumed and injuries that did not recover. One fifth of the RRIs (21.77%) of injured participants, were still recovering and had not resumed training at the time of the questionnaire. Table # displays no distinct preference for recovery of RRIs and returning to training, of the injured participants in the current study.

4.3.6.7 Recurrent RRIs

Of the total number of injuries described (n=467), whether or not the injury was recurrent was disclosed in 417 cases. Of these 417 RRIs, over half (58.27%) were recurrent. Roughly 2 in 5 RRIs (41.73%) were reported as non-recurrent.

4.3.6.8. Medical aspects of RRIs

Table XIII. Medical aspects of RRIs

	Yes	No
Was the RRI diagnosed by a medical professional? (n=467)	57.82%	42.18%
Did the RRI undergo surgery? (n=418)	4.07%	95.93%

Out of 467 injuries, more were reported to professionals than not. More than half (57.82%) of the RRIs were serious enough for the participant to seek professional medical advice. Whether or not an RRI underwent surgery was reported in 418 injury cases. A small percentage of the running related injuries (4.07%) required surgery, however it must be noted that this was only for the injuries that occurred in the past 12 months. Therefore, if this was a yearly trend, in five years, 20% of running related injuries that occurred, would require surgery.

4.3.7 SUMMARY OF DESCRIPTIVE RESULTS

The following summarises the most common descriptive results of the study.

Table XIV. Summary of descriptive results

Section	Variable	Most common	%
Basic participant characteristics and demographics	Province	Gauteng	37.60% of participants
	Running club	Team Vitality	4.65% of participants
	Age category	30 - 39	26.19% of participants
	Sex	Male	59.52% of participants
	Ethnicity	Caucasian	82.80% of participants
	Stature category	1.71 – 1.80 m	36.24% of participants
	Mass category	61 – 70 kg	26.46% of participants
	BMI	Normal	66.14% of participants
	Monthly income	More than R30 000	49.46% of participants
Training characteristics	Weekly running frequency	4 times	36.51% of participants
	Weekly running distance	30 – 50 km	48.42% of participants
	Weekly running duration	5 hours	22.49% of participants
	Running terrain	Road	49.90% of preferences
	Number of terrains	2	37.04% of participants
	Running club involvement	Yes	86.24% of participants
	Run all year round	Yes and no	50/50 of participants
	Changes to training	No	53% of participants
	Training for a long-distance race	Yes	76.20% of participants

Running experience	Years	1 – 5 years	37.57% of participants
	Race distance preference	21 km	30.46% of preferences
	Professional/sponsored runner	Non-professionals	96.83% of participants
Footwear	Type	Normal running shoes with a tapered heel.	79.10% of participants
	Change in footwear	No change	78.58% of participants
	Reason for change	To improve performance	41.51% of participants who changed footwear
	Number of types	One type	57.41% of participants
	Number of pairs	Two pairs	44.44% of participants
	Orthotics	No	80.42% of participants
	Reason for orthotics	Injury	45.05% of orthotic using participants
Cross training	Involvement?	Yes	66.40% of participants
	Number of weekly cross training activities	1 - 2	66.14% of cross training participants
	Weekly duration	2 hours	27.49% of cross training participants
	Type	Weight-bearing	75.00% of cross training participants
RRIs	Currently injured	No	61.64% of participants
	Injured in the past year	Yes	74.07% of participants
	Number of RRIs in the past year	1	49.29% of participants
	Anatomical location	Knee	22.91% of RRIs
	Description of sensation (nature)	Aching	32.31% of RRIs

	Acute/overuse	Overuse	68.10% of RRIs
	Duration	1 – 3 months	22.25% of RRIs
	Full recovery	Yes	39.47% of RRIs
	Recurrent	Yes	58.27% of RRIs
	Professionally diagnosed	Yes	57.82% of RRIs
	Surgery needed	No	95.93% of RRIs

4.4 Running related injury associations

The following section details the results of the significant associations between participants, RRIs and the other variables tested. All RRI variables refer to those which occurred in the 12 months leading up to the questionnaire, unless otherwise stated. Associations between the variables of interest are shown in two ways; either with reference to the RRIs or with reference to the participants. This is clearly stated in the tables and figures. As there were more overall injuries than participants, sample sizes of RRI variables differ between analyses. In some instances, injury details were omitted by the participant therefore changing the sample size in certain analyses.

As with the previous section, each colour in the figures corresponds to a category indicated by the legend on the right-hand side of the graphs. The numbers of participants or RRIs in each category are displayed next to the variable name in the figure. Each category has a unique number of participants (for example within the age category, the 70 years and older group has 6 participants within it), these values are displayed under the percentages, allowing for caution when interpreting results with small sample sizes.

According to Cochran (1954), Roscoe & Byars (1971), and Camilli & Hopkins (1978), a sample size of between 5 and 10 is large enough to support a significant association. Sample sizes that were less than 5 were excluded from the following section, unless otherwise stated, and can be found in the appendices. Additionally, details of analyses in which significant associations were found but no trend could be seen, can be found in the appendices. Many of these unclear but significant associations were those of RRI durations, which may be due to the large number of categories in this variable.

4.4.1 BASIC PARTICIPANT CHARACTERISTICS AND DEMOGRAPHICS

The following section details the significant associations between basic participant characteristics and demographics, and RRI variables.

HYPOTHESIS 1:

There are significant associations ($p<0.05$) between the participant characteristics and demographics (age, sex, body mass index, ethnicity, monthly income) of South African long-distance runners, and running related injuries.

Age, sex, ethnicity, stature, BMI and monthly income were significantly associated with RRI variables. These specific RRI variables were: having an RRI at the time of the questionnaire, the number of RRIs reported, and the location, duration and professional diagnosis of the RRIs.

Within this section, ethnicity presented the largest number of significant RRI associations (four).

<u>4.4.1.1 Age</u>

Table XV. Sub-hypothesis 1A

Sub-hypothesis 1A	
There is a significant association ($p<0.05$) between age and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location and duration of RRIs.

Significant associations between age and RRIs were specifically found with posterior thigh RRIs, and the duration of RRIs.

Table XVI. Association between age and RRI location

	Age (years)						p-value
	19 – 29	30 – 39	40 – 49	50 – 59	60 – 69	70 – 82	
Participants with posterior thigh RRIs	2.53% (n=79)	7.07% (n=99)	10.31% (n=97)	15.38% (n=78)	0.00% (n=18)	0.00% (n=6)	0.04108

Table XVI displays the percentage of participants in each age category, that reported posterior thigh RRIs. 15.38% of 50 – 59 year old participants reported posterior thigh RRIs, the largest portion of participants throughout the age categories. From 19 to 59 years of age, the percentage of participants with posterior thigh injuries increased by 3-5% with each age category increase. However, older participants of 60 – 82 years did not report any RRIs of the posterior thigh which may be an artefact of sample size. With an increase in age, is an increase in the likelihood of posterior thigh RRIs until the age of 60. However, at any age, a runner is still more likely to not have a posterior thigh RRI than to have one.

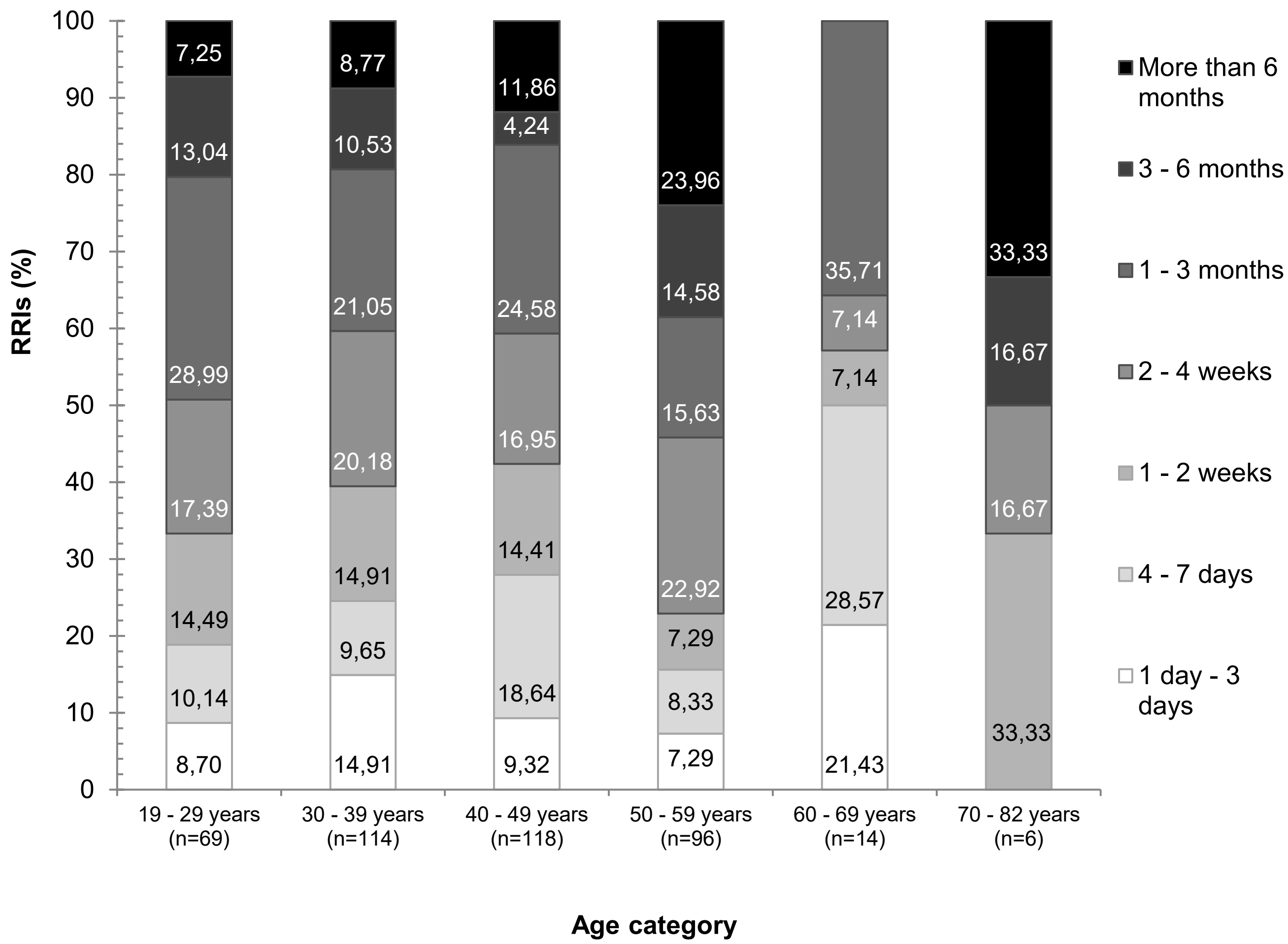

Figure 28. Association between age and RRI duration (p=0.005296)

In the age groups of 19 – 29 to 50 – 59, a trend can be seen. From 19 – 49 years, there was an increase in the percentage of RRIs of shorter durations (1 day to 2 weeks) and a decrease in longer duration RRIs (3 months or more). However, at 50 –

59 years, the proportion of long duration RRIs were high, with very few injuries of short durations. Overall, an increase in age was accompanied by an increase in the duration of RRIs.

From Figure 28 and

Table XVI, it appears that injured participants of 50 years and older may be the most susceptible to posterior thigh RRIs and RRIs that take longer to recover.

4.4.1.2 Sex

Table XVII. Sub-hypothesis 1B

Sub-hypothesis 1B	Partially supported in terms of anatomical location, duration of RRIs, and professionally diagnosed RRIs.
There is a significant association ($p<0.05$) between sex and running related injuries in South African long-distance runners.	

The significant associations that existed between the sex of a runner and RRI variables, consisted of buttock and calf RRIs, professionally diagnosed RRIs, and RRI duration.

Table XVIII. Associations between sex and RRI variables

	Sex		**p-value**
	Male	**Female**	
Participants with buttock RRIs	1.78% (n=255)	7.84% (n=153)	0.00781
Participants with calf RRIs	15.11% (n=255)	7.19% (n=153)	0.02300
Professionally diagnosed RRIs	52.01% (n=298)	65.47% (n=168)	0.00630

Sample sizes differ as RRI location relates to the number of participants whereas professionally diagnosed RRIs relates to the number of injuries.

In the current study, sex was associated with the presence of buttock injuries (p=0.00781) as well as calf injuries (p=0.02300). Out of 255 males and 153 females, a larger portion of female participants (7.84%) reported buttock RRIs compared to males (1.78%) whereas calf RRIs were more common in male participants (15.11%) than in female participants (7.19%).

Analyses on RRIs found a significant association between RRIs that were diagnosed by a medical professional and the sex of the participant (p=0.00630). RRIs reported by females (65.48%, n=168) were diagnosed by a medical professional more often than injuries reported by males (52.01%, n=298). Females were found either to have more RRIs that required medical attention or to be more likely to seek medical attention for RRIs, than males.

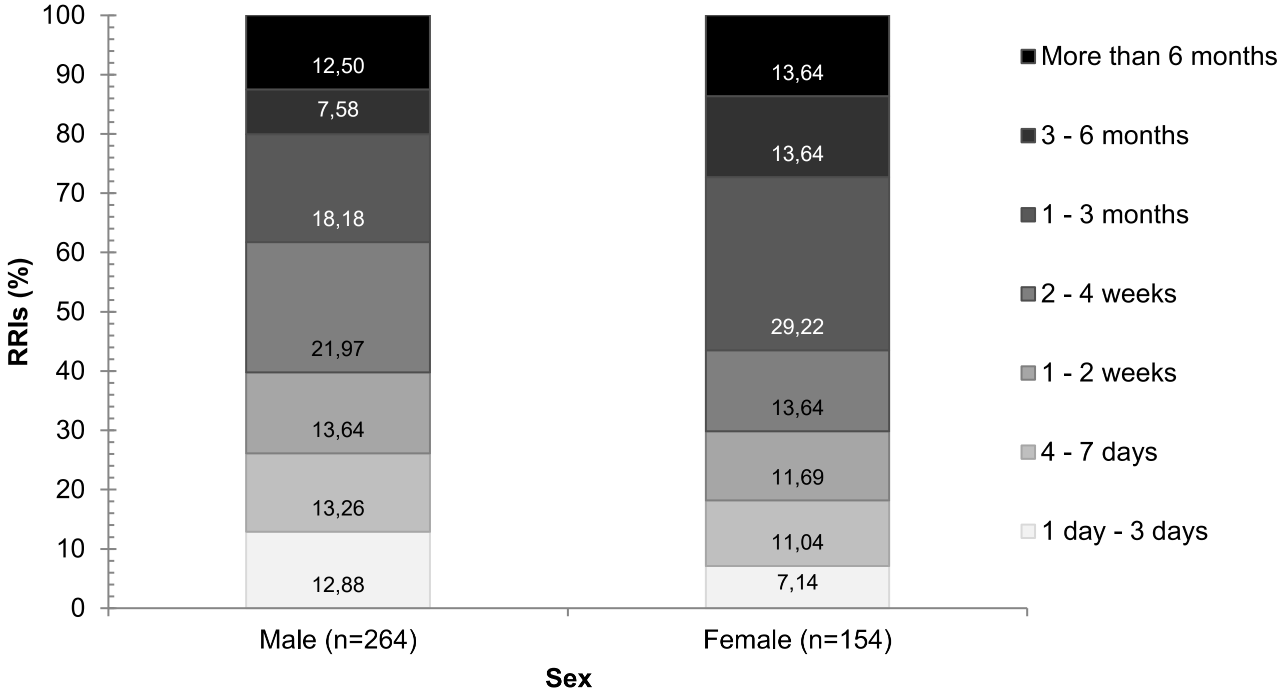

Figure 29. Association between sex and RRI duration (p=0.012310)

The significant association between the duration of RRIs and the sex of the participant is shown in Figure 29. The largest portion of RRIs belonging to male participants, lasted a duration of 2 – 4 weeks. For female participants, almost a third of the RRIs reported, lasted 1 – 3 months. Overall, a larger percentage of female RRIs took longer to recover (1 month or longer) compared to male RRIs.

Overall, females appeared to be at higher risk for buttock RRIs, and RRIs that took longer to recover. Females were also more likely to have their RRIs diagnosed by a professional.

4.4.1.3 Ethnicity

Table XIX. Sub-hypothesis 1C

Sub-hypothesis 1C	
There is a significant association ($p<0.05$) between ethnicity and running related injuries in South African long-distance runners.	Partially supported in terms of current RRI, the number of RRIs in the past year, anatomical location, and professionally diagnosed RRIs.

Ethnicity was significantly associated with current RRI, the number of RRIs in a year, back and knee RRIs, and professionally diagnosed RRIs. Due to the small numbers of participants of the Mixed, Indian and East Asian ethnicities, participants in these categories were pooled into an "Other" category for statistical purposes. It is acknowledged that this is a limitation of the study design through the characteristics of the sample involved in the study.

Table XX. Associations between ethnicity and RRI variables

	Ethnicity				p-value
	Black African	Caucasian (White)	Coloured	Other	
Participants with RRI at time of questionnaire	61.54% (n=26)	35.35% (n=314)	48.28% (n=29)	44.44% (n=9)	0.03745
Participants with back RRIs	0.00% (n=26)	3.50% (n=314)	13.79% (n=29)	0.00% (n=9)	0.02969
Participants with knee RRIs	57.69% (n=26)	19.11% (n=314)	37.93% (n=29)	44.44% (n=9)	0.00001
RRIs that were professionally diagnosed	26.32% (n=38)	62.26% (n=371)	38.10% (n=42)	53.33% (n=15)	0.00002

With reference to participants, the Black African participants showed the highest percentage of injured participants at the time of the questionnaire, while the Caucasian participants reported the lowest values. The Black African participants were the only group with more participants injured at the time of the questionnaire, than not injured, as well as more participants with knee injuries, than those without. Very few participants suffered from back injuries with 14% of the Coloured participants reporting back injuries, the highest value of all the ethnicities.

With reference to RRIs, almost two thirds (62.26%) of RRIs of Caucasian participants, were diagnosed by a medical professional. Just over half of the RRIs belonging to participants of other ethnicities, were seen by a medical professional.

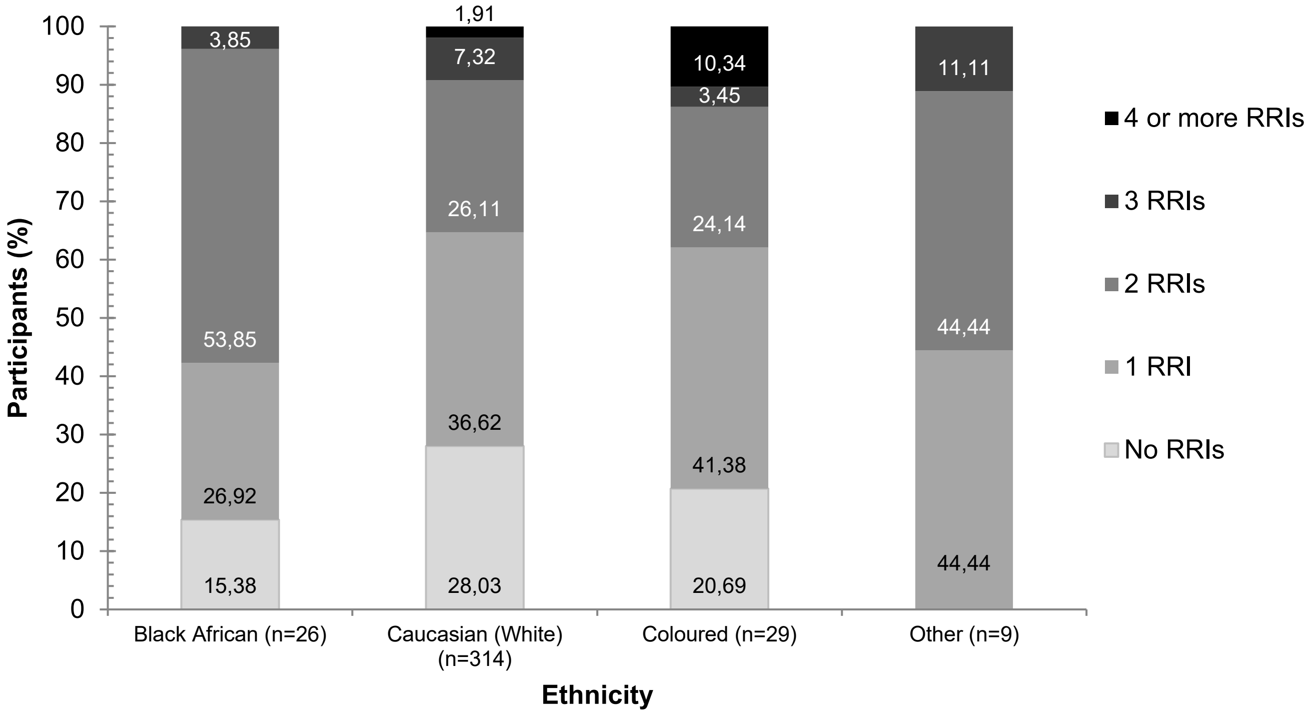

Figure 30. Association between ethnicity and number of RRIs (p=0.02915)

The highest percentage in the above figure belonged to Black African participants with over half (53.85%) of the participants reporting 2 RRIs in a year. The Caucasian and Coloured participant groups, most commonly reported 1 RRI in the past year, while the other ethnicity group had equal amounts of participants reporting 1 or 2 RRIs in the past year.

A tenth of Coloured participants reported having 4 or more RRIs, the highest percentage of this amount of RRIs. Both Black African participants and participants of other ethnicities had no participants with 4 or more RRIs. Black African participants had the highest percentage of participants with 2 or 3 RRIs (57.70%) followed closely by participants of other ethnicities (55.55%). Caucasian participants reported the highest proportion of injury-free participants (28.03%) while no participants of Mixed, Indian or East Asian ethnicity were injury free.

Black African participants and participants of Mixed, Indian and East Asian ethnicities, most commonly reported 2 RRIs, however for participants of Mixed, Indian or East Asian ethnicities, it was equally likely to report 1 RRI. In contrast to Black African participants, Caucasian and Coloured participants were most likely to report 1 RRI in a year.

4.4.1.4 Stature, mass and BMI

Table XXI. Sub-hypothesis 1D

Sub-hypothesis 1D	
There is a significant association ($p<0.05$) between stature, mass, and BMI, and running related injuries in South African long-distance runners.	Partially supported in terms of the number of RRIs in the past year, anatomical location, and duration of RRIs.

Significant associations were found between stature and buttock RRIs. No significant associations were found between any RRI variables, and the mass of a participant. BMI was significantly associated with the number of RRIs reported by a participant, Achilles RRIs, buttock RRIs, and the duration of RRIs.

Table XXII. Association between stature and RRI location

	Stature (m)				**p-value**
	≤ 1.6	**1.61 - 1.7**	**1.71 - 1.8**	**≥ 1.81**	
Participants with buttock RRIs	10.26% (n=39)	7.14% (n=112)	2.19% (n=137)	1.11% (n=90)	0.02436

The highest percentage of buttock RRIs occurred in participants with a stature of 1.6 m or less, the lowest stature category. The percentage of buttock RRIs decreased with each height category, with only 1.11% of buttock RRIs occurring in participants with stature greater or equal to 1.81 m.

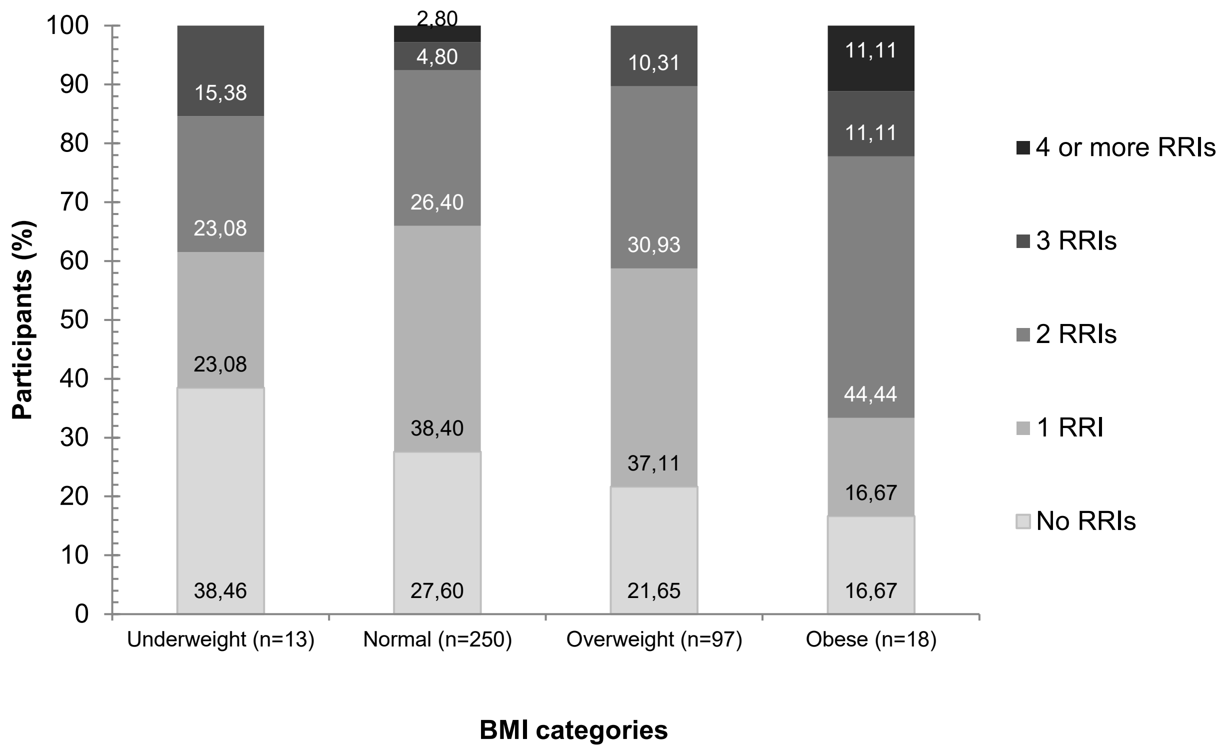

Figure 31. Association between BMI and number of RRIs (p=0.04829)

The largest proportion of underweight participants reported no RRIs, and most normal and overweight participants commonly had 1 RRI over the period of a year. Almost half of the obese participants reported 2 RRIs. Although it should be noted that the sample sizes for both the underweight and obese groups are small. The above figure indicates that having 3 or more RRIs in a year is more likely to occur if a participant falls under the obese category.

Table XXIII. Association between BMI and RRI location

	BMI category				p-value
	Underweight	Normal	Overweight	Obese	
Participants with Achilles RRIs	7.69% (n=13)	7.60% (n=250)	7.22% (n=97)	27.78% (n=18)	0.02786
Participants with buttock RRIs	15.38% (n=13)	4.00% (n=250)	1.03% (n=97)	16.67% (n=18)	0.00396

The largest percentage of participants who had Achilles RRIs, were found in obese participants (27.78%). In contrast, in the other BMI categories, participants with Achilles RRIs made up a smaller percentage of approximately 7%. Buttock RRIs were strongly associated with BMI (p=0.00396) and were found mostly in underweight (15.38%) and obese (16.67%) participants.

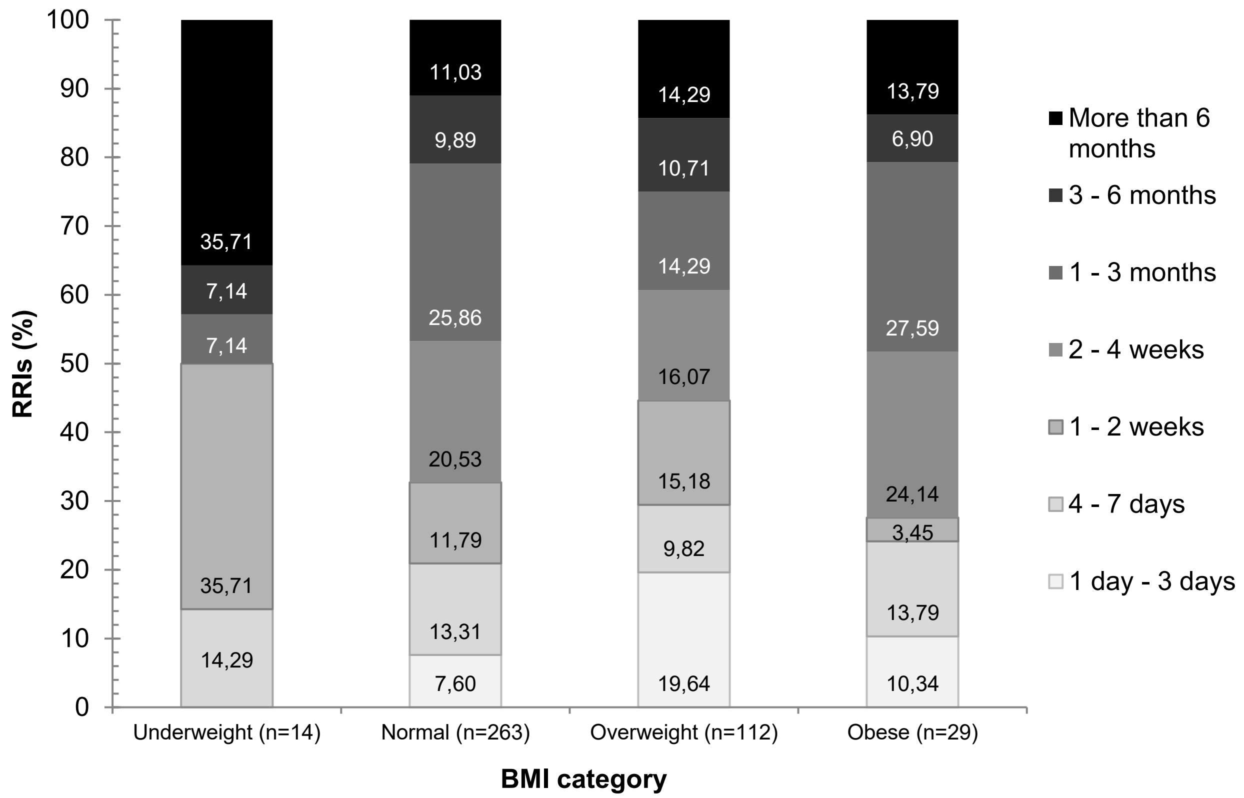

Figure 32. Association between BMI and RRI duration (p=0.003038)

The largest proportions of RRIs in underweight participants, both belonged to RRIs of 1 – 2 weeks duration and more than 6 months (35.71%). The most common RRI duration in participants with a normal BMI, was 1 – 3 months (25.86%). In overweight participants, most RRIs recovered after 1 to 3 days (19.64%). Just over a quarter of RRIs of obese participants lasted 1 – 3 months (27.59%). RRIs of long durations (one month or more) were most common in underweight and obese participants. Overweight participants reported the highest percentage of RRIs that recovered after 3 days or less.

4.4.1.5 Monthly income

Table XXIV. Sub-hypothesis 1E

Sub-hypothesis 1E	
There is a significant association ($p<0.05$) between monthly income and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location, duration of RRIs, and professionally diagnosed RRIs.

Monthly income was significantly associated with ankle RRIs and professionally diagnosed RRIs. Significant associations were found for RRI duration and monthly income ($p=0.008883$) however the results were inconclusive, as there was no clear trend and was difficult to see where exactly this significance lay. This figure can be found in the appendix.

Table XXV. Association between monthly income and RRI variables

	Monthly income					p-value
	≤ R 5 000	R 5 000 - R 10 000	R 10 000 - R 15 000	R 15 000 - R 30 000	≥ R 30 000	
Participants with ankle RRIs	23.08% (n=13)	19.35% (n=31)	16.22% (n=37)	4.55% (n=110)	8.06% (n=186)	0.01704
RRIs that were professionally diagnosed	43.75% (n=16)	35.14% (n=37)	60.53% (n=38)	54.23% (n=142)	62.23% (n=233)	0.02066

The percentage of participants with ankle RRIs was highest in the lowest income group (23.08%). This proportion decreased with an increase in monthly income, with the exception of the highest income group which had 3.51% more participants with ankle injuries than in the income bracket below of R 15 000 – R 30 000.

The smallest proportions of RRIs that had been diagnosed by a professional, belonged to the less affluent groups of a monthly income of R 10 000 or less. Thus, it appears that the wealthier participants were more likely to see a medical professional due to their injuries.

With reference to sub-hypotheses 1A through E, hypothesis 1 is partially supported.

4.4.2 TRAINING CHARACTERISTICS

HYPOTHESIS 2:

There are significant associations ($p<0.05$) between training characteristics (frequency, duration, distance, terrain) of South African long-distance runners, and running related injuries.

The training characteristics associated with RRIs were running club involvement, weekly running frequency, weekly running duration, running terrain, number of terrains, and changes made to training. Highest number of significant associations was found for running terrain.

4.4.2.1 Organised running

In the current study, organised running refers to the participant's involvement in a running club.

Table XXVI. Sub-hypothesis 2A

Sub-hypothesis 2A	
There is a significant association ($p<0.05$) between running club involvement and running related injuries in South African long-distance runners.	Partially supported in terms of RRI in the past year.

Running club involvement was significantly associated with having an RRI in the past year.

Table XXVII. Association between running club involvement and RRIs in the past 12 months

	Running club		**p-value**
	Yes	**No**	
Participants with RRIs in the past 12 months	76.07% (n=326)	61.54% (n=52)	0.04000

A higher percentage of participants who were part of a running club (76.07%) were injured compared to those who were not part of a running club (61.54%), although the percentage of runners that have suffered an injury in the last 12 months was high in each group.

4.4.2.2 Weekly running frequency

Table XXVIII. Sub-hypothesis 2B

Sub-hypothesis 2B	
There is a significant association (p<0.05) between weekly running frequency and running related injuries in South African long-distance runners.	Partially supported in terms of the duration of RRIs, recurrent RRIs, and professionally diagnosed RRIs.

Weekly running frequency was associated with recurrent RRIs and professionally diagnosed RRIs. Significant associations were found for RRI duration and weekly running frequency (p=0.002051) however the results were inconclusive, therefore this figure can be found in the appendix.

Table XXIX. Association between weekly running frequency and RRI variables

	Weekly running frequency						**p-value**
	Twice or less	**3 times**	**4 times**	**5 times**	**6 times**	**7 times or more**	
Recurrent RRIs	36.84% (n=19)	50.00% (n=76)	41.61% (n=161)	35.56% (n=90)	53.85% (n=52)	15.79% (n=19)	0.03338
RRIs that were professionally diagnosed	45.00% (n=19)	67.90% (n=76)	51.35% (n=161)	67.00% (n=90)	52.54% (n=52)	38.10% (n=19)	0.00988

Although a clear trend is not immediately evident in the association between running frequency and recurrent RRIs, what is noticeable in the above table is that those who run every day or more than once a day, reported a considerably lower percentage of recurrent RRIs than those who run less frequently. It is important to note that these findings report only on associations and not causation.

RRIs that were professionally diagnosed occurred least often in those who ran 7 or more times per week (38.10%) followed by participants who ran twice or less times per week (45.00%).

4.4.2.3 Weekly running duration

Table XXX. Sub-hypothesis 2C

Sub-hypothesis 2C	
There is a significant association ($p<0.05$) between weekly running duration and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location, and surgery for RRIs.

The hours spent running by a participant on a weekly basis was measured as weekly running duration. Significant associations were found between weekly running duration and participants with Achilles RRIs, participants with foot RRIs, and RRIs that had undergone surgery.

Table XXXI. Association between weekly running duration and RRI variables

	Weekly running duration (hours)									**p-value**
	≤ 2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**≥ 10**	
Participants with Achilles RRIs	21.05% (n=19)	2.00% (n=50)	5.71% (n=70)	7.06% (n=85)	5.36% (n=56)	9.09% (n=33)	18.75% (n=32)	7.69% (n=13)	20.00% (n=20)	0.04224
Participants with foot RRIs	5.26% (n=19)	22.00% (n=50)	18.57% (n=70)	14.12% (n=85)	28.57% (n=56)	3.03% (n=33)	6.25% (n=32)	15.38% (n=13)	20.00% (n=20)	0.03724
RRIs that had undergone surgery	4.17% (n=24)	11.54% (n=52)	4.49% (n=89)	0.00% (n=108)	5.88% (n=68)	0.00% (n=38)	2.33% (n=43)	0.00% (n=14)	4.76% (n=21)	0.03694

Participants of both the shortest and longest weekly running durations reported the highest percentage of Achilles RRIs. Participants who ran 6 hours a week reported the largest percentage of foot RRIs (28.57%), however those running 3 hours a week as well as those running 10 hours or more, also reported similar proportions of foot RRIs. Running 3 hours a week, the lower end of the weekly duration spectrum, yielded the highest proportion of RRIs that were severe enough to undergo surgery.

4.4.2.4 Weekly running distance

Table XXXII. Sub-hypothesis 2D

Sub-hypothesis 2D	
There is a significant association ($p<0.05$) between weekly running distance and running related injuries in South African long-distance runners.	Not supported.

The table above shows that no significant associations were found between weekly running distance and RRI variables.

4.4.2.5 Running terrain

Table XXXIII. Sub-hypothesis 2E

Sub-hypothesis 2E	
There is a significant association ($p<0.05$) between running terrain and running related injuries in South African long-distance runners.	Partially supported in terms of RRI in the past year, number of RRIs in the past year, anatomical location of RRIs, acute or overuse RRI, duration of RRIs, and surgery for RRIs.

The terrains that were significantly associated with RRI variables were grass, track/tartan, treadmill, and cross country/trail. Sand was not included in the inferential analyses as the sample size was too small for statistical analyses.

Table XXXIV. Associations between running terrain and RRI variables

<table>
<tr><td></td><td colspan="3">Running terrain</td></tr>
<tr><td></td><td colspan="3">Treadmill</td></tr>
<tr><td rowspan="6">Participants with RRI in the past 12 months</td><td>Yes</td><td>No</td><td>p-value</td></tr>
<tr><td>85.53%
(n=76)</td><td>71.19%
(n=302)</td><td>0.01000</td></tr>
<tr><td colspan="3">Track/tartan</td></tr>
<tr><td>Yes</td><td>No</td><td>p-value</td></tr>
<tr><td>88.57%
(n=35)</td><td>72.59%
(n=343)</td><td>0.04000</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="3">Participants with ankle RRIs</td><td colspan="3">Grass</td></tr>
<tr><td>Yes</td><td>No</td><td>p-value</td></tr>
<tr><td>15.19%
(n=79)</td><td>7.69%
(n=299)</td><td>0.04977</td></tr>
<tr><td rowspan="3">Overuse RRIs (gradual)</td><td colspan="3">Cross country/Trail</td></tr>
<tr><td>Yes</td><td>No</td><td>p-value</td></tr>
<tr><td>62.02%
(n=208)</td><td>74.16%
(n=209)</td><td rowspan="2">0.007807</td></tr>
<tr><td>Acute RRIs (immediate)</td><td>37.98%
(n=208)</td><td>25.84%
(n=209)</td></tr>
</table>

In both treadmill and track/tartan runners, a larger proportion of injured participants were reported, compared to participants who did not run on treadmills, or track/tartan. Approximately double the percentage of participants who ran on grass suffered from ankle RRIs (15.19%) compared to those who did not run on grass (7.69%).

RRIs in both those who did cross country and trail running and those who did not. When comparing overuse RRIs, a larger percentage was reported by those who do not include cross country running in their training (74.16%) than by those who were cross country runners (62.02%). In contrast, a larger proportion of acute RRIs occurred in those who were trail runners (37.98%) than those who were not (25.84%).

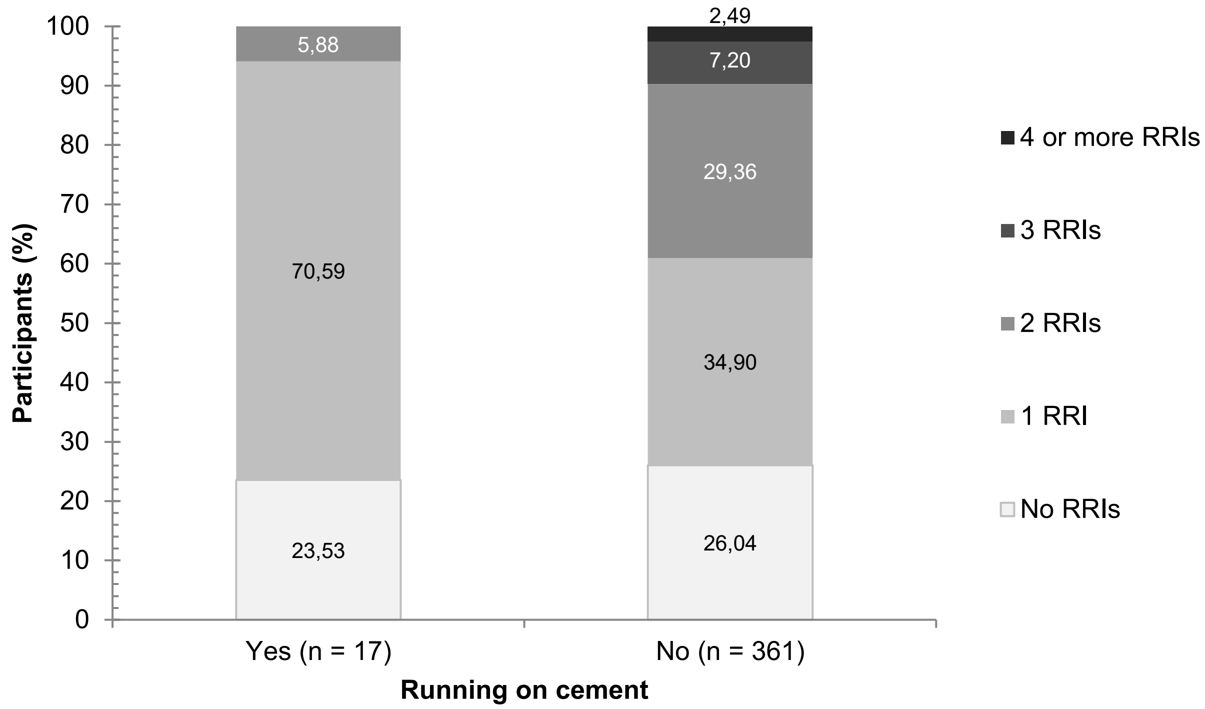

Figure 33. Association between the inclusion of cement as a running terrain and the number of RRIs (p=0.03262)

A higher percentage of participants with more injuries (3 RRIs and up) can be seen in those who did not run on cement, compared to those that did. Most participants who included cement as a running terrain, reported one RRI.

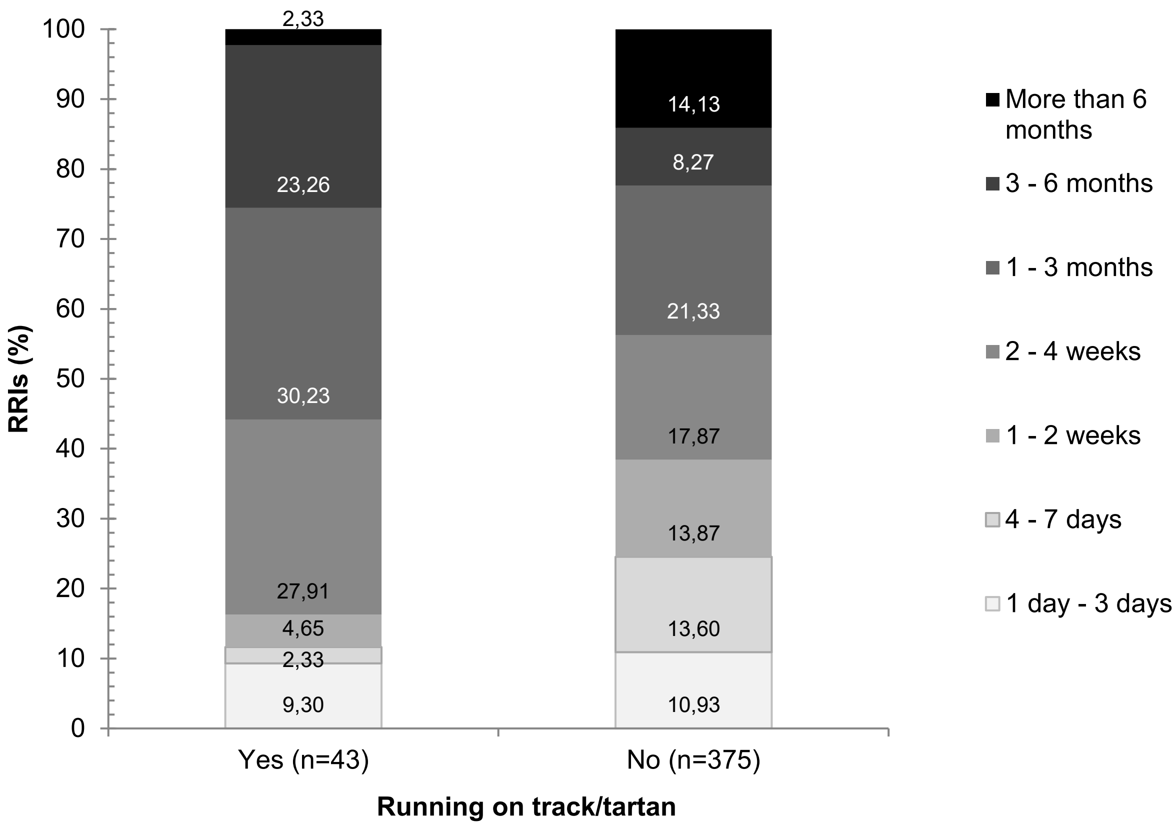

Figure 34. Association between the inclusion of track/tartan as a running terrain and RRI duration (p=0.000795)

RRIs of durations of one month or longer were more common in those who ran on track or tartan (55.82%) than those who did not (43.73%). Most of the RRIs of those who did not include track or tartan running, lasted less than one month (56.27%). Therefore, it can be seen that RRIs have an overall longer duration in those who include track and tartan running in their training programs.

Table XXXV. Association between the number of different running terrains and RRIs that had undergone surgery

	Number of different running terrains				p-value
	1	2	3	4 or more	
RRIs that had undergone surgery	7.19% (n=139)	3.41% (n=176)	0.00% (n=112)	3.33% (n=30)	0.02835

In the table above, n refers to the total number of RRIs in the vertical category. The highest proportion of RRIs that were severe enough to undergo surgery, belonged to participants who ran on only 1 type of terrain. No RRIs belonging to participants, who incorporated 3 different types of terrain into their training, needed surgery.

4.4.2.6 Changes to training

Table XXXVI. Sub-hypothesis 2F

Sub-hypothesis 2F	
There is a significant association ($p<0.05$) between changes to training and running related injuries in South African long-distance runners.	Partially supported in terms of the number of RRIs in the past year, and anatomical location of RRIs.

Changes made to running training were significantly associated with the number of RRIs in the past year, as well as knee RRIs.

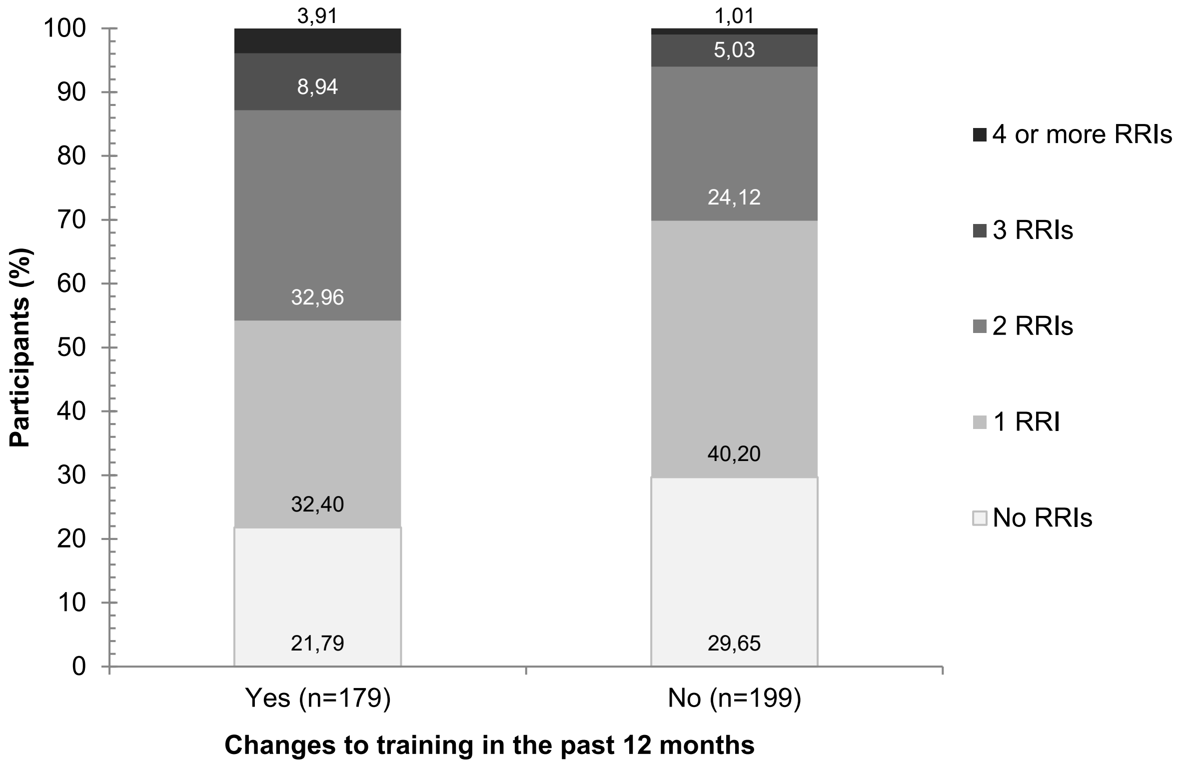

Figure 35. Association between changes to training and the number of RRIs (p=0.01845)

More participants that made changes to their training in the past year reported a higher number of RRIs, specifically two injuries or more. Having no injuries or one injury was more likely to be found in those who did not change anything related to training.

Table XXXVII. Association between changes to training and knee RRIs

	Changes to training		**p-value**
	Changed	**Did not change**	
Participants with knee RRIs	30.73% (n=197)	17.59% (n=199)	0.00358

Almost double the percentage of participants who adjusted their training in the past year, reported suffering from knee injuries, compared to those whose training regime remained the same. This does not necessarily mean that changing training caused knee RRIs but could mean that participants changed their training as a result of knee RRIs.

With reference to sub-hypotheses 2A, B, C, E and F, hypothesis 2 is partially supported.

4.4.3 RUNNING EXPERIENCE

HYPOTHESIS 3:

There are significant associations ($p<0.05$) between running experience (years of running, number of races, preferred race distance) of South African long-distance runners, and running related injuries.

The aspects of running experience that were significantly associated with RRIs were years of running experience with the highest number significant associations, preferred race distance of 42 km or more, the number of 42 km races run in the past year, and whether the participant was a sponsored or professional runner.

4.4.3.1 Years of running experience

Table XXXVIII. Sub-hypothesis 3A

Sub-hypothesis 3A	
There is a significant association ($p<0.05$) between years of running experience and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location of RRI, recurrent RRI, and professionally diagnosed RRIs.

The number of years of running experience was significantly associated with knee RRIs, recurrent RRIs, and professionally diagnosed RRIs.

Table XXXIX. Associations between years of running experience and RRI variables

	Running experience				**p-value**
	Less than a year	**1 - 5 years**	**5 - 15 years**	**More than 15 years**	
Participants with knee RRIs	60.00% (n=25)	26.06% (n=142)	20.17% (n=119)	15.22% (n=92)	0.0004
Recurrent RRIs	35.48% (n=31)	50.30% (n=165)	61.02% (n=118)	73.79% (n=103)	0.000085
RRIs that were professionally diagnosed	47.22% (n=36)	51.63% (n=184)	67.94% (n=131)	55.65% (n=115)	0.01824

60% of participants with running experience of less than a year reported having had a knee RRI in the 12 months preceding the questionnaire. With more years of running experience, the percentage of knee RRIs lessened. This was a trend seen throughout all the running experience groups.

The percentage of recurrent RRIs increased in each category as the years of running experienced increased, with almost three quarters of RRIs being recurrent in those who have more than 15 years of experience running. Injured participants who had been running for more than 15 years, had a 3 out of 4 chance of their injury being recurrent.

RRIs that were seen by a medical professional were most common in participants who had 5 – 15 years of running experience with two thirds of the RRIs in this category having been diagnosed by a medical professional. It is therefore apparent that running experience is differentially related to RRIs depending on the variable under investigation.

4.4.3.2 Race distance preference of 42 km or more

Table XL. Sub-hypothesis 3B

Sub-hypothesis 3B	
There is a significant association ($p<0.05$) between race distances and running related injuries in South African long-distance runners.	Partially supported in terms of the number of RRIs in the past year, anatomical location of RRIs, and duration of RRIs.

Race distances, specifically those of 42 km or more, were significantly associated with the number of RRIs in the past year, knee RRIs, and the duration of RRIs.

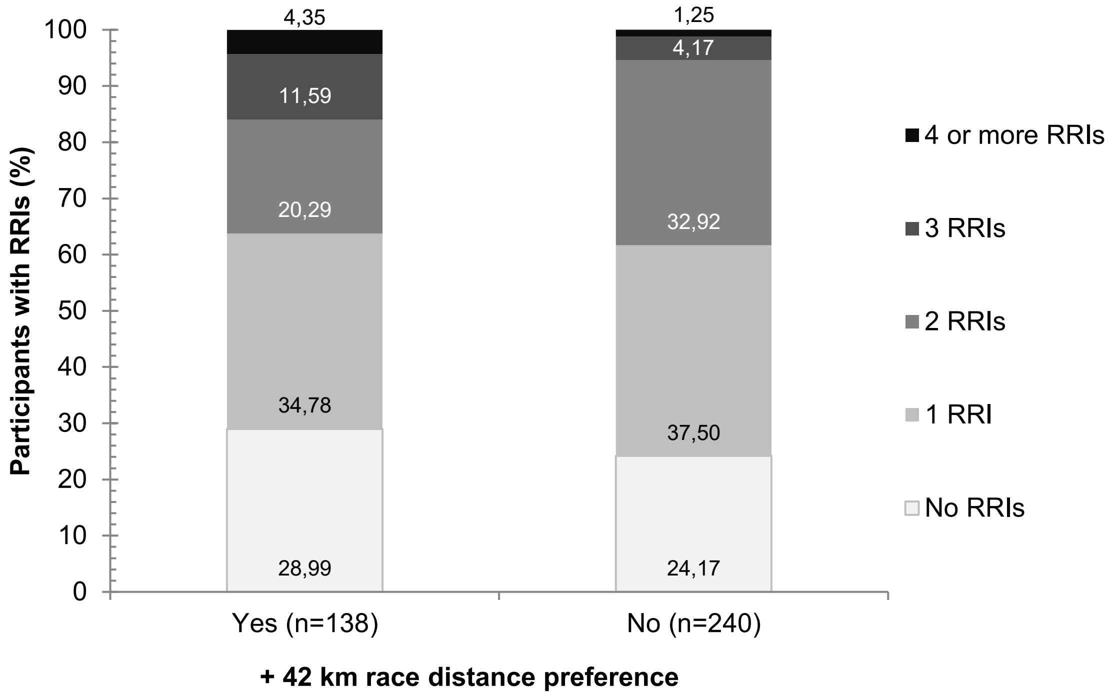

Figure 36. Association between +42 km race distance preference and the number of RRIs (p=0.00246)

There was a higher percentage of participants with three or more RRIs in those who favoured race distances of 42 km (16%), than those who did not prefer 42 km races (5%).

Table XLI. Association between +42 km race distance preference and RRI location

	Preferred race distance of +42 km		**p-value**
	Yes	**No**	
Participants with posterior thigh RRIs	13.38% (n=142)	5.08% (n=236)	0.00622

Those who indicated a preference for 42 km races, were more likely to have posterior thigh RRIs (13.38%) than those who did not indicate a preference for 42 km races (5.08%).

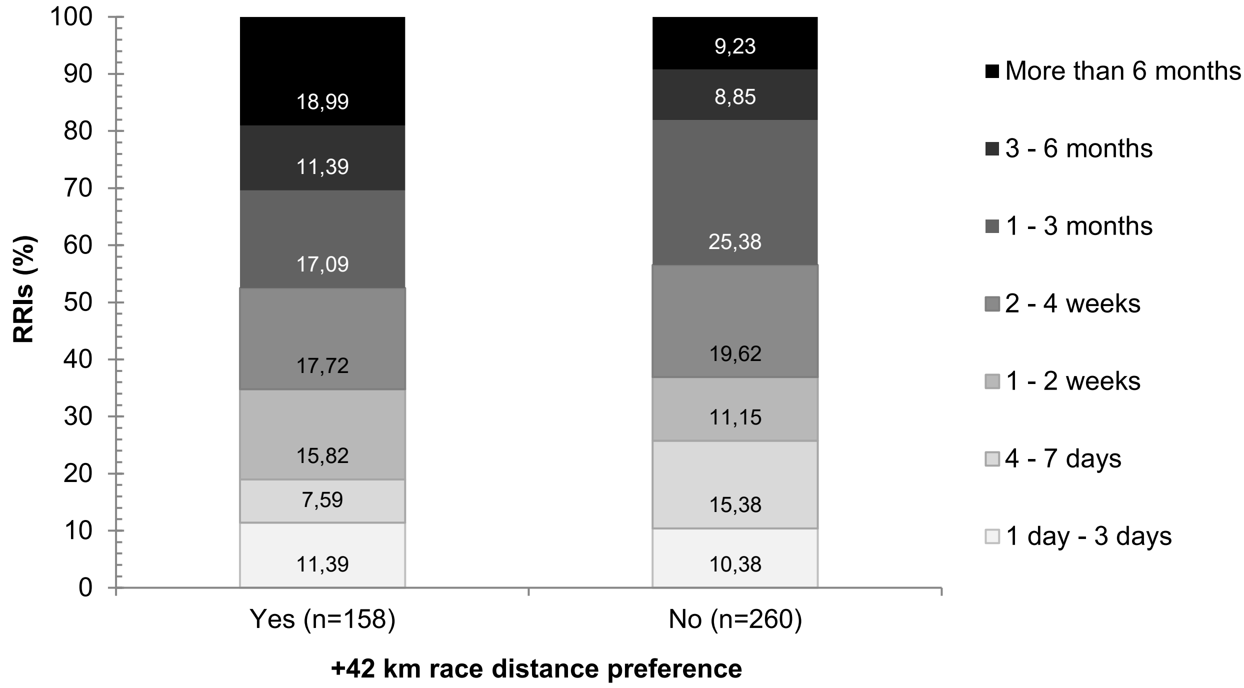

Figure 37. Association between +42 race distance preference and RRI duration (p=0.007134)

The largest proportion of RRIs in participants who favoured races of more than 42 km, lasted the duration of more than 6 months (18.99%). In comparison, only 9.23% of RRIs lasted more than 6 months, in participants who did not favour races of more than 42 km. Additionally, a quarter of RRIs reported by participants who did not prefer this race distance, recovered after 1 – 3 months. Overall, those who favoured races of more than 42 km were most likely to have RRIs that lasted longer durations than those who did not favour this particular race distance.

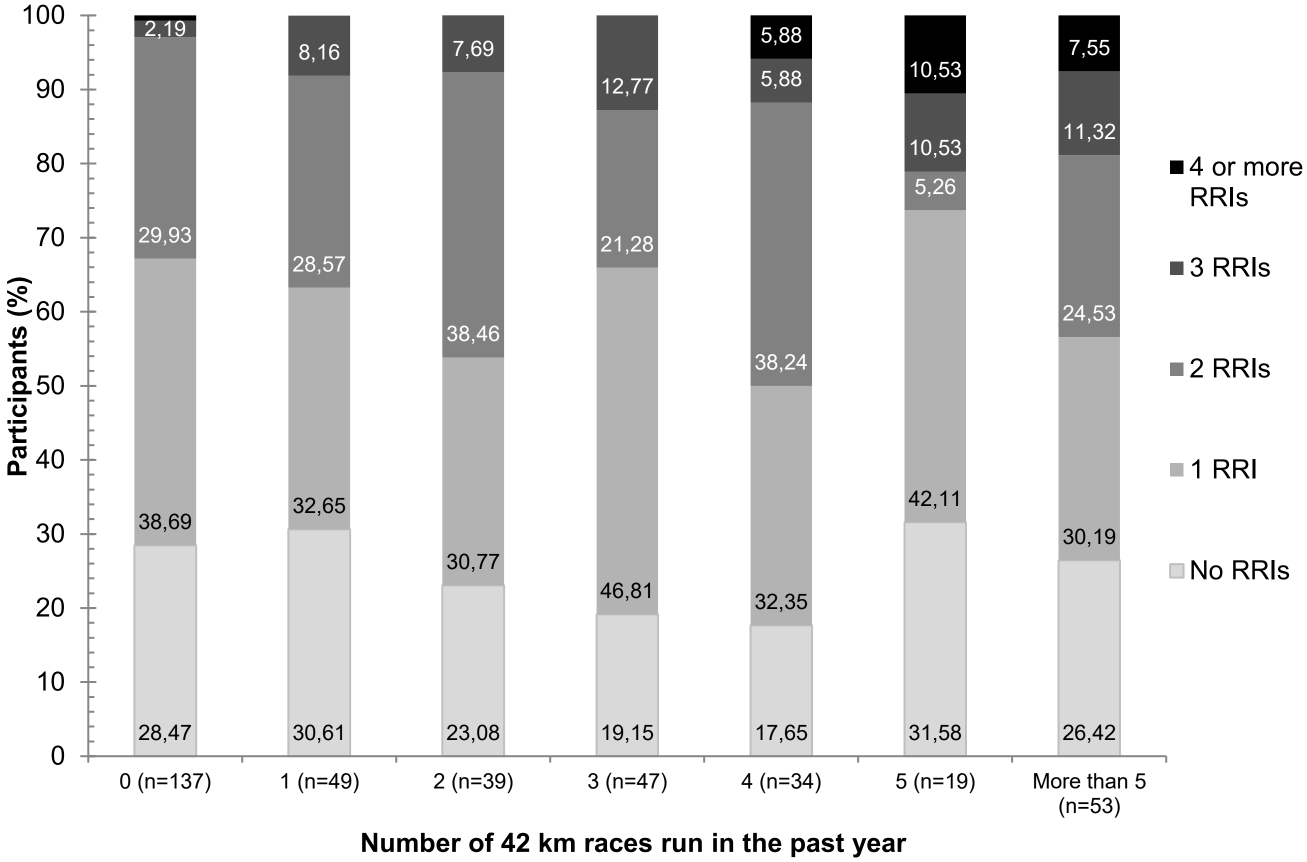

Figure 38. Association between the number of 42 km races run in the past year and the number of RRIs (p=0.02224)

Only participants who ran 4 or more 42 km races, reported having 4 or more RRIs. The highest percentages of participants with three or more RRIs, were reported by those who ran five or more races of 42 km. Although a clear trend is not obvious, running more 42 km races appears to yield the highest percentages of participants with several RRIs. It is more likely that a runner who runs more than 3 marathons in a year, will have more injuries than a runner who runs 3 or less.

4.4.3.3 Sponsored or professional runner

Table XLII. Sub-hypothesis 3C

Sub-hypothesis 3C	
There is a significant association (p<0.05) between sponsored or professional runners and running related injuries in South African long-distance runners.	Partially supported in terms of RRI recovery status.

The calibre of the runner; being a professional or sponsored runner; was significantly associated with the recovery status of the RRIs.

Table XLIII. Association between sponsored/professional runners and the recovery status of RRIs

	RRIs of sponsored or professional runners (n=13)	**p-value**
Full recovery before resuming training - Yes	30.77%	0.014442
Full recovery before resuming training - No	15.38%	
Still recovering	53.85%	

The recovery statuses of 13 RRIs were reported by sponsored or professional runners, making the sample or this particularly variable small. The majority of RRIs belonging to these athletes were reported as “still recovering” (53.85%) which means that over half of the RRIs of professional runners in the current study were existing RRIs. Half of the RRIs that professional runners had in the past year, were existing injuries. A third of the reported RRIs of professional athletes were allowed to heal prior to the runner resuming training. If the participants were a sponsored or professional runner, it is likely that they were still recovering from an injury which means that they were currently injured at the time of the questionnaire. If the participants had recovered from their injury, it is likely that they waited to fully recovery before running again.

With reference to sub-hypotheses 3A through C, hypothesis 3 is partially supported.

4.4.4. RUNNING FOOTWEAR

HYPOTHESIS 4:

There are significant associations (p<0.05) between the running footwear of South African long-distance runners, and running related injuries.

The footwear variables that were significantly associated with RRIs were footwear type, number of footwear types, change in footwear type in the past year, number of footwear pairs and orthotic use. The highest number of significant associations were found between orthotic use and RRI variables.

4.4.4.1 Footwear type

Table XLIV. Sub-hypothesis 4A

Sub-hypothesis 4A	
There is a significant association (p<0.05) between running footwear type and running related injuries in South African long-distance runners.	Partially supported in terms of current RRI, acute or overuse RRI, duration of RRIs, RRI recovery status, and professionally diagnosed RRIs.

Running footwear types were found to be significantly associated with current RRIs, whether the RRI was acute or overuse, the duration of RRIs, the recovery status of RRIs, and whether or not the RRI was professionally diagnosed. Barefoot participants were excluded from the footwear statistical analyses because the sample size was too small (n=1).

Table XLV. Association between footwear type and RRI variables

	Footwear type					p-value
	Combination shoes	**Minimalist shoes**	**Normal running shoes**	**Racing flats**	**Trail running shoes**	
Participants with RRI at the time of the questionnaire	55.56% (n=9)	20.00% (n=15)	35.79% (n=299)	46.15% (n=26)	64.29% (n=28)	0.02000
Overuse (gradual) RRIs	76.92% (n=13)	38.46% (n=13)	67.99% (n=328)	83.87% (n=31)	62.50% (n=32)	0.045106
Acute (immediate) RRIs	23.08% (n=13)	61.54% (n=13)	32.01% (n=328)	16.13% (n=31)	37.50% (n=32)	
RRIs that were professionally diagnosed	38.46% (n=13)	84.62% (n=13)	59.02% (n=366)	38.89% (n=36)	50.00% (n=38)	0.01706

Two thirds of the participants who ran in trail running shoes had an RRI at the time of the questionnaire; the largest proportion of injured participants compared to the other footwear categories. Participants with trail running shoes and those with combination shoes, had more participants who were injured than not injured.

Participants who ran in combination shoes, normal running shoes, racing flats and trail running shoes reported more overuse than acute RRIs. Those who ran in minimalist shoes reported more acute injuries. The highest percentage of overuse injuries occurred in participants running in racing flats and the highest percentage of acute injuries occurred in participants who ran in minimalist shoes. Barefoot running was excluded from this statistical analysis as the sample size was less than 5 and would therefore hold very little statistical power.

Minimalist shoes yielded the most injuries that were diagnosed by a medical professional, followed by normal running shoes and trail running shoes. Participants who wore combination shoes or racing flats for running, reported that just over two thirds of their injuries were diagnosed by a medical professional, the lowest percentages among the footwear types.

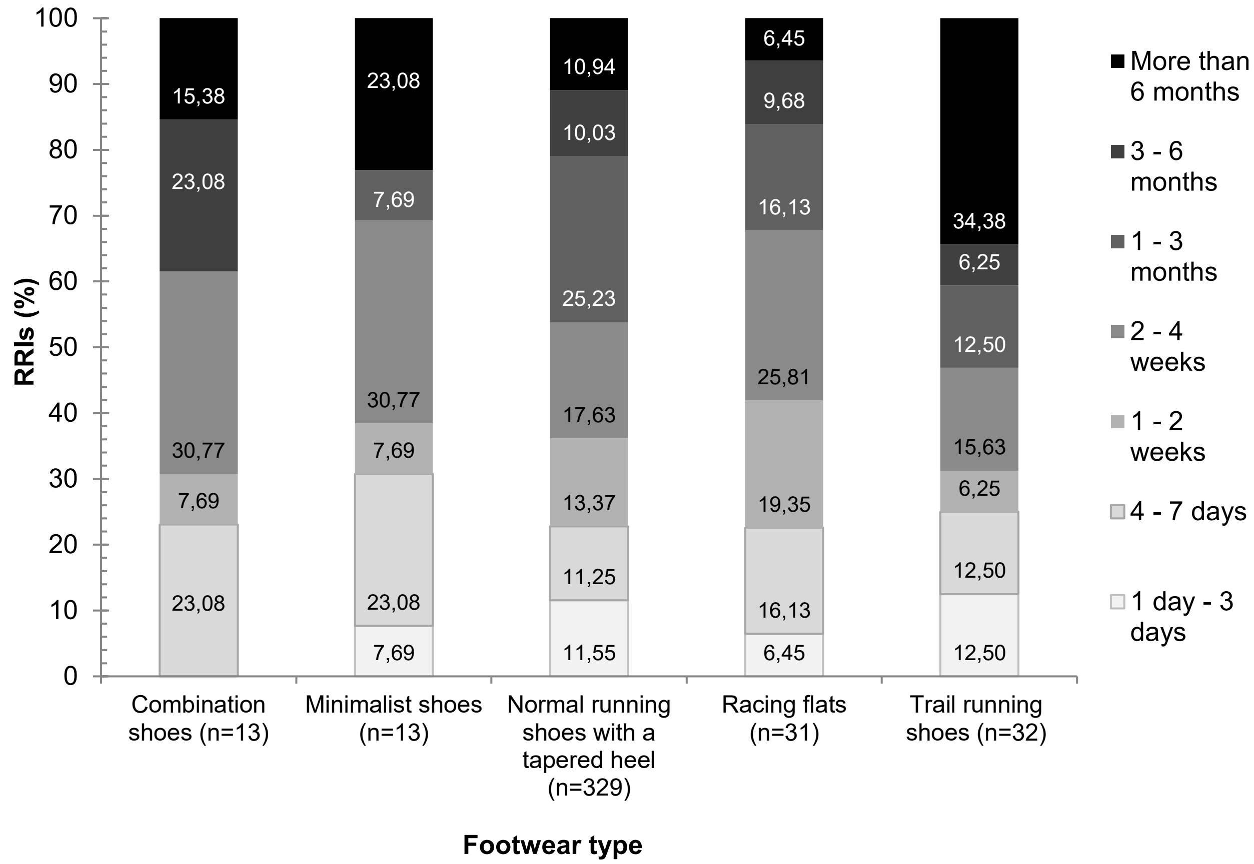

Figure 39. Association between footwear type and RRI duration (p=0.042168).

Participants who wore trail running shoes had the highest percentage of the longest duration injuries (more than 6 months). Most of the RRIs in the normal running shoes category healed after 1 – 3 months. The highest percentages of RRIs in the combination shoes, minimalist shoes and racing flats categories, healed after 2 – 4 weeks. When looking at RRIs that took 3 months or more to recovery, trail running shoes and combination shoes yielded the largest proportion. Racing flats had the highest percentage of RRIs of durations lasting 2 weeks or less.

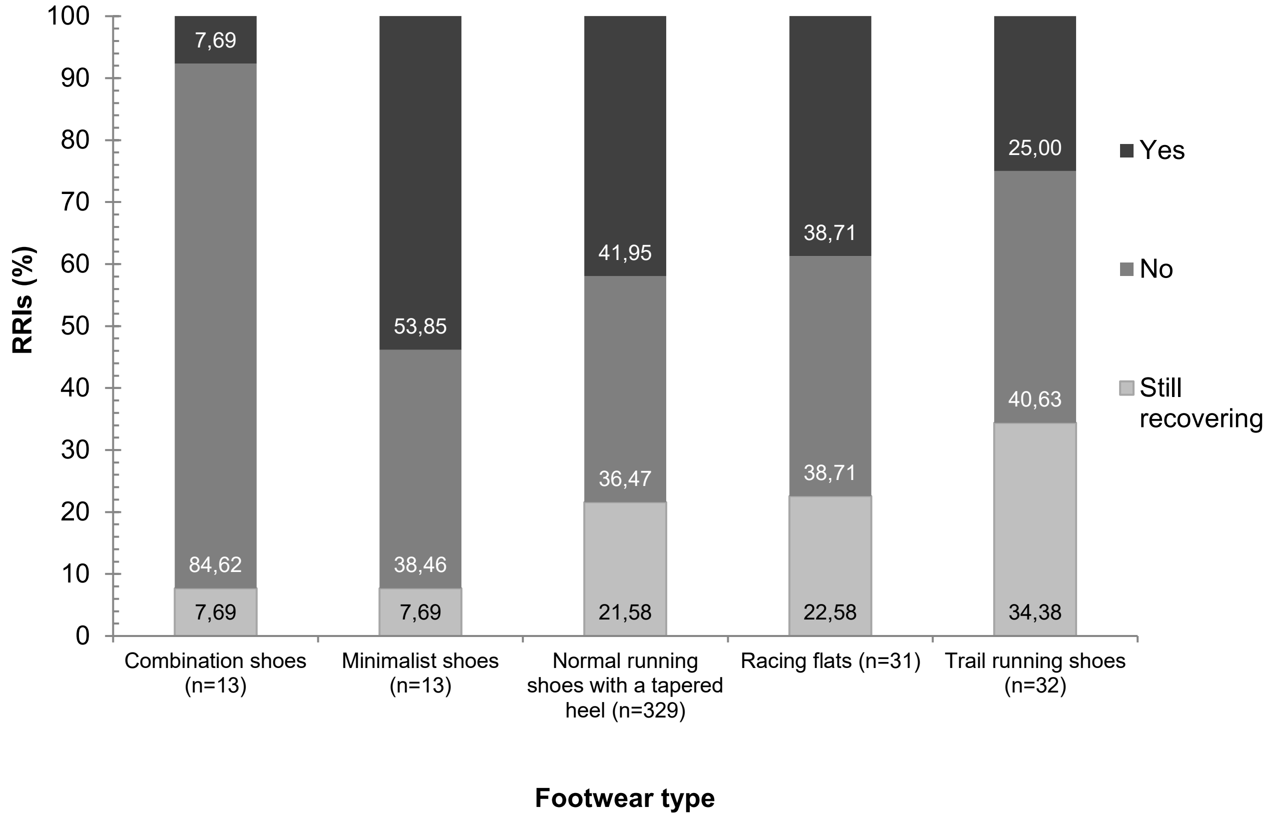

Figure 40. Association between footwear type and recovery status (p=0.018040).

The largest proportion of RRIs still recovering, were reported by participants who ran in trail running shoes. This means that a third of RRIs of trail shoe wearers, were current RRIs; more than reported in the other categories. This being said, the majority of injuries in this footwear category were not fully recovered before training resumed (40.63%). RRIs in the minimalist shoe group and normal running shoe group had mostly recovered prior to returning to training, however in the racing flats group, there were equal amounts of RRIs that had and had not fully recovered before the participant started running again. Most RRIs belonging to participants who ran in combination running shoes, did not fully recover before the participant resumed training (84.62%). This percentage was more than double that of unrecovered RRIs in the other footwear categories.

4.4.4.2 Number of different footwear types

Table XLVI. Sub-hypothesis 4B

Sub-hypothesis 4B	
There is a significant association ($p<0.05$) between the number of different running footwear types and running related injuries in South African long-distance runners.	Partially supported in terms of current RRI, and duration of RRIs.

The number of different footwear types used by a runner, were found to be significantly associated with whether or not the participant was injured at the time of the questionnaire, and the duration of the RRIs.

Table XLVII. Association between the number of different footwear types used concurrently and participants with an RRI at the time of the questionnaire

	Number of different footwear types				**p-value**
	1	**2**	**3**	**4 or more**	
Participants with RRI at time of questionnaire	30.88% (n=217)	47.86% (n=117)	47.22% (n=36)	62.50% (n=8)	0.00500

Participants who used four or more different running footwear types, reported the highest percentage of currently injured participants, however the small sample size should be taken into consideration. Those who ran in only one type of footwear, were found to have the smallest proportion of participants who were injured at the time of the questionnaire. There was a definite increase in the percentage of injured participants with an increase in the number of footwear types ran in.

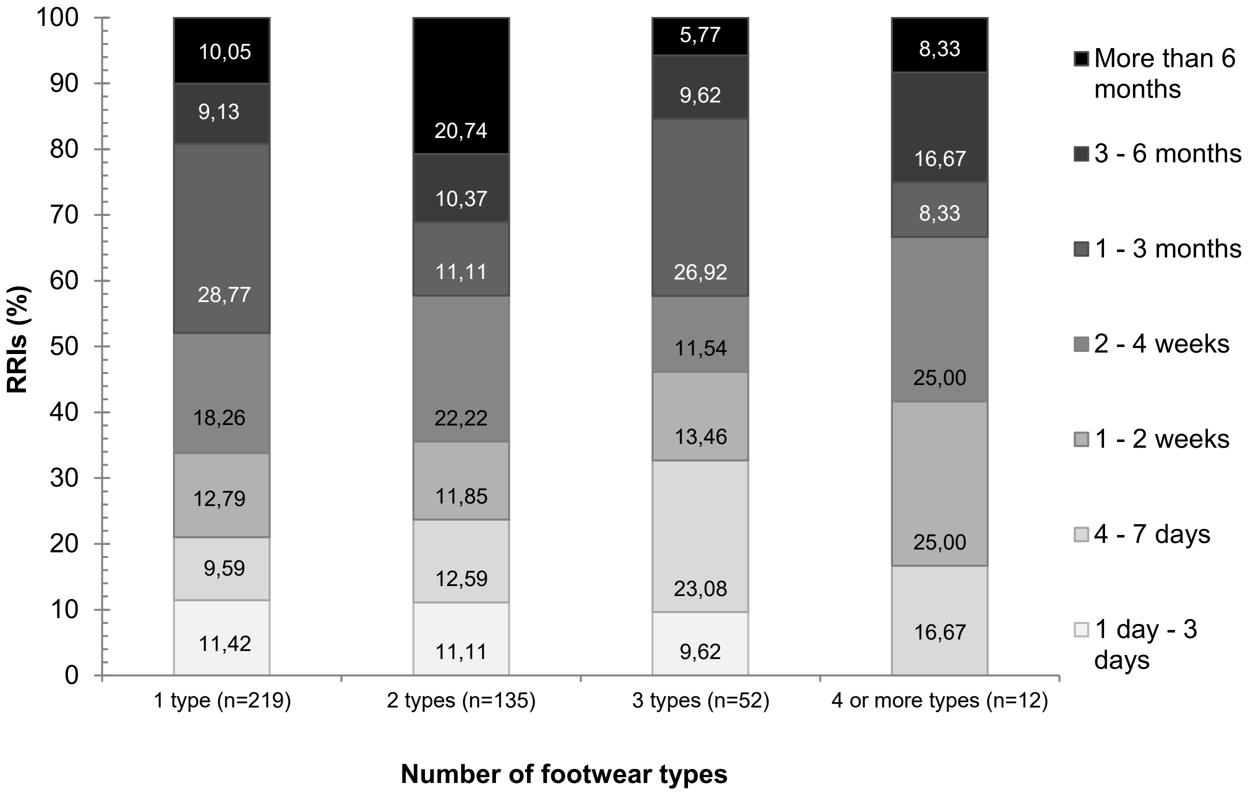

Figure 41. Association between the number of different footwear types and RRI duration (p=0.007317)

Having fewer footwear types yielded a higher percentage of RRIs of one month and more. Injuries of those who had 4 or more different types of running footwear had a lower percentage of long duration RRIs. An increase in the percentage of shorter duration injuries (one day to two weeks), can be seen from participants who used one footwear type to those who used 3 different types.

<u>4.4.4.3 Change in footwear type</u>

Table XLVIII. Sub-hypothesis 4C

Sub-hypothesis 4C	
There is a significant association ($p<0.05$) between changes in running footwear type and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location of RRIs.

Having changed the running footwear type of the runner, was significantly associated with foot RRIs.

Table XLIX. Association between changing footwear types and RRI location

	Changed footwear type		p-value
	Yes	No	
Participants with foot RRIs	24.69% (n=81)	14.14% (n=297)	0.02802

A quarter of participants who made changes to their footwear type over the past year, reported suffering from foot injuries. In contrast, a lower percentage of those who did not make footwear changes, suffered from foot RRIs.

4.4.4.4 Number of footwear pairs

Table L. Sub-hypothesis 4D

Sub-hypothesis 4D	
There is a significant association ($p<0.05$) between the number of running footwear pairs and running related injuries in South African long-distance runners.	Partially supported in terms of the number of RRIs in the past year, and the duration of RRIs.

A significant association was found between the number of pairs of running footwear used by the participant, and the number of RRIs in the past year, and RRI duration.

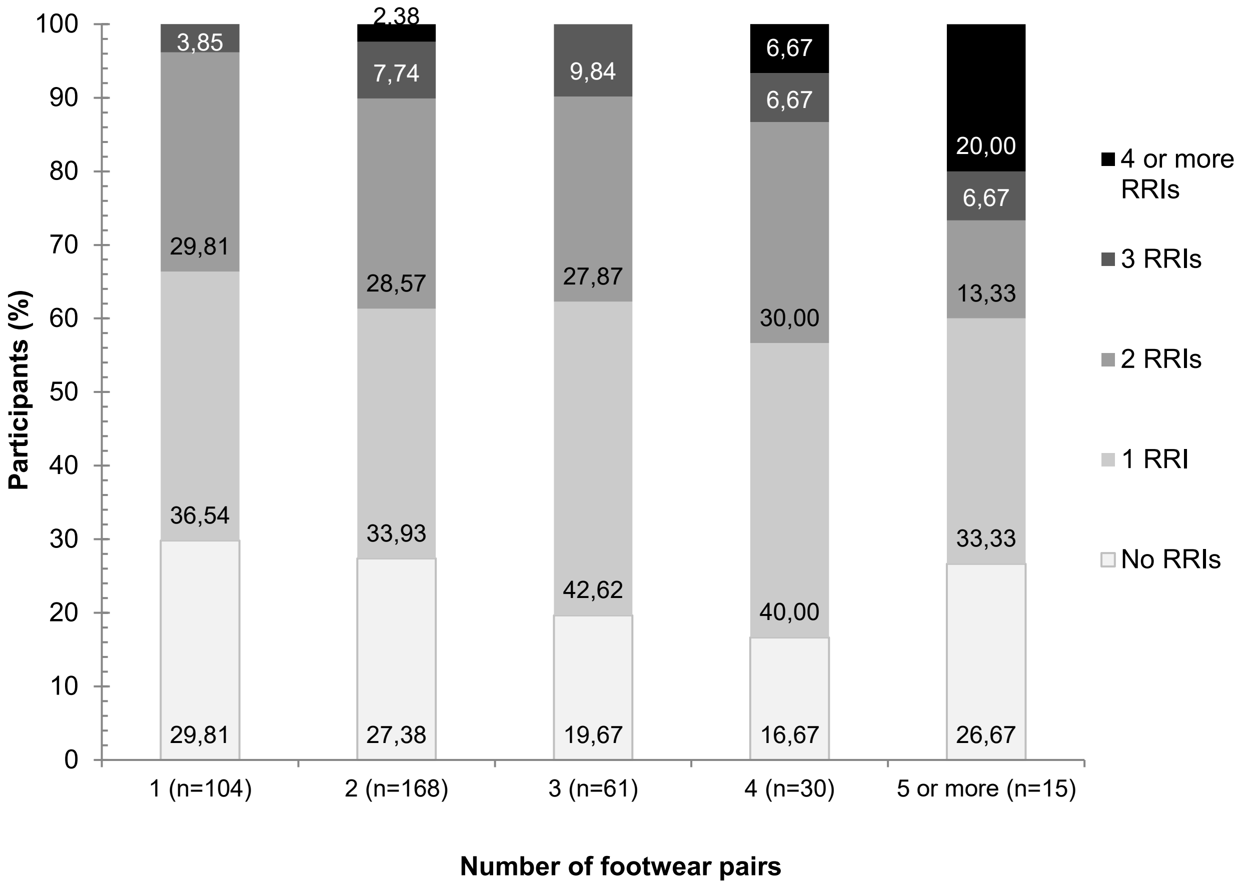

Figure 42. Association between the number of running footwear pairs used concurrently and the number of RRIs in the past year (p=0.00698)

Participants who had five or more pairs of running shoes reported the highest percentage of 4 or more RRIs.

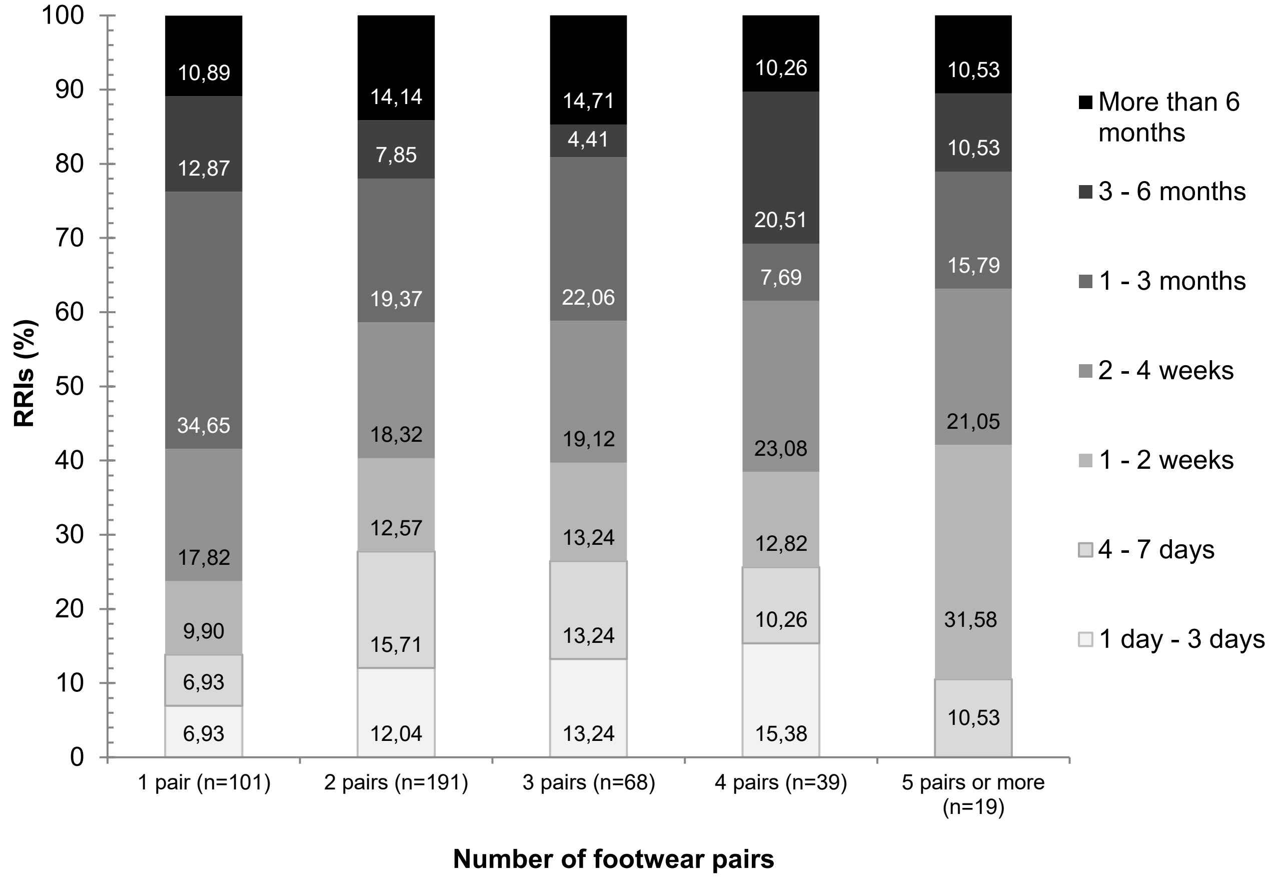

Figure 43. Association between the number of running footwear pairs used concurrently and RRI duration (p=0.047450)

Having 1 pair of running shoes was significantly associated with having more RRIs that lasted one month or more. The percentage of short duration RRIs (1 day – 3 days) was highest in those with 4 pairs of shoes and lowest in those with 1 pair.

4.4.4.5 Orthotic use

Table LI. Sub-hypothesis 4E

Sub-hypothesis 4E	Partially supported in terms of current RRI, RRI in the past year, the number of RRIs in the past year, anatomical location of RRIs, duration of RRIs, and professionally diagnosed RRIs.
There is a significant association (p<0.05) between the use of orthotics and running related injuries in South African long-distance runners.	

Orthotic use was found to be associated with several factors, specifically current RRI, whether or not the participant had an RRI in the past year, the number of RRIs in the past year, Achilles, knee and foot RRIs, the duration of RRIs, and professionally diagnosed RRIs.

Table LII. Association between orthotic use and RRI variables

	Orthotics use		p-value
	Yes	No	
Participants with RRI at the time of the questionnaire	54.67% (n=75)	34.32% (n=303)	0.00100
Participants with RRI in the past 12 months	88.00% (n=75)	70.69% (n=303)	0.00200
Participants with Achilles RRIs	14.67% (n=75)	6.93% (n=303)	0.03826
Participants with knee RRIs	33.33% (n=75)	21.45% (n=303)	0.03469
Participants with foot RRIs	26.67% (n=75)	13.86% (n=303)	0.01368
Professionally diagnosed RRIs	66.36% (n=71)	54.04% (n=194)	0.02625

More participants who used orthotics were injured at the time of the questionnaire, reported more RRIs throughout the year, and reported more Achilles, knee and foot RRIs, compared to those who did not wear orthotics. Additionally, two thirds of the RRIs of participants who used orthotics, were assessed by a medical professional (66.36%). Less RRIs of those who did not wear orthotics were professionally diagnosed (54.04%).

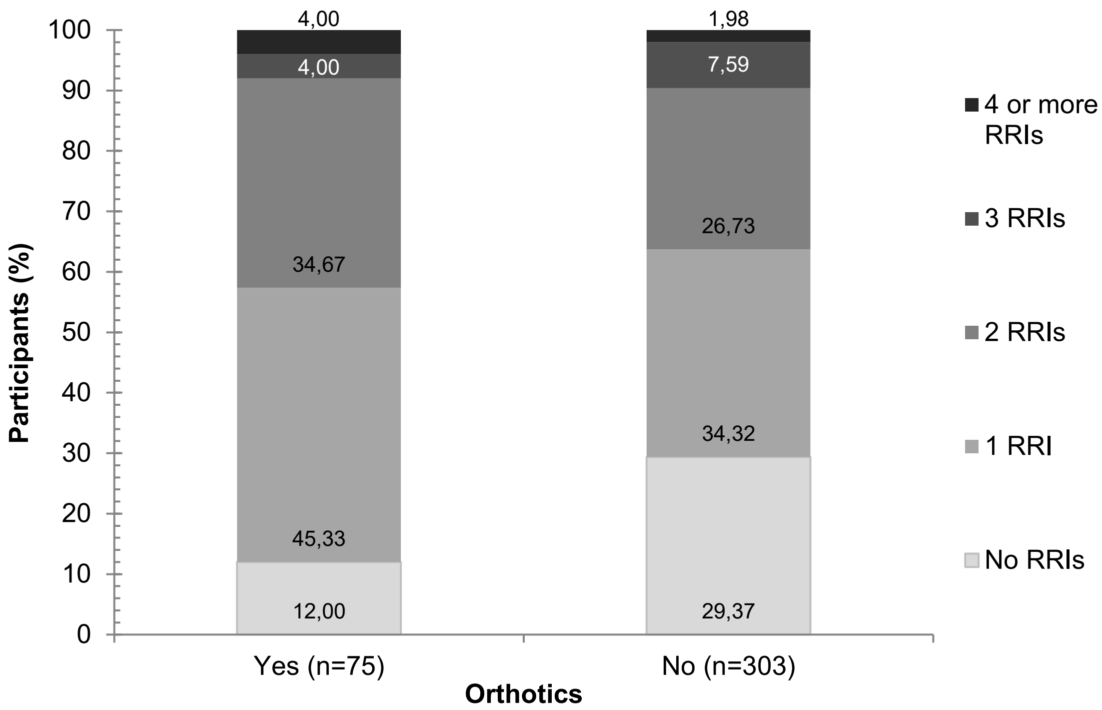

Figure 44. Association between orthotic use and the number of RRIs in the past year (p=0.01406)

Reporting no injuries was more common in those who did not wear orthotics. In those who did wear orthotics, it was more likely to report having 3 or more RRIs.0

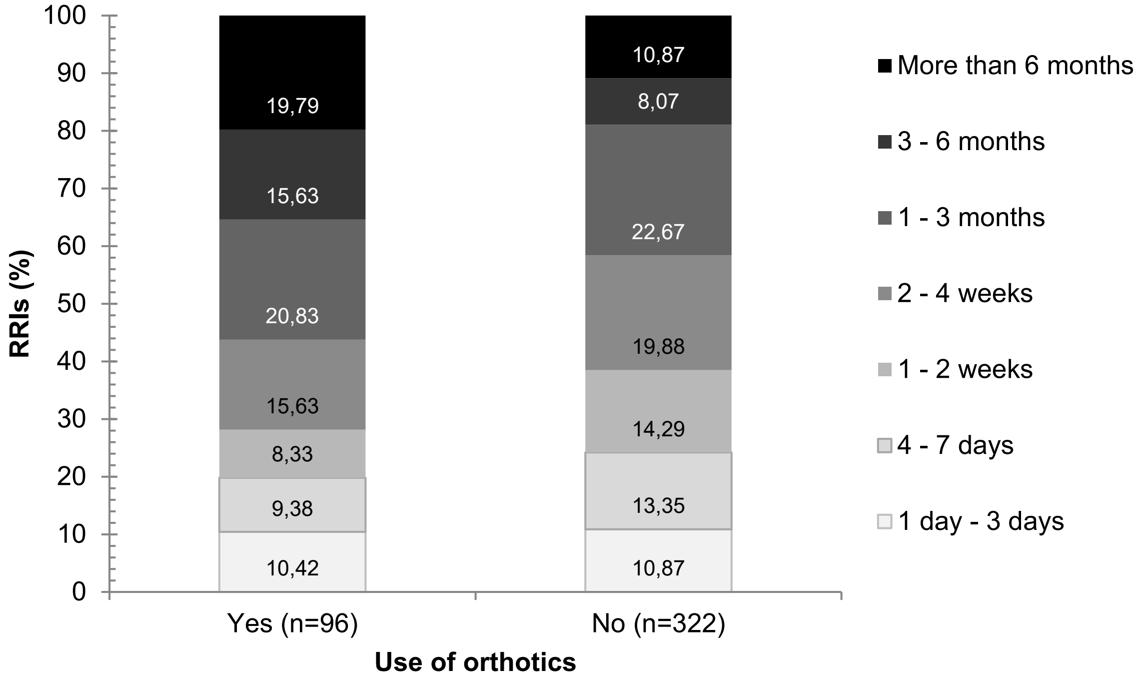

Figure 45. Association between orthotic use and RRI duration (p=0.048802)

Compared to those who did not use orthotics, a higher percentage of RRIs of participants who did wear orthotics, took one month or more to recover. More RRIs of non-orthotic using participants were of shorter duration, specifically one day to two weeks. Overall, the use of orthotics was associated with longer duration RRIs.

With reference to sub-hypotheses 4A through E, hypothesis 4 is partially supported.

4.4.5 CROSS TRAINING

HYPOTHESIS 5:

There are significant associations ($p<0.05$) between cross training factors of South African long-distance runners, and running related injuries.

Cross training participation and the number of weekly cross training activities were significantly associated with one RRI variable each.

4.4.5.1 Cross training participation

Table LIII. Sub-hypothesis 5A

Sub-hypothesis 5A	
There is a significant association ($p<0.05$) between cross training participation and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location of RRIs.

Cross training participation was significantly associated with calf RRIs.

Table LIV. Association between participation in cross training and calf RRIs

	Cross training		**p-value**
	Yes	**No**	
Participants with calf RRIs	14.34% (n=251)	7.09% (n=127)	0.04378

Double the percentage of participants who cross trained, reported having calf injuries (14.34%), compared to participants who did not participate in cross training (7.09%).

Table LV. Sub-hypothesis 5B

Sub-hypothesis 5B	
There is a significant association (p<0.05) between the type of cross training activities and running related injuries in South African long-distance runners.	Not supported.

No significant associations were found between the type of cross training activities and RRI variables.

4.4.5.2 Number of cross training activities

Table LVI. Sub-hypothesis 5C

Sub-hypothesis 5C	
There is a significant association (p<0.05) between the number of different cross training activities and running related injuries in South African long-distance runners.	Partially supported in terms of anatomical location of RRIs.

The number of different weekly cross training activities was significantly associated with back RRIs.

Table LVII. Association between the number of weekly cross training activities and RRI location

	Number of weekly cross training activities					p-value
	1	2	3	4	5 or more	
Participants with back RRIs	2.41% (n=83)	9.64% (n=83)	0.00% (n=56)	0.00% (n=16)	0.00% (n=13)	0.02654

Participants who took part in 1 or 2 cross training activities on a weekly basis reported back RRIs, with more occurring in those who participated in 2 cross training activities. Those who took part in more than two per week did not report any back injuries.

With reference to sub-hypotheses 5A and C, hypothesis 5 is partially supported.

4.4.6 SUMMARY OF SIGNIFICANT ASSOCIATIONS

The following table displays a matrix of all the significant associations found between participant factors, and RRI variables.

Table LVIII. Significant associations between researched factors and RRI variables

	RRI at time of questionnaire	RRI in the 12 months preceding the questionnaire	Number of RRIs in the 12 months preceding the questionnaire	RRI location	Overuse/Acute RRI	RRI duration	RRI recovery status	Recurrent RRIs	Professionally diagnosed RRIs	Surgery for RRIs
Basic participant characteristics and demographics	Ethnicity	NA	Ethnicity BMI	Age: Thigh (posterior) Sex: Buttock, calf Ethnicity: Back, knee Stature: Buttock BMI: Achilles, buttock Monthly income: Ankle	NA	Age Sex BMI Monthly income	NA	NA	Sex Ethnicity Monthly income	NA
Training characteristics	NA	Running club Terrain (Track/tartan, Treadmill)	Terrain (Cement) Changes to training	Weekly running duration: Achilles, foot Terrain (Grass): Ankle Changes to training: Knee	Terrain (Cross country/trail)	Weekly running frequency Terrain (Track/tartan)	NA	Weekly running frequency	Weekly running frequency	Weekly running duration Number of terrains

Running experience	NA	NA	Race distance preference: +42 km Number of 42 km races	Years running: Knee Race distance preference (+42 km) : Thigh (posterior)	NA	Race distance preference (+42 km)	Sponsored/professional runner	Years running	Years running	NA
Footwear	Footwear type Number of different footwear types Orthotic use	Orthotic use	Number of footwear pairs Orthotic use	Change in footwear type: Foot Orthotic use: Achilles, foot, knee	Footwear type	Footwear type Number of different footwear types Number of footwear pairs Orthotic use	Footwear type	NA	Footwear type Orthotic use	NA
Cross training	NA	NA	NA	Cross training participation: Calf Number of activities: Back	NA	NA	NA	NA	NA	NA

CHAPTER V

DISCUSSION

5.1 Introduction

The aim of the current study was two-fold; to create a descriptive profile of South African long-distance runners, and to identify associations between the characteristics of South African long-distance runners, and running related injury (RRI). The following chapter firstly discusses the characteristics of the RRIs found in the current study, followed by the descriptive characteristics of the sample, and subsequently the associations found between RRIs and the other characteristics of the sample.

5.2 Running related injuries

Over a third of the participants were injured from running at the time of the questionnaire and three quarters of the participants in the current study had developed an RRI within a period of 12 months. These numbers were higher than in previous studies (Wen et al., 1997; Buist et al., 2008; van Middelkoop et al., 2008b; Buist et al., 2010b; Hespanhol Junior et al., 2012; Folscher et al., 2015; van Poppel et al., 2016) apart from in the study done on South African half marathon runners, where 90% of the participants were injured over a 12-month period (Ellapen et al., 2013). These discrepancies between findings may be either a result of differing RRI definitions, or the different running populations studied (Reinking et al., 2013).

In the current study, a running related injury was defined as any pain or injury caused by running but did not necessarily stop or reduce training volume, which is in line with the injury definition used by Knobloch et al. (2008). The time-loss injury definition that has been used in previous studies (Wen et al., 1997; Dick et al., 2007; Buist et al., 2008) was not used in the current study as this may result in injuries being overlooked if the injuries did not affect training. Baltich et al. (2016) stated that if a time loss injury definition was used for their study, it is likely that many RRIs may have been missed.

Reinking et al. (2013) studied exercise-related leg pain (ERLP) as opposed to specifically running-related injuries, and did not use a time-loss definition but did limit all pain or injury to the leg. They found that 50% of their sample had experienced ERLP in the past year. Ellapen et al. (2013) used the following injury definition: running-related injuries experienced as a sensation of distress or agony, and which prevented them from physical activity for a minimum of 24 hours. Although a time-loss definition was used by Ellapen et al. (2013), the percentage of injured participants were still higher than normal. It is possible that the South African running population may be more susceptible to running injures than other previously studied populations. The latter will be explored in later sections. Ristolainen et al. (2010) found that 75% of long-distance runners reported an injury over a period of 12 months, which is the same as in the current study. Ristolainen et al. (2010) included both overuse and acute injuries, as well as injuries that did not affect training, which may explain the high percentage of injuries runners in the current study too.

In the current study, half of the participants who had an RRI in the past year, had more than 1 RRI. Lun et al. (2004) found that over a period of 6 months, most injured runners had only 1 RRI, and Hespanhol Junior et al. (2013) found that over a period of 12 weeks, 70% of the injured runners had 1 RRI, meaning that the remaining 30% had more than one RRI. Over 12 months, 52.3% of the injured long-distance runners in the study by Ristolainen et al. (2010), reported two or more injuries over 12 months, findings similar to those of the current study.

5.2.1 Injury location

Figure 46 denotes that running injuries occurred most often in the lower extremities (95.5%). In the studies by Taunton et al., (2002), Knobloch et al. (2008), Buist et al. (2010a), de Araujo et al. (2015), and the review done by van Gent et al. (2007), similar results were seen, which may explain the reason for many studies focusing mainly on RRIs to the lower extremity (Puckree et al., 2007; van Middelkoop et al., 2008a; Bennett et al., 2012; Reinking et al., 2013; Chaudhary et al., 2016). Ristolainen et al. (2010), reported that the anatomical location of injuries is highly likely to be influenced by the loading pattern of the specific sport, and in long-distance running, the lower extremities are loaded with the most stress due to direct impact.

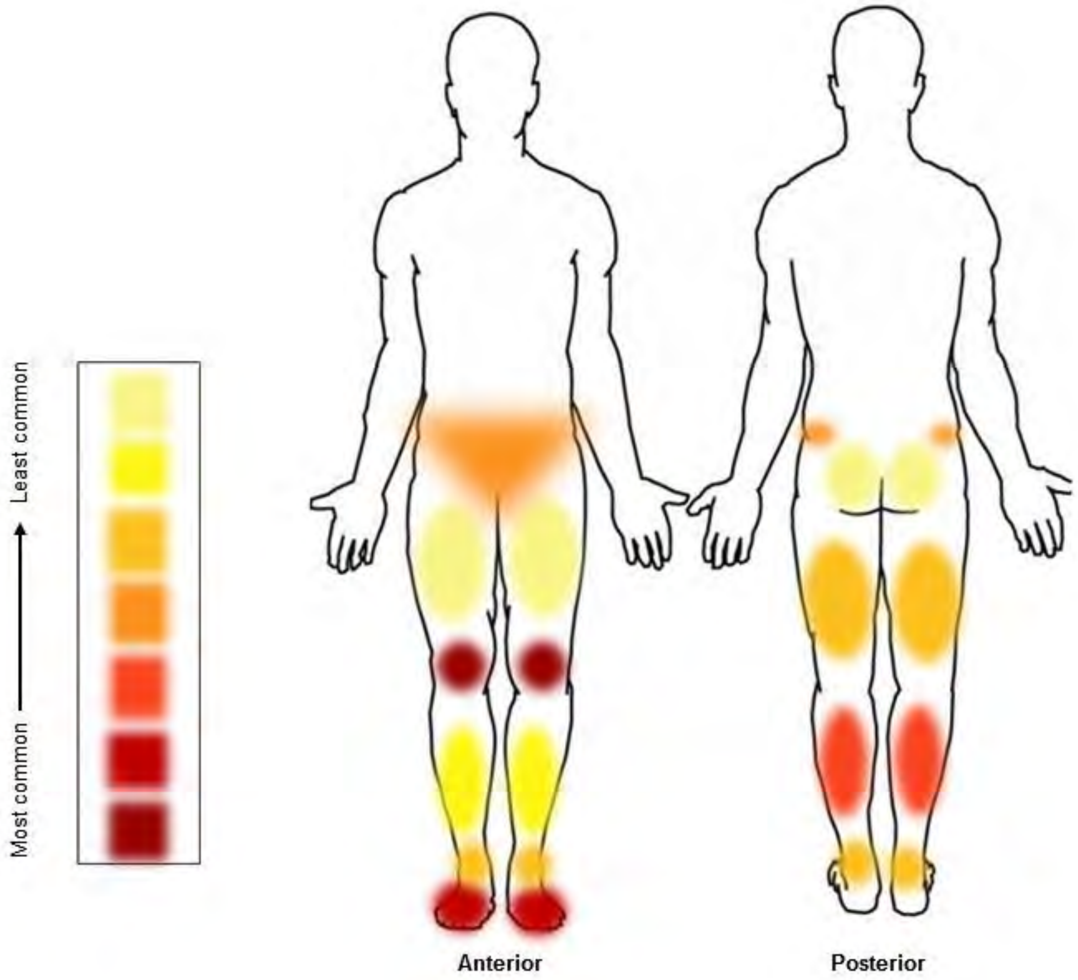

Figure 46. Colour-coded chart of RRI prevalence in various anatomical locations

In the current study, the prevalence of knee injuries was the highest (22.91%) which mirrors the findings of many previous studies (Taunton et al., 2002; Taunton et al., 2003; Puckree et al., 2007; van Middelkoop et al., 2008b; van Ginckel et al., 2009; Chang et al., 2012; Ellapen et al., 2013; Hespanhol Junior et al., 2013; van Poppel et al., 2016; Hespanhol Junior et al., 2016). De Araujo et al. (2015) investigated RRIs of the entire body as done in the current study and found that knee RRIs made up 46.2% of RRIs, double that of the current study.

Any injury location results in the current study that differ from previous studies may be due to other studies reporting only on lower extremities whereas the current study reported on RRIs of any part of the body.

5.2.2 Descriptions of RRIs

The following paragraph discusses the nature of the RRIs in the current study, encompassing the sensation of the pain and injuries described, the overuse or acute nature of the RRIs, and recurrent RRIs.

Few previous studies reported on the sensation of the pain or injuries experienced by runners, making it challenging to discuss the findings of the current study. This being said, Ellapen et al. (2013), one of the few studies done on South African runners, investigated the nature and sensation of the injuries and pain of the participants. Most RRIs in the current study were described as aching (32.31%) and sharp pain (31.34%). These results closely mirror those of Ellapen et al. (2013), whereby dull aching (43%) and sharp pain (20%) were the most common symptoms of RRIs.

Overuse injuries can be defined as an injury that causes pain during activity but with no obvious cause (Ristolainen et al., 2010). Over two thirds (68.1%) of the RRIs in the current study were overuse as opposed to acute. Acute injury occurs suddenly during activity, often with a distinct cause (Ristolainen et al., 2010). Several previous studies have found overuse injuries to be more common than acute injuries, in long-distance runners (Knobloch et al., 2008; Ristolainen et al., 2010; Saragiotto et al., 2014; Folscher, Grant, Fletcher, Christina, & Rensberg, 2015; Kerr et al., 2016). Ristolainen et al. (2010), additionally found that overuse injuries in the lower extremity were significantly more prevalent in long-distance runners than in soccer players, swimmers and cross-country skiers. Ristolainen et al. (2010), mentioned the importance of differentiating between acute and overuse injuries as a way forward in prevention and treatment of these injuries by understanding their risk factors.

A recurrent injury has been defined as an injury of the same type and location as a previous injury, and has occurred after the athlete has returned to training after the original injury (Fuller et al., 2006). Many studies have found previous injury to be a risk factor for further injury (van Middelkoop et al., 2008b; Rasmussen et al., 2013; Reinking et al., 2013; Malisoux et al., 2016). More than half of the RRIs in the current study were reported as recurrent, which is higher than in previous studies (Malisoux et al., 2014; Hespanhol Junior et al., 2016) which again may be a result of injury definition and the population studied. Instead of using the injury as a unit of analysis, some studies looked at how many runners had recurrent injuries. Lun et al. (2004) and Knobloch et al. (2008), reported that approximately a third of injured runners had a recurrent injury. Recurrent injuries could be a result of inadequate recovery, continuous biomechanical issues and other factors that may have originally increased susceptibility to injury (Marti et al., 1988; Rasmussen et al., 2013; van der Worp et al., 2015).

5.2.3 Severity of RRIs

The severity of the RRIs in the current study includes the duration of RRIs, the recovery status, and the medical implications of RRIs (professional diagnosis and surgery).

Injury duration reported on throughout existing literature is inconclusive and differs in definition. Most injuries (22.25%) in the current study lasted 1 – 3 months. Similarly, Lopes et al. (2011), reported a median running related pain duration of one month. The RRI duration in the current study is longer than most previous studies, however this may again be a result of differing injury definitions, specifically the fact the duration of RRIs in many studies refers to the time taken off from training (Lun et al., 2004; Ristolainen et al., 2010; de Araujo et al., 2015; Vitez et al., 2017). Ristolainen et al. (2010) reported that injured long-distance runners stopped training for approximately 2 months and proposed that because overuse RRIs are more common than acute RRIs in long-distance runners, overuse RRIs take longer to recover which may explain the long recovery period in the long-distance runners in their study, compared to other sports (Ristolainen et al., 2010). In contrast, de Araujo et al. (2015), found most injuries to be mild (absent from running for less than 8 days) and suggested that the reason for this may be due to running not being a contact sport of which injuries are often more severe.

With regards to RRI recovery status, a third of the injuries did not fully recover before the runner resumed training, in the current study, which is slightly higher than in previous studies. Knobloch et al. (2008) reported a quarter of the runners not fully recovering before resuming training, and Lopes et al. (2011) found that 1 in 5 runners were training through pain. Although these studies reported on participants, and the current study measured the injuries, it can be seen that fully recovering before resuming training is an issue that should be addressed in running communities. As most running injuries are overuse (Knobloch et al., 2008; Ristolainen et al., 2010; Saragiotto et al., 2014; Folscher et al., 2015; Kerr et al., 2016), it has been previously stated that due to the gradual onset of overuse injuries, runners often continue training despite the pain of overuse injuries (Bahr, 2009; Clarsen et al., 2012). The high proportion injuries that were not fully recovered could account for the large amount of recurrent injuries (58.27%) reported in the current study as inadequate recovery has been proposed as a reason for recurrent injury (van Middelkoop et al., 2008b; Rasmussen et al., 2013; Reinking et al., 2013; Malisoux et al., 2016).

57.82% of injuries were seen by medical professionals in the current study, similar to the 43% of RRIs that were professionally diagnosed in the study by Lun et al. (2004). Injuries defined by medical attention were reported more often in ultra-marathon runners (66%) than all other runners (1 – 16%) (Kluitenberg et al., 2015a), however, in ultra trail runners, a lower percentage of 31.85% of RRIs were medically diagnosed (Malliaropoulus et al., 2015). Looking at the large percentage of those who ran at least one ultramarathon over the 12-month period of the current study (40.74%), the injuries seen by medical professionals could be mostly those that ran ultramarathons, however this is only a theory. Additionally, road running was more popular than trail running in the current study. Only 4.07% of injuries needed surgery in the current sample, which could indicate the low severity of most of the RRIs. However, it is possible that some injured runners could not afford surgery.

5.2.4 Conclusion

Based on the sample in the current study, South African long-distance runners have higher injury rates than those reported in previous studies in done on other long-distance running populations. Additionally, recurrent RRIs were more common in the current study than in previous studies. RRIs took longer to recover, and more runners did not fully recover before resuming training, compared to previous studies. Recovery time and the fact that the runners in the current study were more likely to resume training before they were fully recovered may be linked. Furthermore, the high number of recurrent RRIs reported could have been a result of the participants not fully recovering before resuming training, as this has been stated as a reason for recurrent

RRIs (Marti et al., 1988; Rasmussen et al., 2013; van der Worp et al., 2015). The most common RRI location, the knee, was supported by many previous studies which found the knee to be most susceptible to injury in long-distance runners. As previously mentioned, the sensation of the pain or injury has not been reported often in previous studies, however, the results in the current study aligned with those from another South African study on long-distance runners (Ellapen et al., 2013); most RRIs were described as aching, or sharp pain. Overuse RRIs were the most common RRIs in the current study as in almost all previous studies on long-distance runners. The percentage of RRIs that were diagnosed by a medical professional was similar to previous studies. Overall, the injury rates were higher in the current study, however the nature of the RRIs appeared to be in line with previous studies.

5.3 Descriptive findings

The following section discusses the descriptive profile of the sample of the current study in relation to similar previous studies where applicable. This section is divided into personal characteristics and demographics, training characteristics, running experience, running footwear, and cross training.

5.3.1 PERSONAL CHARACTERISTICS AND DEMOGRAPHICS

5.3.1.1 Age

The average age of the participants of the current study was 41.2 years, which is similar to previous studies throughout the world (Knobloch et al., 2008; Buist et al., 2010b; Hespanhol Junior et al., 2013; Rasmussen et al., 2013; Phinyomark et al., 2014). When divided into categories, 30 – 39 years old was the most common age of the current sample, which is slightly younger than in previous studies (Marti et al., 1988; Satterthwaite et al., 1999; Vitez et al., 2017). There was a large range of ages throughout the sample (19 – 82) with 63 years between the oldest and youngest participant which is similar to the study by Reinking et al. (2013) with an age range of 18 – 79 years of age. The age range of the current sample was larger than that of participants in previous South African runner studies (Puckree et al., 2007; Ellapen et al., 2013).

5.3.1.2 Sex

In 2014, there were more females in SA than males (Stats SA, 2014). However, the current study did not reflect this as there were 1.5 times more male than female participants. If the sample was representative of the long-distance running population, then these findings may imply that there are more male long-distance runners in SA, than females. Interestingly, the South African study by Ellapen et al. (2013) also reported more male participants than female participants. It appears that male runners dominate long-distance running in SA, as well as in many other countries, as reported in many previous studies (Chang et al., 2012; Rasmussen et al., 2013; Phinyomark et al., 2014; de Araujo et al., 2015; Hespanhol Junior et al., 2016).

5.3.1.3 Stature, mass and BMI

The average stature of the sample was 1.73 m, similar to previous studies (Hespanhol Junior et al., 2013; Phinyomark et al., 2014; Hespanhol Junior et al., 2016). 71.51 kg was the mean mass for the total sample, which also aligns with previous studies (Hespanhol Junior et al., 2013; Phinyomark et al., 2014; Hespanhol Junior et al., 2016). This being said, Ellapen et al. (2013) found slightly lower stature and mass in the South African long-distance runners in their sample. Knobloch et al. (2008) reported higher mean stature of 178 cm which may be attributed to the fact that males made up 85.8% of their sample, and males were found to be significantly taller than female participants in the current study and in the study by Ellapen et al. (2013).

The World Health Organisation (WHO) provides data on the BMI details of many countries around the world, SA being one of them. BMI is usually divided into four categories; underweight, normal, overweight and obese. The average BMI of all participants of the current study was 23.76 kg.m^{-2}, which is considered normal according to WHO, and is similar to the average BMI reported on in previous studies on long-distance runners (Taunton et al., 2002; Knobloch et al., 2008; Ellapen et al., 2013; Hespanhol Junior et al., 2013; Rasmussen et al., 2013; Reinking et al., 2013; Vitez et al., 2017). Furthermore, two thirds of the participants in the current study had BMIs that were labelled as normal.

The average BMI for female and male participants was 22.49 $kg.m^{-2}$ and 24.62 $kg.m^{-2}$, respectively, almost identical to the values reported by Ellapen et al. (2013). More female participants were considered underweight than male participants, while the overweight and obese BMI categories consisted of more male participants than females. Female long-distance runners have been reported as being at risk for the female triad, one of which being eating disorders causing weight loss (Hall, 2007; Folscher et al., 2015), which may explain the findings in the current study.

5.3.1.4 Ethnicity

Black Africans make up the majority of the South African population (Stats SA, 2012), however the current study consisted of mostly Caucasian participants which made up 82.8% of the sample. Similarly, in the study by Ellapen et al. (2013), most of the participants were Caucasian, however this proportion was lower (50%) than the current study. The remaining percentage of ethnicities of the current study differed from those of Ellapen et al. (2013) with 1.85% Indian compared to 33% Indian, 6.88% Black African compared to 12%, and 8% Coloured compared to 6% Coloured in the study by Ellapen et al. (2013).

It could be theorised that the mismatch between the predominant ethnicity in SA and that of the current sample, was linked to the questionnaire being in English. English was the most spoken home language among participants (61.42%) and the majority (85.9%) of the participants with English as a home language were Caucasian. It is possible that the questionnaire being in English deterred a large amount of potential participants whose home languages were not English and since most of the English speakers were Caucasian, this may account for the large percentage of Caucasian participants.

5.3.1.5 Provinces

Provincial population distribution in SA in 2011 is displayed in Table LIX according to Stats SA (2012). The percentage of participants and running clubs distributed throughout SA can also be seen in the following table.

Table LIX. Populations throughout each province in SA and the percentage of participants and running clubs in each province

Province	Population	%	% of participants	% of running clubs
Gauteng	12 272 263	23.71	37.6	25.8
KwaZulu-Natal	10 267 300	19.83	10.8	14.4
Eastern Cape	6 562 053	12.68	20.6	10.9
Western Cape	5 822 734	11.25	20.9	18.3
Limpopo	5 404 868	10.44	1.1	8.5
Mpumalanga	4 039 939	7.80	0.8	6.2
North West	3 509 953	6.78	2.6	7.6
Free State	2 745 590	5.30	4.5	5.5
Northern Cape	1 145 861	2.21	1.1	2.9
TOTAL	51 770 561	100	100	100

The top four provinces with the highest number of inhabitants (Stats SA, 2012) were also the top four provinces with the most participants in the current study; Gauteng, Kwa-Zulu Natal, Eastern Cape and Western Cape. The remaining five provinces with the least number of inhabitants do not follow the same trend as the number of participants in the current study. The Northern Cape and Limpopo had the same percentage of participants however the number of people living in Limpopo are closer to the number of people in the Western Cape. It could be speculated that there are not many long-distance runners in Limpopo, there are more rural runners with no internet access and therefore no access to the questionnaire, or there are less English speaking runners in Limpopo. The same could apply to Mpumalanga; although it is the

6th most inhabited South African province, it only accounted for 0.8% of the participants in the current study.

The percentage of running clubs in each province can be seen in Table LIX. Although not all participants were part of a running club, the majority were (86.24%). The total number of known running clubs in SA was 1757, according to Runner's Guide (2013). The four provinces with the highest percentage of running clubs are Gauteng (25.84%), Western Cape (18.27%), KwaZulu-Natal (14.40%) and Eastern Cape (10.93%), the same four provinces where the majority of participants were from. These four provinces account for just over two thirds (69.47%) of South African running clubs. Limpopo (8.48%), North West (7.63%), Mpumalanga (6.15%) and Free State (5.46%) all consist of between 5 – 9% of the running clubs in SA. The lowest percentage of running clubs in found in the Northern Cape (2.85%) which was home to a similarly small percentage of participants (1.1%).

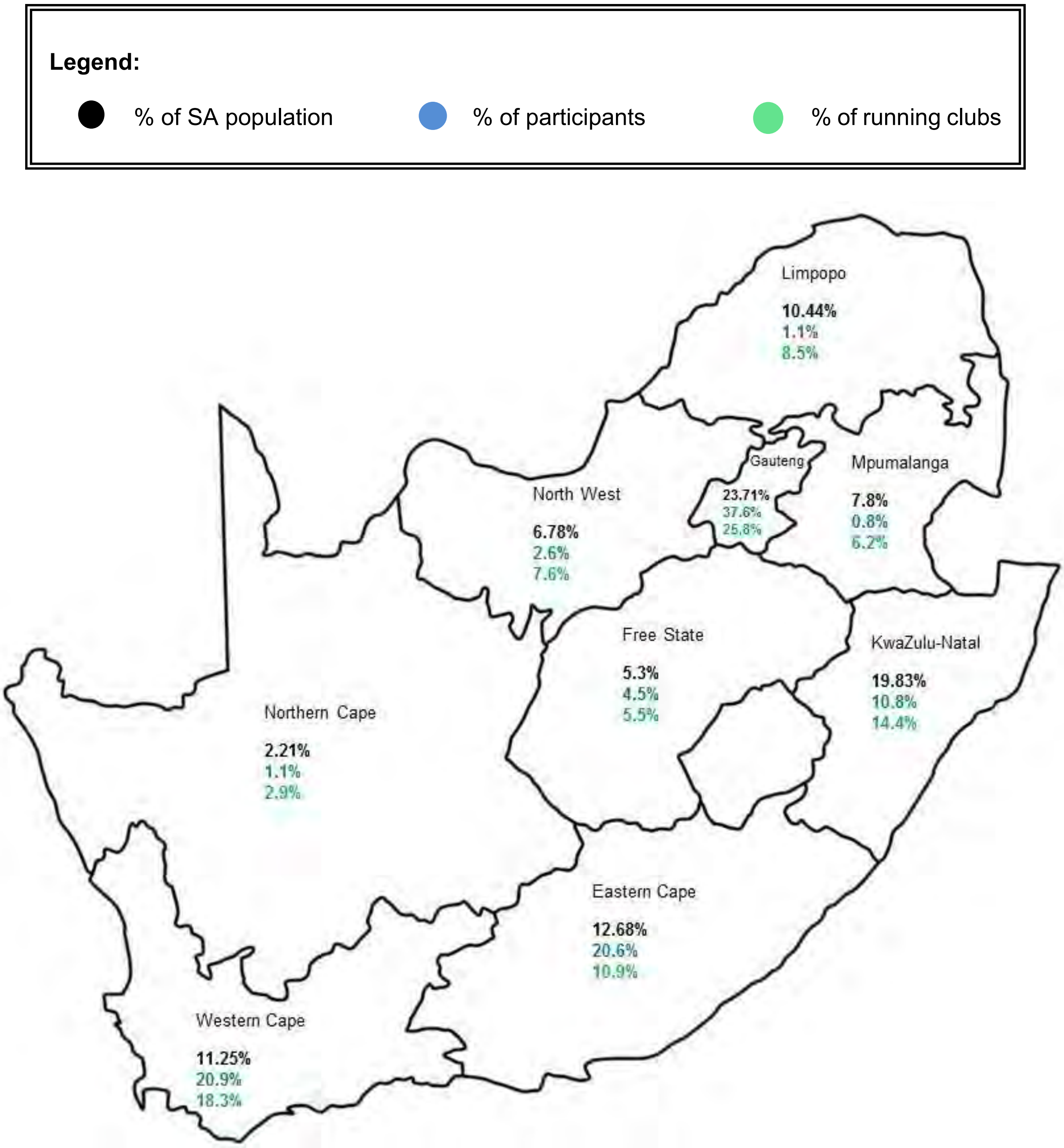

Figure 47. Map of South African provinces with percentages of the total population, participants, and running clubs.

5.3.1.6 Socioeconomic status: Monthly income

Approximately half of the sample from the current study indicated a monthly income bracket of more than R 30 000, the highest income category in the questionnaire. Households earning this amount on a monthly basis are considered to be upper middle class (based on an article by BusinessTech, 2016). This may not appear to be representative of the South African population as more than half of South Africans have been said to be living below the poverty line of R779 per month (Lehohla, 2015) and in 2011, the average monthly household income in SA was R 8600 (Stats SA, 2012). There are a few plausible reasons for the large number of wealthier participants. Firstly, due to the questionnaire being internet-based, it could be assumed that the majority, if not all, of the participants had easy internet access. In order to have access to the internet, one must be able to afford the costs of internet or own a computer. In 2011, only 21.4% of South African households owned a computer (Stats SA, 2012). Secondly, when answering the questionnaire, almost all of the participants filled in their name and surname despite this not being a required field. This may have removed the security of anonymity although only the investigator and supervisor of the current study had access to these names. A feeling of insecurity and perhaps embarrassment of falling into a lower income bracket, may have resulted in participants not answering this question completely honestly. Lastly, Kamphuis et al. (2008) found that lower participation in sports is associated with lower socioeconomic status, which may further explain the reason for few participants falling under the lower monthly income bracket.

5.3.2 TRAINING CHARACTERISTICS

In the current study, training characteristics included the weekly frequency, duration and distance run, the running terrain and other training aspects.

5.3.2.1 Weekly running frequency

Over a third of the participants ran 4 times per week, the most common running frequency in the current study. Weekly running frequency differs throughout previous studies however, a few studies reported similar results to those of the current study (Lun et al., 2004; van Middelkoop et al., 2008b; Chang et al., 2012; de Araujo et al., 2015; Hespanhol Junior et al., 2016). Some previous studies reported lower weekly running frequency than that of the current study (Buist et al., 2008; Abate et al., 2012; Malisoux et al., 2014) however, the current study predominantly used categorical data whereas the previous studies often used averages.

5.3.2.2 Weekly running duration

Almost a quarter (22.49%) of participants spent 5 hours running each week, the most common weekly running duration. Over half of the runners ran between 4 – 6 hours per week. Taunton et al. (2002), reported an average of 5.4 hours run per week however, other studies reported a lower duration than the current study (Buist et al., 2010a; Malisoux et al., 2014; Hespanhol Junior et al., 2016) or did not report on weekly running duration at all. Previous studies often reported the average duration per week or per session, which may account for differences in findings as the current study reported on categorical data.

5.3.2.3 Weekly running distance

Participants displayed a range of weekly running distances that were almost equally popular. However, weekly distances of 50 km or less were more common than weekly distances of more than 50 km. Almost half of the participants in the current study ran between 30 – 50 km per week. Vitez et al. (2017) reported on categorical data and found that the most common weekly running distance (21 – 30 km) was less than that of the current study. It could be speculated that the runners in the study by Vitez et al. (2017) ran shorter weekly distances as they were training for races of shorter distance than the participants of the current study however, the most popular race distance was 21 km in both studies. Studies in which the average weekly distance fell within 30 – 50 km were Lun et al. (2004), Reinking et al. (2013) and Hespanhol Junior et al. (2016).

5.3.2.4 Training months per year

Half of the participants trained all year round; a result that is lower than previous studies (Lun et al., 2004; Malisoux et al., 2014) and may be related to the fact that the injury rate was higher in the current study, possibly hindering runners from training as much. However, it should be noted that it was very unlikely for participants to train for less than 11 months throughout the year.

5.3.2.5 Changes to training

The amount of participants that had made changes to their training over a period of 12 months, was only 5.2% less than those runners whose training program remained the same. These findings are of interest as changes to training habits have been found to be associated with RRIs, especially if done radically (Beck, 1998; Taunton et al., 2003). The significant associations found between changes to training, and RRIs, is discussed later.

5.3.2.6 Training for a long-distance race

A large majority of the sample was training for a long-distance race at the time of the questionnaire (76.2%) which may account for the high RRI rates, as it has been previously reported that injury rates increase during the period leading up to a race (van Poppel et al., 2014; Kerr et al., 2016). During this period, runners often increase their training volumes, increasing exposure time and thus the risk for injury (van Poppel et al., 2014). The extent of these findings are discussed alongside the significant associations in the latter section.

5.3.2.7 Organised running

86.24% of participants reported that they were part of an organised running club which is approximately double that of previous studies (van Middelkoop et al., 2008b; Hespanhol Junior et al., 2013; van Poppel et al., 2016; Hespanhol Junior et al., 2016). Baltich et al. (2016) stated that being part of an organised running group may increase motivation to keep running, and not to drop out of the sport. There have been conflicting findings in terms of whether or not running in organised groups is a risk factor for RRIs however, there have not been many studies that have reported on this factor.

5.3.2.8 Running terrain

Running on 1 or 2 different types of terrain were most common among participants, with asphalt as the most popular terrain, followed by trail running, which mirrors the study by Taunton et al. (2003). Almost half of the participants in the current study ran on asphalt roads. Roads are easily assessable in urban areas, which may be the reason for this finding. Previous studies have similarly reported asphalt road running as the most common choice of terrain (Knobloch et al., 2008; Hespanhol Junior et al., 2013; Fonseca et al., 2015). Trail running was the second most popular running terrain among participants, and is reportedly increasing in popularity amongst long-distance runners (Easthope et al., 2010).

5.3.3 RUNNING EXPERIENCE

5.3.3.1 Years of running experience

Although most participants had been running for 1 – 5 years, the years of running experience of the sample were almost evenly distributed between those with 1 – 5 years of running experience, 5 – 15 years and more than 15 years. Therefore, the sample displayed a range of novice to experienced long-distance runners. Throughout the existing literature, running experience varies. Vitez et al. (2017) found that most of their participants had been running for between 4 – 10 years, Rasmussen et al. (2013) reported that more than half of their participants had more than 5 years of running experience, and Chang et al. (2012) found that a large majority of their sample had been running for less than 5 years. The median years of running experience in the studies by Hespanhol Junior et al. (2013) and Hespanhol Junior et al. (2016), was 5 years, and the average years running in other existing literature, ranges from 6 years to 10 years (Marti et al., 1988; Taunton et al., 2002; Lun et al., 2004; Ellapen et al., 2012).

5.3.3.2 Race distance preferences

Half marathons or races of approximately 21 km were the most common race distance preference among participants, which was also found by Knobloch et al. (2008) and Vitez et al. (2017). The least popular race distance in the current study was the shortest distance of less than 10 km which was similar to Knobloch et al. (2008) which found the shortest distance of 1500 m to 3000 m to be the least popular. In contrast, Chang et al. (2012) found that 10 km races were the most popular.

5.3.3.3 Sponsored or professional runners

Only 12 participants indicated that they were sponsored or professional runners. 13 RRIs were reported by professional runners, meaning that there were more injuries than runners in this particular subgroup. Taunton et al. (2002) suggested that the more competitive runners, are likely to train more and may have suffered from previous injury, increasing their risk of further injury.

5.3.4 RUNNING FOOTWEAR

5.3.4.1 Running footwear types

A large majority of participants listed normal running shoes with a tapered heel as the footwear type that they predominantly run in, similar to the study by Hespanhol Junior et al. (2016). Second to normal running shoes, were trail running shoes, followed by racing flats. Only 1 participant ran barefoot which indicates that South African runners possibly did not follow the barefoot running 'fad'. 13% of participants in the study by Vitez et al. (2017), reported running barefoot.

Just over a fifth of the sample made changes to their running footwear such as adding different types of running shoes to their training, or completely changing their footwear type. Most of these reasons were to improve performance and to reduce injury risk. Lun et al. (2004) found that when changing footwear, most runners bought shoes for biomechanical purposes.

Over half of the participants used only one type of running footwear but most participants in the current study (44.44%) had 2 pairs of running shoes, which differed from Lun et al. (2004) who found that the largest percentage of participants used 1 pair of running shoes at a time.

5.3.4.2 Orthotic use

A fifth of the sample reported using orthotics when running and the main reason for orthotic use was injury; either to prevent injury or to treat an existing one. A third of master runners wore orthotics in the study by (Knobloch et al., 2008), and almost half of the participants in the study by Lun et al. (2004), used orthotics. In the studies by Chang et al. (2012) and Hespanhol Junior et al. (2016), a small percentage of approximately 14% of the sample, reported using orthotics.

5.3.5 CROSS TRAINING

Two thirds of the sample participated in cross training on a weekly basis. Most participants, who cross trained, did so once or twice a week and for three hours or less. Cross training appears to be a popular practice amongst long-distance runners (Buist et al., 2008; Buist et al., 2010b; van Poppel et al., 2016; Vitez et al., 2017).

Three quarters of these participants incorporated non-weight bearing activities such as, cycling, into their cross training programs, which is in line with the study by Satterthwaite et al. (1999), but differs from the studies by Buist et al. (2008) and Buist et al. (2010b).

5.3.6 CONCLUSION

The age, sex, stature, mass and BMI of the participants aligned with those of previous studies on long-distance runners. Most participants were Caucasian, which was also found by Ellapen et al. (2013), however these proportions differ from the South African population along with the most common monthly income, which was higher than that of the general South African population. The most populated provinces in SA aligned with the number of participants from each province in the current study.

Several of the training characteristics of the current sample, did not differ substantially from previous studies apart from more participants being involved in organised running, than reported in previous studies. Years of running experience differs throughout previous literature, and those of the current study were quite evenly distributed amongst each category. The preference of 21 km race distances aligned with a few previous studies, however not many studies have reported on this specific aspect. Most participants were not professional or sponsored runners, however this was challenging to compare to previous literature as it is not a commonly studied variable.

In terms of running footwear, most participants used the conventional running shoe, which is still seen throughout the literature, and most participants stuck to this particular type of shoe, even though many participants had 2 pairs of running shoes which is less common in previous literature. The use of orthotics differs throughout previous literature; however, it appears as if the sample of the current study were on the lower end of the number of orthotic users, as one fifth of the sample used orthotics.

Cross training habits were similar to previous studies apart from the type of cross training which is another variable that differs throughout previous literature.

5.4 Associative findings

The following section of this chapter, discussed the significant associations found between the investigated factors, and RRI variables. The extent of these associations are discussed and compared to previous literature where possible. It must be noted that the data collected do not give information on cause and effect, only associations. Therefore, the current study cannot confirm directional relationships between variables, however, it can provide insight into possible injury contributors that could be further investigated by prospective studies.

5.4.1 PERSONAL CHARACTERISTICS AND DEMOGRAPHICS

Hypothesis 1, regarding the presence of significant associations between personal characteristics and demographics, and RRI variables, was partially supported. These significant associations are discussed in the subsequent paragraphs.

5.4.1.1 Age

Age was significantly associated with two RRI variables; RRI location and duration.

Age was significantly associated with posterior thigh RRIs with most participants with this injury, being 50 – 59 years of age. As the age increased to 50 – 59 years, the posterior upper thigh RRIs also increased. No participants over the age of 60 reported this RRI. It is unknown as to what type of RRIs these were, however it is known that both bone and muscle tissue degrade with aging (Doherty, 2001; Taunton et al., 2002; Karamanidis & Arampatzis, 2005) which could explain the higher proportion of older participants with posterior thigh RRIs. In partial support of the current results, Taunton et al. (2002) found that female runners over the age of 50 were at a higher risk of RRIs than younger female runners. Additionally, Vitez et al. (2017) reported that older participants were at an increased risk for lower leg RRIs. Wen et al. (1997) found that runners with hamstring RRIs were older than those without and since the current study reported the higher proportion of posterior thigh RRIs (the area of the hamstring) in older runners, this study draws parallels with that of the current study.

The duration of RRIs and age were found to be significantly associated. The main findings were that the participants between the ages of 50 and 59, and 70 and 82 years of age had RRIs that took longer to recover than the participants younger than 50 years old. Most of the injuries in participants younger than 50, were reported as taking 1 – 3 months to recover. Marti et al. (1988) found that although RRI incidence decreased with increasing age, the duration of RRIs increased, as found in the current study. It is likely that this longer recovery period in older runners is a result of less effective regenerative capacity of the aging body (Marti et al., 1988).

5.4.1.2 Sex

Three injury variables were found to be significantly associated with sex; anatomical location of the RRI, RRI duration, and medical diagnosis of the RRIs.

Sex was associated with buttock RRIs and calf RRIs in the current study; males were more susceptible to calf injuries while females were more susceptible to buttock RRIs. Similarly, Satterthwaite et al. (1999) and Kerr et al. (2016) found that males were more susceptible to calf RRIs than females, and Lun et al. (2004) reported that the lower leg and knee were the most commonly injured site in male runners. Male runners over the age of 34 were found to be susceptible to Achilles tendinopathy (Taunton et al., 2002) which may explain the larger amount of calf RRIs in males reported in the current study, as Achilles tendinopathy can manifest in the calf area. The higher incidence of buttock RRIs in females may be attributed to females often presenting excessive frontal plane hip movements (Ferber et al., 2003; Chumanov et al., 2008; Phinyomark et al., 2014) which are linked to the occurrence of ITBS (Fredericson et al., 2000, Leetun et al., 2004; Noehren et al., 2007). Additionally, Chumanov et al. (2008) found that females had higher gluteus maximus activity during running, compared to males. High muscle activation levels results in muscular fatigue (Olin & Gutierrez, 2013) which could lead to damage of the muscle if the muscle continues to work past the fatigue limit (Chumanov et al., 2008). Clearly males and females are predisposed to different types of RRIs as found by Taunton et al. (2002) and as demonstrated in the current study.

Sex was associated with the duration of RRIs, with injuries of females lasting longer than injuries of males. Additionally, sex was associated with whether or not RRIs were diagnosed by a medical professional. A higher percentage of RRIs reported by females were diagnosed by a medical professional, compared to RRIs of male participants which is supported by the findings that females are more likely to report injuries than males (Taunton et al., 2002; Roos et al., 2015; Kerr et al., 2016). This finding may also be linked to the longer duration of RRIs in females. It could be that because females are more likely to report injuries than males, the onset of injuries appear to occur earlier in females as males may only acknowledge the injury when it becomes unbearable. Therefore, the perceived duration of RRIs are longer in females as they acknowledge the injury at the early stages. This being said, Lun et al. (2004) reported that females had more severe RRIs (measured by duration) than male runners, which is in line with the findings of the current study.

5.4.1.3 Ethnicity

Four variables were significantly associated with ethnicity; current injury, the number of RRIs reported in the year preceding the questionnaire, RRI location and the professional diagnosis of RRIs.

The ethnicity of a participant was found to be significantly associated with whether or not the participant was injured at the time of the questionnaire. Over a third of participants of each ethnicity reported being injured as a result of running. Black African participants had the largest proportion of injured participants at the time of the questionnaire, followed by Coloured participants and then participants of other ethnicities. Lastly, Caucasian participants were found to have the lowest percentage of participants who reported having an RRI at the time of the questionnaire. The results for a current RRI and the number of RRIs throughout the year presented similar findings. The number of RRIs that occurred over the period of a year was found to be significantly associated with ethnicity. Over half (57.70%) of the Black African participants reported having two or more RRIs over a period of 12 months prior to the questionnaire, more than the other ethnicities, while the Caucasian participants had the largest proportion of injury-free participants. There are very few studies that present direct findings on the association between ethnicity and RRI, however one could theorise the reasons for the findings of the current study. Football players of Black ethnic origin (Wood et al., 2004) were found to be at a higher risk of hamstring injuries possibly due to an anteriorly tilted pelvis or a higher proportion of Type II muscle fibres. Kohn et al. (2007) reported a higher predominance of Type II (fast twitch) muscle fibres in Black South African runners, and these particular fibres are particularly susceptible to fatigue (Verrall et al., 2001). This is important as pushing through the fatigue threshold has been found to increase the likelihood of injuries occurring (Chumanov et al., 2008; Olin & Gutierrez, 2013). In contrast to the findings of the current study, Friedl et al. (1992) found that the lowest risk of stress fractures occurred in Black army females, in comparison to non-Hispanic white, Hispanic and Asian army females. Additionally, Hall (2007) stated that osteoporosis is most prevalent in Caucasian and Asian populations. It has also been reported that Caucasians may be more prone to muscle damage after exercise as they have been found to have higher relative levels of creatine kinase (McKune et al., 2009), however the current study demonstrated opposing results.

Although the Black African participants reported a higher percentage of participants with a higher amount of injuries, very few of these injuries were seen by a medical professional. In contrast, the Caucasian participants had the highest percentage of injury-free participants however, reported having more RRIs that were diagnosed by a medical professional. The highest percentage of RRIs that were diagnosed by a professional was found in the Caucasian group (62.26%). This may be due to the severity of the injuries found in this group, or the fact that there were more Caucasian participants in the current study. Differences in injury rates in runners of different ethnicities may also be attributed to differences in health care access and quality (Parra et al., 2004) however this was not measured in the current study.

RRI location was significantly associated with ethnicity. Albeit a small portion, the highest percentage of participants with back RRIs were Coloured participants (13.79%). Participants with knee RRIs were common throughout the sample however 57.69% of Black African participants reported knee RRIs; the highest percentage compared to the Caucasian participants (19.11%), Coloured participants (37.93%) and participants of other ethnicities (44.44%). These findings prove challenging to discuss as there are no previous studies that directly address injury location in various ethnicities.

5.4.1.4 Stature, mass and BMI

No significant associations were found between mass and RRI variables, however stature was significantly associated with RRI location, and BMI was significantly associated with the number of RRIs in the past 12 months, RRI location, and RRI duration.

A significant association was found between stature and participants with buttock RRIs. Participants with a stature of 1.6 m or less reported the highest percentage of buttock RRIs (10.26%). The occurrence of buttock injuries decreased as stature increased. Although not buttock RRIs, Taunton et al. (2002) also found that a shorter stature increased the risk of certain RRIs, specifically PFPS in females and plantar fasciitis in males. Wen et al. (1997) found that male runners with foot injuries were shorter, lighter and had lower BMIs than male runners without foot injuries, however the mechanisms of these findings were not discussed.

No significant associations were found between mass and injury variables in the current study, which differed from the study by Taunton et al. (2002), in which it was found that female runners of a lower mass, specifically less than 60 kg, were less likely to develop RRIs such as plantar fasciitis (Taunton et al., 2002).

Three variables were found to be significantly associated with BMI in the current study. BMI was significantly associated with the number of RRIs reported in the 12 months preceding the questionnaire. A higher number of RRIs per participant were reported more often in obese runners, which is supported by previous studies. Several studies have found that runners with a higher BMI were at an increased injury risk (Jones et al., 1993; Buist et al., 2010a; Buist et al., 2010b; Nielson et al., 2013; Malisoux et al., 2014; van Poppel et al., 2016; Chaudhary et al., 2016; Vitez et al., 2017) which may be due to the additional weight needed to be supported by the body (Abate et al., 2012), unfavourable running kinematics (Chumanov et al., 2008), and higher GRFs (Taunton et al., 2002).

With regards to more specific injuries, participants with Achilles RRIs were most prevalent in the obese category with just over a quarter of injured, obese participants reporting Achilles injuries. Similarly, in a study by Abate et al. (2012), runners with a BMI of over 25 kg.m^{-2} showed a high amount of tendon abnormalities which could lead to increased injury risk. The increased stress experienced by the Achilles tendon as a result of extra weight is likely to contribute to early onset of Achilles tendinopathy (Abate et al., 2012).

Participants with buttock RRIs were most common in underweight and obese participants. Marti et al. (1988) reported the highest injury incidence in the groups of runners with the lowest BMI and the highest BMI, suggesting that those with a normal BMI were least susceptible to injury. The only previous study to our knowledge that has reported on buttock RRIs and BMI, was the study by Taunton et al. (2002) which found no association between the two variables. Apart from Taunton et al. (2002), no studies have reported on the nature of the association between BMI and buttock RRIs, however the existing literature can assist in understanding the potential mechanisms behind this association found in the current study. Although the exact type of affected tissue in the buttock area is unknown, in terms of tendons, load-bearing tendons are put under extra stress with obese runners, increasing the risk of injury (Heinemeier & Kjaer, 2011; Abate et al., 2012). In terms of the underweight participants, being underweight increases the chance of osteoporosis, leading to possible stress fractures in runners (Hall, 2007). Being underweight may also mean that the participant has low muscle mass and therefore low muscle strength. Poor muscular strength results in less controlled movements when running with the end result being soft tissue strain (Baltich et al., 2016).

The duration of RRIs was significantly associated with BMI in the current study. RRIs of underweight participants took the longest to recover. The duration of the recovery period of RRIs and the BMI of a runner has not been previously studied directly, however previous literature on BMI and RRIs can provide insight into this relationship. An abnormally low BMI, may indicate less muscle mass and strength (Baltich et al., 2016), and subsequently lower shock absorption abilities (Bus, 2003; Buist et al., 2010b; Devita et al., 2015). Moreover, being underweight increases the chance of osteoporosis, leading to possible stress fractures in runners (Hall, 2007). The combination of porous bones and inadequate muscle strength to compensate for the external loads imparted on the body during running, makes the underweight runner highly susceptible to stress fractures. Furthermore, stress fractures have been reported as recovering only after a long period of time off from running (Beck, 1998).

With this literature in mind, it must be noted that the type of injury in the current study is unknown.

5.4.1.5 Socioeconomic background

Three variables were significantly associated with monthly income, namely ankle RRIs, RRI duration, and professionally diagnosed RRIs.

Monthly income and having had an ankle RRI in the 12 months preceding the questionnaire were found to be significantly associated. Those who were earning less than R 5 000 per month, had the highest percentage of participants with ankle RRIs (23.08%). The proportion of participants with ankle RRIs decreased with an increase in monthly income with the exception of those earning R 30 000 or more per month. Cubbin et al. (2000), found that socioeconomic status was negatively associated with injury risk, and Smith, (1999) and Mayosi et al. (2009) previously reported that poor health accompanies low income, which may explain the findings of the current study. Moreover, poor nutrition is rife in areas of low household income and can lead to reduced bone mineral density and consequently an increased risk of injuries such as stress fractures (Duckham et al., 2012; Folscher et al., 2015). With weakened bones, the added stress of running, further increases the risk of injury (Hall, 2007; Lane et al., 1986). Although the study by Faelker et al. (2000) focused on children in Canada, it was reported that non-fatal injury rates of the most poverty-stricken group were 1.67 times higher than the least poor group.

The duration of an RRI, and medical diagnosis of the RRIs were significantly associated with monthly income in the current study. Overall, the less affluent groups appear to have had a larger proportion of RRIs of shorter duration, and less RRIs that were diagnosed by a medical professional, which may seem counterintuitive. However, Onywera (2009) put forward an interesting concept: poorer populations are more likely to have less official or less experienced coaches which may result in the runners becoming more skilled at understanding their own bodies, and adapting to avoid injuries. Thus, the RRIs that develop in the less affluent groups may be less severe and may not need to be seen by a medical professional. On the other hand, it could also be postulated that those earning less per month may not be able to afford medical treatment as differences in injury rates in runners may also be attributed to differences in health care access and quality (Parra et al., 2004) as a lack of affordable medical treatments, accompany low income (Morrow et al., 2014). As a result, injuries are not treated properly, or medical treatment is delayed (Morrow et al., 2014) thus increasing the likelihood of recurrent injuries or the exacerbation of the existing injury (Morrow et al., 2014). With high socioeconomic status, more resources can be allocated towards health care (Kington & Smith, 1997) which may explain the higher proportion of RRIs that were tended to by medical professionals, in the higher income group of runners.

5.4.2 TRAINING CHARACTERISTICS

Hypothesis 2, regarding the presence of significant associations between training characteristics, and RRI variables, was partially supported. These significant associations are discussed in the subsequent paragraphs.

5.4.2.1 Organised running

Having an RRI within the period of 12 months preceding the questionnaire was found to be significantly associated with involvement in a running club. More participants who were part of a running club reported having an injury (76.07%), than participants who were not part of a running club (61.54%). Similarly, van Poppel et al. (2016) reported that running in organised groups was a risk factor for RRIs in marathon runners. In contrast to the findings of the current study, van Middelkoop et al. (2008b) found that being a member of an athletics association was a protective factor for calf injuries. No theories were put forward in these previous studies as to why being part of a running club may affect RRIs, however the results in the current study may be due to participants pushing their bodies too far when training in order to keep up with other runners in their running clubs.

5.4.2.2 Weekly running frequency

Professional diagnosis of RRIs and weekly running frequency were significantly associated. Participants running 7 times per week had the lowest percentage of RRIs that were diagnosed by a medical professional which may be a result of the healthy runner effect whereby runners who are not injury-prone, continue to run on a regular basis (Wen et al., 1997; Buist et al., 2010a). Additionally, van Middelkoop et al. (2008b) found that increased weekly running did not result in higher injury rates and suggested that running more frequently throughout the week may be a preventative measure for avoiding injury, as this allows the body to adapt to the continuous loading of running (van Middelkoop et al., 2008b). Furthermore, less than two running sessions per week have been associated with RRIs (Taunton et al., 2003; Malisoux et al., 2014).

5.4.2.3 Weekly running duration

Weekly running duration was significantly associated with two variables; RRI location and RRIs that had undergone surgery.

Achilles injuries mostly occurred in participants who ran the least and those who ran the most hours, on a weekly basis. One explanation could be that Achilles injuries could be attributed to underconditioning, as well as overtraining. With regards to high running volume, overtraining can lead to overloading of the musculoskeletal system (Satterthwaite et al., 1999; van Gent et al., 2007; Malisoux et al., 2014) and tendons, such as the Achilles, are likely to be at increased injury risk as a result of overtraining (Magnusson et al., 2010). In terms of low running volume increasing RRI risk, under-conditioning may occur (Satterthwaite et al., 1999; Malisoux et al., 2014). Running less than 2 hours a week was associated with increased injury rate (Malisoux et al., 2014). Moreover, low training volume prior to a marathon may result in the body not being conditioned to run marathon distances thus resulting in overload and subsequently injury (Rasmussen et al., 2013).

A significant association exists between running duration and foot RRIs in the current study. Grouping the participants showed that those running less than 6 hours per week had a lower percentage of RRIs than those running more than 6 hours a week. Chang et al. (2012) also reported that a training session of more than 60 minutes increased the incidence of foot pain which could be attributed to overload and the fatigue of tissues. RRIs cannot occur with zero weekly volume as there is no risk exposure, which may explain more injuries seen with higher weekly volume (Wen et al., 1997).

It is possible that some participants may have decreased their weekly running durations due to foot and Achilles RRIs whereas others may have developed these injuries as a result of a high weekly duration.

Weekly running duration and RRIs that underwent surgery were significantly associated in the current study. The highest percentage of RRIs that were operated on, were those of participants who ran for a total of 3 hours per week. This was on the lower end of the weekly running durations. It may seem unlikely that a participant who runs this little would have an injury severe enough to need surgery, however this finding may be due to participants who had the surgery or had a severe injury and needed to decrease their weekly running duration, as there is no indication of the direction of the association between surgery and weekly running duration.

5.4.2.4 Running terrain

The following section discusses each terrain along with the associated injury variables, separately. It should be noted that sand was excluded from the statistical analyses as the sample size was not large enough (n=3). No significant associations were found between road/tar/asphalt and RRI variables and therefore this terrain will not be discussed for the sake of brevity. In terms of the number of different terrains that each participant trained on, whether or not the RRI received surgery, was found to be significantly associated to the number of terrains. Those choosing to train on fewer different terrains, were found to report more injuries that required surgery. As there is no previous literature that reported directly on this same association, it can only be theorised that the reason for this significant association found in the current study, was that training on different terrains conditions the body differently. Using different biomechanical pathways with the different terrains may allow some parts of the body to recover while other parts are strengthened, decreasing the runner's susceptibility to RRIs.

RRIs that underwent surgery were significantly associated with the number of different terrains incorporated into a runner's training regime. The largest proportion of RRIs that were operated on, were those of participants who included only 1 type of running terrain in their training. Terrain that is too hard results in reduced shock absorption when landing and therefore can cause strain to the legs (Beck, 1998). This being said, if the terrain is too soft, it can cause strain on the triceps surae. It has been suggested that the training terrain should be varied in order to strengthen different muscles and avoid overuse from using the same muscles, and therefore reduce the likelihood of overuse injuries (Beck, 1998).

When looking at those who ran on cement, less RRIs were reported per participant, compared to those who avoided running on cement. In a similar study, Wen et al. (1997) reported that participants with certain RRIs, ran significantly less on asphalt or concrete. Running on harder surfaces such as cement could therefore either be a protective factor, or the participants who suffered from more RRIs, avoided running on cement due to the perception of cement increasing injury risk.

Cross country and trail running was associated with whether the injury was overuse or acute. More participants who did not run on trails suffered from overuse injuries whereas more cross country/trail runners suffered from acute injuries. As the ground on trails is more uneven than most other terrains (Tessutti et al., 2012), more acute injuries may occur as a result of trips and falls. Rougher terrain that involves challenging footing may increase the risk of RRIs such as ankle sprains and other acute injuries (Kerr et al., 2016). Ankle sprains were excluded from the study by Malliaropoulos et al. (2015) done on ultra trail runners, as these injuries were reported as too frequent.

Running on grass was found to be significantly associated with ankle injuries in the current study. More participants who ran on grass reported ankle RRIs, than those who did not train on grass. Knobloch et al. (2008) found an increased risk for Achilles tendinopathy when running softer terrains which is likely a result of increased range of motion and the need for stronger propulsion against the softer surface. In contrast, Tessutti et al. (2012) reported that runners who train on grass are less likely to become injured. Running on softer surfaces such as grass is likely to increase the shock absorption throughout the runner’s body and therefore decrease the risk of injury (Satterthwaite et al., 1999). Therefore, running on grass may have been a retrospective measure for athletes with RRIs around the ankle area, to decrease pain.

An RRI in the past year was associated with running on track or tartan, with a higher percentage of those who ran on this terrain reporting more RRIs than those who did not run on track/tartan. Similarly, van Poppel et al. (2016) reported that training on tartan surfaces was an independently associated risk factor for RRIs in marathon runners. Additionally, compared to concrete or asphalt, a more compliant synthetic track, such as one made of tartan, increased the risk of ankle pain (Chang et al., 2012). Malliaropoulos et al. (2015) also reported that more RRIs were found in participants who trained on synthetic material, such as track and tartan, compared to those who trained on mountainous terrain. Track and tartan were further associated with RRI duration. Longer duration RRIs were more common in participants who ran on track/tartan with the exception of RRIs that lasted more than 6 months which were more common in participants who did not run on track or tartan. It may be that the specific RRIs that occurred in those running on track and tartan, were the type of injuries that generally had a longer recovery period. Looking at the study by Malliaropoulos et al. (2015), Achilles tendon RRIs were the most common injuries with a long recovery period, and Chang et al. (2012) reported ankle pain in track runners, therefore although the type of injuries in the track and tartan runners are unknown in the current study, it could be plausible that these injuries were around the ankle or Achilles region, explaining the long duration of these RRIs.

Having had an RRI in the past year was found to be significantly associated with treadmill running. A higher percentage of those who included the treadmill in their running routine reported being injured in the past year compared to those who did not include treadmill running in their training. Most previous literature does not support the findings of the current study. In opposition to the current study, male runners who incorporated treadmill running into their training had 20.5% less RRIs than those who excluded treadmill running (Fonseca et al., 2015). Tessutti et al. (2010), proposed that this enhanced shock absorption may be a result of more movement available at the foot-ankle complex when running on more compliant terrain. It may be likely that some participants, who were injured, opted for treadmill running as an alternative terrain.

It should also be noted that the retrospective design of the studies by Wen et al. (1997), Knobloch et al. (2008), Chang et al. (2012) and Fonseca et al. (2012), create “temporal ambiguity” (Wen et al., 1997) with regards to the findings, meaning that the terrain may have not influenced the injury risk or prevalence, but rather that the injured runner changed to a perceivably safer running terrain in order to prevent exacerbation of a current injury or prevent further injury (Wen et al., 1997; Knobloch et al., 2008; Chang et al., 2012).

5.4.2.5 Changes to training

A significant association was found between participants who made changes to their training in the past year and the number of injuries reported in the past year. Overall, there were higher percentages of participants, who had changed their training, with two RRIs or more, than in participants who had not changed their training. Additionally, changes made to training were associated with a higher incidence of knee RRIs. Participants may have changed their training as a result of their injuries, or participants may have become injured due to a change in their training. The latter is likely if the participant increases their training volume drastically and did not implement this change gradually. A drastic increase in training load does not allow the body enough time to adapt and can therefore result in injury (Beck, 1998; Taunton et al., 2003). A radical change in training habits is a common cause of RRIs such as stress fractures (Beck, 1998; Castro et al., 2014) which often develop within the first 2 months of increased or altered training (Beck, 1998). Furthermore, Satterthwaite et al. (1999) reported that increasing weekly running frequency by one day was associated with anterior thigh RRIs in runners. Because of the cross-sectional nature of the study, it is unknown as to whether the injuries were a result of training changes, or whether the participant made changes to their training due to their injuries, however the findings show that an association is present and the directional relationship between these factors warrants further investigation in future research.

5.4.3 RUNNING EXPERIENCE

Hypothesis 3, regarding the presence of significant associations between running experience, and RRI variables, was partially supported. These significant associations are discussed in the subsequent paragraphs.

5.4.3.1 Years of running experience

Years of running experience were found to be significantly associated with knee RRIs. Participants with less running experience reported more knee injuries. Similarly, Marti et al. (1988) found that knee pain was associated with fewer years of running experience. Reinking et al. (2013) reported that less than 3 years of running experience was a risk factor for ERLP and Taunton et al. (2002) found that less than 8.5 years of activity was a risk factor for tibial stress syndrome. A phenomenon known as the 'healthy runner bias' or 'survival phenomenon' may explain these finding; runners who start running and become injured drop out of the sport and therefore the ones with the least amount of injuries tend to have more years of experience as they kept running due to no or little injuries (Satterthwaite et al., 1999). Additionally, underconditioning could play a role in this instance. Those with less experience have had less exposure time to running and therefore their bodies may have not had time to adapt or 'harden' to the stresses of running. Moreover, intervention training programs for novice runners showed the highest injury rate to be within the first 8 weeks of the start of the program (Baltich et al., 2016), meaning that the novice runners' bodies may not be used to the stresses of running and therefore more susceptible to RRIs. It is also possible that inexperienced runners train erroneously, for example, increasing the running volume before the body has adapted, thus increasing the risk of injury (Taunton et al., 2002). In contrast to the findings of the current study, van Middelkoop et al. (2008b) found that more than 15 years of running experience increased the risk for knee injury which may be explained by potential overuse of the knee in that specific population of runners which differed to the population in the current study.

In the current study, the proportion of recurrent RRIs increased with years of running experience with a quarter of the injuries being recurrent, in runners with more than 15 years of experience. The fact that the experienced runners have had more exposure time to the sport may explain this finding. Eccentric muscle actions which occur with every step in running, cause muscle damage, especially after running distances of 21 km or more (Gibson et al., 2004). Thus, with many years of running experience, the accumulation of muscle damage may contribute to the onset of RRIs. Knobloch et al. (2008) and Roos et al. (2015), suggested that more years participating in sport could increase the likelihood of an overuse injury as a result of accumulated microtrauma and the increased possibility of a previous injury, which has been linked to increased risk of further injury. Recurrent injuries can occur from previous injuries that were not fully recovered before the runner resumed training (Hreljac, 2004). As a more experienced runner has had more exposure time, it is more likely that they have developed an injury in the past that had possibly not healed properly or that had weakened the injured area.

The highest percentage of professionally diagnosed RRIs were reported by participants with 5 to 15 years of running experience and the lowest percentage, in those with the least amount of experience. Although there is no existing literature to explain these findings, it could be theorised that these results may be due to the more experienced runners knowing their bodies better and therefore knowing if the injury needs medical attention.

5.4.3.2 Race distance preferences

All associations regarding race distance preferences, were related to races of more than 42 km. There was a higher percentage of participants with three or more RRIs in those who favoured race distances of more than 42 km, the approximate distance of a marathon. Van Poppel et al. (2014) reported that RRI incidence was higher in participants competing in races of 15 km – 21 km, compared to those competing in 5 km – 10 km races. Chang et al. (2012) found that full marathon runners had the highest injury rate, followed by half marathon runners, and lastly 10 km runners. It was theorised that these results were due to the higher training volumes of most of the full marathon runners, in comparison to the half marathon runners and 10 km runners. Furthermore, in the current study, a higher percentage of posterior thigh RRIs were found in runners who preferred races of 42 km or more, compared to those who did not. Similarly, thigh RRIs were more common in longer distance runners than in 5 km – 10 km runners (van Poppel et al., 2014), more hamstring RRIs were reported by longer distance runners in the study by Wen et al. (1997), and Chang et al. (2012) found that full marathon runners were prone to thigh pain.

A significant association was found between the number of races of 42 km or more, and the number of RRIs in the past year. The highest percentage of participants with three or more RRIs, were reported by those who ran five or more races of more than 42 km, which is in line with the findings in the study by van Middelkoop et al. (2008b), who reported that RRI risk increased in those who ran more than six races per year.

Most RRIs lasted the duration of more than 6 months in participants who favoured races of more than 42 km. Overall those who favoured races of more than 42 km were most likely to have RRIs that lasted longer durations than those who did not favour this particular race distance.

Participants who favoured 5 different race distances reported the highest percentage of posterior thigh injuries. The general trend was that more participants with thigh RRIs, reported a higher amount of different race distance preferences. These findings may be a result of these participants running more races overall as van Middelkoop et al. (2008b) found that participating in more than 6 races in a year, increased RRI risk in runners.

The above findings suggest that races of more than 42 km were a risk factor for RRIs in the current sample. Moreover, it appears that posterior thigh RRIs, were connected to race distances in the current study.

5.4.3.3 Sponsored or professional runners

Most RRIs of professional runners were reported as still recovering at the time of the questionnaire, meaning that more professional or sponsored runners were injured than not, at the time of the questionnaire. Taunton et al. (2002) suggested that runners of higher competition levels, are likely to train more and have more previous injuries therefore putting them at higher risk for further RRIs. Additionally, Daoud et al. (2012) found a high injury rate in their sample and theorised that this could be due to the runners being competitive.

Between the RRIs that were fully recovered and those that were not fully recovered before the runner resumed training, more RRIs were fully recovered. Those that did allow for their injuries to recover, may have had injuries too serious to continue training or had the knowledge to know that full recovery is essential. Although not necessarily the case, if we assume that professional runners are more experienced runners, it is likely that they are more aware of the capabilities of their body (Taunton et al., 2003; Buist et al., 2010a; Rasmussen et al., 2013) and will not resume running until they are sure that their injuries have healed. Without allowing the injury to fully recover before resuming training, further injury is likely (Hreljac, 2004).

5.4.4 RUNNING FOOTWEAR

Hypothesis 4, regarding the presence of significant associations between running footwear, and RRI variables, was partially supported. These significant associations are discussed in the subsequent paragraphs.

5.4.4.1 Footwear types

A significant association was found between being injured at the time of the questionnaire and the various footwear types. The highest percentage of injured participants was those who used trail running shoes. Malliaropoulos et al. (2015) found that 90% of the trail runners in their study reported RRIs, however these runners were all ultra trail runners therefore the high percentage of RRIs may be attributed to the longer distance races. Only one participant ran barefoot and was not injured at the time of the questionnaire; however, one injury-free participant does not provide enough evidence. Excluding the barefoot participant, the lowest percentage of injured participants were those who ran in minimalist shoes. Minimalist shoes often have little or no difference in height between the forefoot and heel which has been said to promote forefoot or midfoot striking when running. This technique has been theorised to reduce injury risk for specifically stress fractures, as a result of decreasing the impact force when landing (van der Worp et al., 2016).

A significant association was found between footwear types and whether the injury was an acute or overuse injury. Out of all of the footwear types, minimalist shoe wearers were the only ones who suffered from more acute RRIs than overuse RRIs. It could be theorised that acute RRIs such as ankle sprains may occur more in minimalist shoes due to the lack of joint support provided by the footwear. On the other hand, Daoud et al. (2012) mentioned that minimalist shoes are designed to reduce overuse RRIs, which may emphasise that the main finding in the current study, was that less overuse RRIs occurred with minimalist shoes. Runners who wore racing flats reported the highest percentage of overuse injuries compared to the other footwear groups. This may be a result of less cushioning in the racing flats, exposing the runner to higher loading rates and impact forces (Logan et al., 2010), decreasing the stress limit of the body and consequently resulting in overuse impact injuries such as stress fractures (Logan et al., 2010; van der Worp et al., 2016). Although we are unsure of the exact RRIs of those who ran in racing flats, stress fractures are a common overuse RRI in runners (van der Worp et al., 2016). In contrast, Giandolini et al. (2013) found no difference in loading rates between racing shoes and normal running shoes. Most racing flats provide no rearfoot motion control (Logan et al., 2010) which may contribute to the high overuse RRI rate. Whether racing flats are more similar to minimalist shoes or standard running shoes is difficult to state, making it challenging to discuss our findings.

RRI duration was significantly associated with footwear types. Participants who wore trail running shoes had the highest percentage of the longest duration injuries (more than 6 months). However, this may be due to the activity of trail running and not necessarily the shoes, as trail runners have been found to have high injury rates (Malliaropoulos et al., 2015). Minimalist shoes showed the largest amount of RRIs of short durations, taking 1 week or less to recover. This finding may be linked to the fact that the highest percentage of RRIs that were seen by a medical professional, were those of minimalist shoe runners. It is possible that these RRIs were treated and therefore recovered sooner than other RRIs.

In the current study, footwear type and RRI recovery status were significantly associated. Injured participants who wore combination shoes had the highest percentage of injuries that did not fully recover before training. Those running in minimalist shoes had the most RRIs that did recover before resuming training which may be a result of the minimalist RRIs healing the quickest. Participants, who used trail running shoes, had the highest percentage of injuries that were still recovering at the time of the questionnaire, which could be a result of these injuries taking the longest to recover. Additionally, the participants who ran in trail running shoes had the most participants who were currently injured at the time of the questionnaire.

The more different types of footwear owned by a runner, the more likely the participant was to have reported a current RRI. This was also seen with the number of footwear pairs and the number of injuries reported; the likelihood of having 3 or more RRIs increased with the number of footwear pairs. The findings of the current study differed from those by Wen et al. (1997) who found that there were less knee injuries in runners with more than 2 pairs of shoes compared to those with one pair of running shoes.

Similarly, Malisoux et al. (2013) found that training with more than one type of shoe concurrently was shown to be a protective factor. It is possible that the results of the current study differed due to the cross-sectional nature of the study; those with injuries may have bought different shoes in attempt to reduce injury risk.

Changing the type of running footwear was significantly associated with foot RRIs. Participants who made changes to their running footwear reported a higher percentage of foot injuries than those who did not change their footwear. It may be that the runner became injured and therefore decided to change their footwear. Wen et al. (1997) found that runners with injuries changed their shoes more frequently than those without injuries. Another possibility is that the runner made a drastic change to their footwear and did so suddenly. Although the types of footwear that the runner changed to, was not known in the current study, it is important to discuss the existing literature. Injuries may additionally occur as a result of transitioning too quickly from shod to barefoot or minimalist running (Cauthon et al., 2013; Olin & Gutierrez, 2013; Daumer et al., 2014; Hryvniak et al., 2014). Daumer et al. (2014) found that in a group of runners who transitioned from shod to barefoot or minimalist shoes, most of the injuries occurred during the transition phase; three times more than during the shod phase and seven times more than the barefoot/minimalist shoe phase. Additionally, impact peak shock has been found to be higher in the first attempt at barefoot running when both forefoot and heel striking, therefore during the transition period from shod to barefoot running, there is an increased risk of overuse injuries (Olin & Gutierrez, 2013). The foot may have been the injured area associated with footwear, as the footwear is directly in contact with the foot.

5.4.4.2 Orthotic use

A higher percentage of participants who used orthotics were injured at the time of the questionnaire than those who did not wear orthotics. The same was found for participants who were injured over the past year, those with Achilles, foot, or knee RRIs, as well as participants with injuries that were diagnosed by a professional. Furthermore, participants who wore orthotics were more likely to have more RRIs and RRIs that took longer to recover, compared to those who did not wear orthotics. Because of the cross-sectional nature of the current study, temporal ambiguity exists, and it cannot be decided as whether it was orthotics that contributed to RRIs or whether the participants opted to use orthotics as a reactive approach to rectifying already existing RRIs. Thus, both scenarios are discussed.

Wen et al. (1997) and Chang et al. (2012) found more RRIs in participants who used inserts or orthotics. Additionally, Chang et al. (2012) found that knee orthotics were associated with a higher rate of knee pain and ankle braces were associated with a higher rate of ankle pain, but shoe orthotics were protective against hip and knee pain. The cause and effect were not known, as in the current study, but it was suggested that the injured runners may have used knee and ankle orthoses to reduce pain. Furthermore, shoe orthotics may have reduced injury rate due to shock absorption and alignment correction. A systematic review by Collins et al. (2007), reported that orthotics were efficient in preventing lower limb overuse injuries, however, with regards to the treatment of injuries, proof is lacking. Runners with pronation have been found to benefit from motion-control footwear and are at a higher risk of injury than those with neutral feet, if they run with normal shoes lacking motion-control features (Malisoux et al., 2016). Excessive pronation is a risk factor for Achilles tendinopathy (McCrory et al., 1999) therefore orthotics are likely to assist with correcting pronation. With regards to knee RRIs, patellofemoral joint loading was significantly reduced in recreational runners when running with orthotics (Sinclair et al., 2015). Since the risk of patellofemoral injuries are increased with high patellofemoral joint loading, orthotic intervention could reduce the incidence of knee injuries in runners through reducing joint loading. Again, it could be hypothesised that those with existing knee RRIs in the current study, opted to try orthotics to reduce further injury. Wen et al. (1997) also found more foot RRIs in those who used orthotics compared to those who did not. Ribeiro et al. (2015) suggested that orthotics that control rearfoot valgus alignment and reduce loading could reduce the risk of plantar fasciitis, as rearfoot valgus was found to be associated with increased plantar loads over the rearfoot, in runners with plantar fasciitis. Since orthotics should reduce impact forces during running (Laughton et al., 2003) and provide arch support, the risk of plantar fasciitis could be lowered. However, it has been theorised that orthotics that provide arch support may result in weakened muscles thus increasing strain and leading to plantar fasciitis (Lieberman et al., 2010).

As previously mentioned, it may have been the orthotics that increased the injury risk of the participants in the current study. A systematic review by van der Worp et al. (2015), found moderate evidence to support that the use of orthotics increases injury risk in the leg, which is in line with the current study as the Achilles, knee and foot were the associated sites of injury with orthotic use.

Regardless of the unknown temporal nature of the associations between orthotics and RRIs, it is clear that orthotics play an important role in RRI and should be studied further in future research.

5.4.5 CROSS TRAINING

Hypothesis 5, regarding the presence of significant associations between cross training, and RRI variables, was partially supported. These significant associations are discussed in the subsequent paragraphs.

Cross training variables were found to mostly be associated with the anatomical location of RRIs. Participants who took part in cross training reported a higher incidence of calf injuries than those who did not cross train, which could be due to the additional strain on the calf muscles from the type of cross training activities. Participation in sports that involve running and jumping has been found to be a risk factor for developing Achilles tendinopathies because of the extended duration of plantar flexion (Ishikawa et al., 2014). Satterthwaite et al. (1999) found that certain cross training activities increased the risk of RRIs in different locations. With aerobics, hamstring pain or injury was increased, and with cycling, there was an increased risk for front thigh pain or injury. Cross training activities without axial loading, increased injury risk in runners (Buist et al., 2010a; Buist et al., 2010b). It was theorised that these findings may be due to most non-axial loading sports, improving cardiorespiratory endurance making these runners fitter and able to train more intensively. However, the musculoskeletal system may have not adapted well enough to withstand the repetitive forces of running at a high intensity. Therefore, it is possible that those participating in non-axial loading sports may be less resistant to the forces of running and therefore more prone to RRI. In the current study, almost half of the cross training participants took part in cycling, which is a non-axial loading sport which may explain the increased number of calf RRIs in these participants.

Taking part in 1 or 2 activities per week was associated with a higher percentage of back injuries than taking part in 3 or more. A fair number of participants in the current study were trail runners and with trail runners, Malliaropoulos et al. (2015) reported that lower back RRIs were the most common RRI. It could be hypothesised that if participants took part in more cross training activities per week, this might assist with reducing the number of back RRIs if the cross training activities do not target the back area. It is also plausible that those with back RRIs in the current study, reduced their weekly number of cross training activities as a result of the RRIs.

5.5 Limitations

The questionnaire was only in English. 61.36% of those excluded did not speak English as a home language and therefore may have struggled with the questionnaire, hence the incomplete or inconclusive data.

Selection bias may have been a limitation as a result of the current study aiming to find risk factors of injuries, runners who have been injured were likely to participate in the study (Reinking et al., 2013; van Poppel et al., 2016).

Recall bias may also have been a limitation of the current study. In order to decrease the likelihood of recall bias, most questions in the current study extended to within the past 12 months from the time of the questionnaire as done in previous studies (Gerlach et al., 2005; Ristolainen et al., 2010; Roos et al., 2015). Nonetheless, recall bias was still a possibility (Knobloch et al., 2008; van Poppel et al., 2016).

Self-report of injuries was the main method of reporting injuries, rather than being diagnosed by physician. Daoud et al. (2012), suggested that injury rates in studies that used self-report may be lower, as participants might be less inclined to not report minor injuries. That being said, this may have been counteracted by asking the participants to refer to include pain when reporting injuries. Another limitation of self-report is that the emotional state of a participant at the time of the questionnaire could influence their answers (Schwarz, 1999), however, as many of the questions were objective, this is unlikely.

The length of the questionnaire may have limited the involvement of potential participants and may have resulted in participants not completing the questionnaire or not starting it at all (Ristolainen et al., 2010).

Retrospective analyses, such as the cross-sectional design of the current study, may not yield 100% accurate data as it relies on self-report and not actual diagnoses by medical practitioners (Walter & Hart, 1990).

Lastly, it is possible that some associations occurred by chance as a result of the large sample size (Meeuwisse, 1994).

CHAPTER VI

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The following final chapter summarises each previous chapter, highlighting the main points. The thesis is concluded, and recommendations are made for future research on RRIs in South African long-distance runners.

6.2 Summary

Chapter I addressed the need for the current study and skims the surface of the existing literature and where the gaps exist regarding RRIs and potential contributors, within the population of South African long-distance runners. The research aims, objectives, and questions are addressed, and the hypotheses and sub-hypotheses are subsequently set up.

Chapter II delved into the details of RRIs and the subsequent mechanisms involved. The previously investigated potential risk factors are reviewed and further deconstructed to establish which aspects of each potential risk factor needs further investigation, particularly in the population of South African long-distance runners.

Using the literature from Chapter II, Chapter III described the methods used in the current study in attempt to address the gaps in the literature and subsequently answer the research questions posed in Chapter I. The methodologies throughout previous research, were used to build and support the methods in the current study.

Chapter IV, the results chapter, was divided into two sections; the descriptive results and the significant associations found between the RRI variables and other participant factors. The descriptive results built a descriptive profile of the average South African long-distance runner, while the significant associations brought to the surface, factors that may contribute to RRIs and factors that are linked to RRIs, therefore forming a basis for future research.

Chapter V discussed the results from Chapter IV with reference to previous literature. The descriptive profile of South African long-distance runners did not differ drastically from previous populations of long-distance runners studied. In terms of the significant associations found, many training characteristics were associated with RRI variables which has also been found in previous studies. Races of 42 km or more were a recurring theme in the associations with RRI variables. Throughout the footwear category, many significant RRI associations were also found, supporting the need for further research in this area, specifically within the population of South African long-distance runners.

6.3 Conclusion and recommendations

Overall, the current study was able to identify a descriptive profile of the average South African runner and compare this population to those of previous studies done, around the world. Moreover, the current study was able to contribute to the current RRI literature, by identifying possible RRI contributors and potential risk factors, through associations. These associations could act as a framework for future injury studies on South African long-distance runners, that could delve deeper into the nature of these associations and perhaps establish direct relationships between RRIs and runner characteristics. In each category, there were factors that were associated with RRIs, thus partially supporting each hypothesis. Significant RRI associations were most prevalent within the training characteristics and footwear categories and because these factors are modifiable, these associations should be studied further as the current study could not determine a causal relationship. Although, cross-sectional in nature, the current study is clinically relevant as it is a step forward in RRI research in the South African long-distance running population.

Moving forward, any future research done on RRI prevention should not only focus on effective methods for preventing injuries, but also on the implementation strategies. Hulme & Finch (2015) discuss the importance of ensuring that interventions to reduce injury prevalence, are effectively carried out. Essentially, preventative programs should aim to decrease the stress or load that may result in injury, however the runner should be monitored to ensure that they do not then adjust to a riskier behaviour due to the idea that the preventative program is protective enough. For example, a runner may decide that they can now run longer distances as a result of specific running footwear made for longer distances, however increasing their distance drastically may nullify the protective aspects of the shoes. Additionally, runners, coaches and medical practitioners, should be educated on injury contributors and prevention strategies (Folscher et al., 2015).

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APPENDICES

Appendix A – Running club details

Table LX. List of 1811 running clubs in SA from Runner's Guide (2013)

Running Clubs	
24.com Athletics Club	Meadowlands Athletic Club
Aberdare Cables AC	Medihelp
ABI Athletic Club	Medunsa Atletiekklub
ABSA Card Runners	Meerendal Athletic Club
ABSA UWC Athletic Club	Meg Kennedy
Achilles Amateur Athletics Association	Melkbos Athletic Club
ACSA Athletic Club	Melon Slush Run Club
Acsa Running Club	Memel Sakekamer
Active Escapes and SA Adventure Trails	Mercury Athletic Club
Adamas Athletic Club	Merewent Athletic Club
Addicted 2 Life Multisport and Life	Messina Marathon Club
Adidas Athletic Club	Metro Athletic Club
Adoptions4Ever	Metropolitan Athletic Club
ADT AC EP	Meyerton Athletic Club
ADT Athletics Club	Michaelis German School
Adventure Racing Club	Midack Athletic Club
Adventure Works	Midas Spartans Amateur Athletic Club
Aerosud	Middelburg Lions club
Affies Marathon Club	Middelburg Marathon Club
African Bank Runners	Middelburg Mines Athletic Club

African Health Placements	Midlands Athletic Club
Afrika Tikkun Athletics Club	Midrand Country Striders
Afrikaans High School Kroonstad	Midrand Striders
Afrox Brits Athletic Club	Mitchell's Plain Titans
Afrox Running Club	Mittal Athletic Club - Newcastle
Agape & Faranani Athletic Clubs	Mittal Athletics Club AGN
Agape Athletic Club	Mittal Athletics Club AVT
AGSA	Mittal Pretoria Athletic Club
Akasia Athletic Club	Mmanaba Thaba Nchu Atlettiekklub
Alafang High School Athletic Club	Mmotong Athletic Club
Albany Road Runners	Moakeng Golden Sprinters
Albatross Travel	Modderfontein Nedbank RC
Alberton Amateur Athletic Club	Modern Athlete Club
Alberton Christian Social Council	Modikwa Platinum Mine
Alcatel Altech Running Club	Moggach Group of Companies & Koster M C
Alex Wasps Athletic Club	Mogodumo Athletic Club
Alexandra Athletic Club	Mogol Club (Limpopo)
Alexandra Beaters Athletic Club	Mogoshi Athletic Club
All Out Adventures	Mohlakamotala Athletic Club
Allstar Athletic Club	Mohlakeng Athletic Club
Alpha Athletic Club	Mohlakeng Celtic Harriers
Alpha Centurion Runners & Walkers (ACRW)	Mokerong Athletic Club
Alphendale	Molapo Cadres
Amandelbult Road Runners	Moletjie Athletic Club
Amanzi Athletic Club	Moloto Athletic Club
Amanzimtoti Athletic Club	Momentum

Amatola Pirates Running Club	**Monaco**
Amersfort Marathonklub	**Monaco/Transwerk AC**
Amicable Coalfields Marathon Club	**Mondipark Athletic Club**
Amric	**Montagu Athletic Club**
Anglo Platinum Mine	**Morgan's Bay Community and the Goons**
Anglo RPM	**Morningside Runners**
Anna Foundation	**Morula Casino & Hotel**
Apel Athletics Club	**Morula Running Club**
Arcadia Running Club	**Mossel Bay Endurance Walking Club**
ArcelorMittal Athletics Club VT	**Mossel Bay Harriers**
ArcelorMittal Saldanha Athletic Club (WP)	**Mossel Bay Correctional Centre**
ARD Athletic Club	**Mothle Athletic Club**
Arete Sport Club	**Mount Currie Athletic Club**
Arnot Marathon Club	**Mount Edgecombe Villagers Athletic Club**
Art of Motion	**Mount Everest Athletic Club**
AS Eagles Atletiekklub	**Mountain Runner Events**
Ashley Athletic Club	**Mountain Splendour Resort**
Asics Athletic Club	**MPU Correctional Services**
Aspen Athletics Club	**Mpumalanga Combined Clubs**
Assegaai Marathon Club	**Mpumalanga Road Running**
Assmang Athletic Club	**Mr Price AC (Mpl) & Ermelo Association**
ASWD	**Mr Price Athletic Club**
Atalanta Athletics Club	**Mr Price Athletic Club (KZN**
ATC Multisport & Running	**Mr Price Athletic Club (Mpl)**
Athletes for Christ	**Mr Price Athletic Club (Vaal)**
Athletics Alive	**Mr Price Bloemfontein Athletics Club**

Athletics Central North West	**Mr Price Celtic Harriers**
Athletics Club Eersterust	**Mr Price CG Athletic Club**
Athletics Club Talaria	**Mr Price Gauteng North**
Athletics Federation of the SWD Province	**Mr Price GFSAC**
Athletics Free State	**Mr Price Korrektiewe Dienste Atletekklub**
Athletics Gauteng North	**Mr Price Maties**
Athletics Griqualand West	**Msukaligwa Marathon Association**
Athletics Limpopo Province	**Msuthu Running Club**
Athletics Mpumalanga	**M-Tel Athletic Club**
Athletics North	**MTN SA Foundation**
Athletics North West North	**Mtubatuba Athletic Club**
Athletics SA	**Mtunzini Athletic Club**
Athletics South Africa	**Muden Athletic Club**
Athletics South Africa / Central Gauteng	**Muirite Striders**
Athletics South Africa/ Eastern Province	**Muirite Striders and NMMU Sports**
Athletics South Africa/Free State	**Multichoice Athletic Club**
Athletics South Africa/Gauteng North	**Multi-Sport Maniacs**
Athletics South Africa/KwaZulu-Natal	**Munsieville Athletic Club**
Athletics South Africa/Limpopo	**Murraysburg Sakevereniging**
Athletics South Western Districts	**Muwaweni Athletic Club**
Athletics SWD / Nedbank Running Club	**Mvunonala Athletics Club**
Athletics SWD Race Walking Commission	**My Road Less Travelled**
Athletics Transkei	**My Training Day Athletics Club**
Athletics Vaal Triangle	**Myne & Industrie**
Athletics Western Province	**Naboom Marathonklub**
Atlanta AC	**Namakwa Joggers**

Atlantic Athletic Club	**Namakwaland Diamond Funds Trust**
Atlantis Harriers Athletic Club	**Namaqua Athletics Club**
Atletiek Vrystaat	**Namaqua Ventures**
Atletiek Vrystaat Padwedlope	**Nantes Athletics Club**
Atteridgeville Athletic Club	**Naphuno Athletic Club**
Aurecon AC	**Naschem Atletiekklub**
Aurecon Western Cape Run-Walk Club	**Nashua Richards Bay Athletic Club**
Aventura Road Runners	**Natal Carbineers Athletic Club**
Avis Athletic Club	**Natal University Athletic Club (PMB)**
Awesome Runners Athletic Club	**Nation Athletic Club**
Babanango Valley Lodge	**National Port Authority**
Babelegi Marathon Club	**NB Sports Development**
Backyard Adventures	**NCP Chlorchem Athletic Club**
B-Active Sports	**NCZ Great Train Race**
Bafokeng Athletic Club	**Ndaba Athletic Club**
Balele Athletics Club	**NDFT Daisy Marathon**
Bank Marathon Club	**Ndlovu Road Runners**
Bankserv Athletic Club	**Nedbank A.C**
Bantu Bonke Athletic Club	**Nedbank Bloemfontein Achilles**
Barberton Athletic Club	**Nedbank Development Club CNW (Klerksdorp)**
Barberton Correctional Services	**Nedbank Franschhoek Athletic Club**
Barberton Gijimas	**Nedbank KZN**
BARRC	**Nedbank LVCC Running Club Mpumalanga (Nelspruit/Mbombela)**
Bashewa	**Nedbank RC PTA**
Bastion Athletic Club	**Nedbank RC Soweto**
Baviaanskloof Trail Run	

Bayview Striders Athletic Club	Nedbank Running Club - Head Office
Beacon Athletics Club	Nedbank Running Club (Vanderbijlpark) NRCVT
Beacon Willie Mtolo Athletics Club	Nedbank Running Club Boland (Stellenbosch)
Beaufort West Drawwers/Runners	Nedbank Running Club CG Johannesburg
Beaufort-Wes Munisipaliteit	Nedbank Running Club Diepkloof (Soweto)
Bedfordview Country Club	Nedbank Running Club EP (Port Elizabeth)
Beefcor Sports Club	Nedbank Running Club Gauteng North (Pretoria)
Bekkersdal Athletic Club	Nedbank Running Club Kwazulu-Natal (Durban)
Belle Ombre Athletic Club	Nedbank Running Club SWD (George)
Bellville Athletic Club - Road Running Division	Nedbank Staff Initiative
Benoni Harriers Athletic Club	Nederduitsch Hervormde Kerk Buffelspoort
Benoni High Athletic Club	NEI Athletic Club
Benoni Northerns Athletic Club	Nelspruit Marathon Club
Benoni Striders Athletic Club	Nerve Events & Durban Athletic Club
Berea Rovers Athletic Club	NESAC
Bergville Athletics Club	Nestle Employee Wellness
Berlin School	NET Athletics Club
Bert’s Bricks Athletic Club	New Balance Athletic Club
Bethal Marathon Club	New Balance Athletic Club - EP
Bethlehem Marathon Club	New Balance Athletic Club (CGA)
Bethulie Marathonklub	New Balance Athletics North
Bibi Cash & Carry Athletic Club	New Balance Guguletu Athletic Club
Bidvest Athletic Club (WP)	New Balance Multisport Club Eden
Biggarsberg Athletic Club	New Balance Pacesetters
Billy’s Runners	New Generation Athletics Club
Birchwood Athletic Club	Newcastle Harriers Club

Bishops Running Club	**Newlands Athletic Club**
BKS Road Runners (GN)	**Newlands Striders**
BKS Road Runners (WP)	**Newton Olympic Atletiekklub**
Black Mountain Athletic Club	**Ngodwana Marathon Club**
Blackmountain Harriers	**Ngodwana Valley Marathon Club**
Bloemfontein Enthusiasts	**Nguni Classic**
Bloemfontein Military Athletic Club	**NHK Hartebeeshoek**
Bloemfontein Striders	**Nigel Marley Athletic Club**
Bloemhof School	**Nissan and Due South**
Blouberg Athletic Club	**Nissan Road Runners**
Blue Downs Athletic Club	**Nkangala Athletic Academy**
Bluewater Bay Road Runners	**Nokia Algoa Athletics Club**
Bluff Athletic Club	**Nokia Algoa/Mr Price UPE Athletic Club**
BMW Road Running	**Nomads**
Body Concept Road Runners	**Nongoma Marathon Club**
Body Walk	**Noordelike Atliekklub**
Boesmanland Harriers Aggeneys	**Noordheuwel Atletiek Klub**
Boksburg Athletic Club	**Noord-Oos Athletic Club**
Boland Athletics	**North Eastern Cape Forests Athletic Club**
Boland Correctional Services	**North West**
Boland Masters	**North West Athletic Club**
Bonang Athletic Club	**North West Cape Athletics**
Bonnievale Athletic Club	**North West University Triathlon Club**
Bonnievale Drawwers	**Northam Marathon Club**
Bonteheuwel Athletic Club	**Northam Platinum Athletic Club**
Boo-Karoo Marathon Club	**Northam Platinum Mine Marathon Club**

Bopanang Athletic Club	**Northern Athletic Club**
Border Athletics	**Northern Harriers PE**
Border Masters Athletics Association	**NP Road Running**
Border Road Running Commission	**NPO AC**
Border Runners Against Gravity	**NSRI - Mossel Bay**
Border Surfer's Association	**Ntsikayethu Future Striders Club**
Born 2 Run Athletic Club	**Ntunjambili Athletic Club**
Born 2 Run Athletic Club (CG)	**Nyetse Athletic Club**
Born 2 Run Athletic Club (KZN)	**Nylstroom Marathonklub**
Born 2 Run Athletic Club (Western Cape)	**Nzhelele Athletics Club**
Born2Move	**O D Striders**
Bospoort Adventure Charity Trust	**Oasis Crescent Sporting Club**
Bothaville Marathonklub	**Observatory Running Club**
Botrivier Education Foundation/Elgin Grabouw AC	**Ofcolaco Harriers Athletics Club**
Botshabelo Road Runners	**Ofcolaco Marathon Club**
Bottelary Athletics Club	**Ogwini Comprehensive Athletic Club**
Brackenfell Athletic Club	**Okiep Athletic Club**
BRAG Club	**Old Edwardian Athletic Club**
Brakpan Athletic Club	**Old Mutual Athletic Club**
Bredasdorp Athletic Club	**Old Selbornian Road Runners**
Bridger North	**Old World Concretes AC**
Brits Athletic Club	**Olifantsrivier Athletic Club**
Bronkhorstspruit Athletics Club	**Olympia Athletic Club**
Bronkhorstspruit Marathonklub	**Ommiedraai Friends Athetic Club**
Brooklyn Primary School	**Onderberg Marathon Club**
Brooks Striders	**Onderwyskollege Pretoria**

Brotherhood Athletic Club	Oos-Transvaal Weermag Atletiekklub
Bruce Butler	Oos-Vrystaat Polisie Atletiekklub
Buffalo Road Runners	Open Box Running Club
Bundu Bashers MTB Club	ORAK/Matzikama Municipality
Burgersfort Marathon Club	Orange Farm Athletic Club
Butterworth Athletic Club	Orion Athletic Club
Buzz Bolton	Orlando Athletic Club
C.G.A. Masters Athletics	Osizweni Athletic Club
Cabstrut Raiders Athletic Club	OT Weermwag Atletiekklub (Mpl)
Cadac Athletic Club	Otter Estates
Cadbury Runners Club	Otwak/MP Weermag
CAP Fitness Centre A.C.	Oudtshoorn Amateur Athletic Club
Cape Multisport Club	Oudtshoorn Run/Walk for Life Athletic Club
Cape Town College of Education	Outhere Trails
Capricorn High School	Overkruin Athletics Club
Carbineers Athletic Club	Overtakers Sports Club
Carel du Toit Centre	Owabahle Athletics Club
Carleton Harriers	Oxford Striders
Carletonville Athletic Club	Paarl Athletic Club
Carlton Athletic Club (CGA)	Pacers Athletic Club
Carnival Runners	Palamine Athletics Club
Carousel Athletic Club	Panorama
Castle Light Athletics Club	Parkrun Delta
Caxton KHOSA Athletic Club	Parktown Girls High Running Club
Celtic Harriers Club	Parliament of RSA Athletic Club
Central Athletics Club	Parys High School

Central Building Athletic Club	Parys Rotary Club
Central Gauteng Athletics	Pat Cornick Road Runners
Centurion (Campus) College	PE High Schools
Centurion Atletiekklub	PE Primary Schools
Centurion Christian School	PE Technikon Atletiekklub
Centurion Runners' Association	Peace Winning Athletic Club
Centurion Runners Club (GN)	PEB Print/Adidas Athletic Club
Century City AC & West Coast AC	Peddie Athletic Club
Century City Athletic Club	Pegasus Athletic Club
Ceres Athletic Club	Pennypinchers AR Team
CGA/Brakpan Athletic Club	Pentagon Pistols
Chaeli Sports and Recreation Club	PetroSA Running Club
Chain Gang Events	Petzatakis Athletics Club
Chamber Running Club	Phalaborwa Road Runners
Champ Marketing	Pharasumaline Athletic Club
ChampionChip Africa	Philani Joggers
Champs Club	Phiri Athletics Club
Chappies Running Club	Phobians Athletic Club
Chappies Siyalana (WP)	Phobians/Alpha Centurion
CHAR	Phoenix Striders Athletic Club
Charlo Athletic Club	Phosphate Club
Chat-A-Long for Charity	Pick 'n Pay Athletic Club
Checkout Verulam Falcons AC	Pierre van Ryneveld Athletic Club
Cheetah Athletic Club	Pieter du Preez
Child Welfare Durban & District	Pietermaritzburg Athletic Club
Chiltern Athletic Club	Pietersburg Road Runners

CHOC Childhood Cancer Foundation

Christelle Louw

Christiana Maratonklub

City of Ekurhuleni AC and Soul City AC

City of Johannesburg Health and Social Development

City Striders Athletics Club

Clayton Bekker

Cliffe Dekker Hofmeyr

Club Fast Forward

Coaldust

Coasters Athletic Club

Coastline Athletic Club

Coega Development Athletic Club

Colin Mann Primary School

College Road Runners

Collegians' Harriers

Colman Foods Athletic Club

Combined Witbank Clubs

Computer Stars Athletic Club

Comrades Marathon Association

Connie’s Athletic Club

Constantia Kloof Primary School

Cool Running AC

Corobrik Athletic Club (CGA)

Corobrik Road Runners

Pilgrims Runners Club

Pinelands Athletic Club

Pinetown & Districts Athletic Club

PinkDrive

Pioneer Marathon Club

Pirates Marathon Club/I Can Foundation

Pirates Road Running

Plettenberg Bay Athletics Club

Pniel Congregational Church

POK Atletiekklub

Police Academy Athletic Club (POLAC)

Polokwane Athletic Club

Pongola Athletic Club

Port Elizabeth Amateur AC/Charlo AC

Portshepstone Development

Post Office Athletic Club

Potch Korrektiewe Dienste AK

Potchefstroom Defence Marathon Club

Potgietersrus Athletics Club

Potties Athletics Club

Power Athletic Club

Power Athletics CGA

Powerade Athletic Club

PPC Athletic Club (EP)

PPC Athletic Club WP

Prestasie Atletiekklub

Correctional Services – St. Albans	Prestige Academy - Bellville
Correctional Services (AGN)	Prestige Sports Club
Correctional Services (Bethal)	Pretoria Atletiekklub
Correctional Services (Boksburg)	Pretoria Health & Racquet Club
Correctional Services (Border)	Pretoria Joggers
Correctional Services (CGA)	Pretoria Marathon Club
Correctional Services (KZN)	Pretoria Military Marathon Club
Correctional Services (Limpopo)	Pretoria Police Marathon Club
Correctional Services (Mpl)	Prieska Atletiekklub
Correctional Services A.C WP	Prisma Comms Athletic Club
Correctional Services Brandvlei	Profile Public Relations Consultancy
Correctional Services Drankenstein	Promosa Brother and Sisterhood
Correctional Services Mosselbay	Protea Athletic Club
Cosmo Industrial	Protea Guineas Athletic Club
CPUT Athletic Club	Provincial Heritage Celebrations
Creighton Sports Club	PTM Gijimas (KZN)
Crescent Sporting Club	PUK Atletiekklub
Crocodile Harriers	PUK/McArthur
Cross Roads Athletic Club	Pulse Committee (Tuks)
Crown Consolidated Running Club	Pulse Point
Crown Striders	Pulsesport
Crusaders Athletic Club	Puna Athletic Club
CSIR Running Club	Pure Adventures
CVO Marmer Skool	PVM Atletiekklub
CX Athletic Club	Qalakahle Athletic Club
Dabulamanzi Canoe Club	Quantum Adventures

Daily Dispatch	Queens College
Dainfern Athletic Club	Queensburgh Harriers
Daisy Athletic Club	Queenstown Harriers
Dale College	Quirk Cape Town Running Club
Darling Athletics Club	Quite Cool Athletic Club (CGA)
Dash Athletic Club	Quite Cool Athletic Club (FS)
Dashing Diamonds AC	Qwa Qwa Champs
Dave’s Trail Running Club	RaceInterface
Daveyton Hearts Athletic Club	RAF Athletic Club
Daxina Striders	Raiders Athletic Club
DCS Bavianspoort	Rainbow Athletic Club (CGA)
DCS Pretoria	Rainbow Athletic Club (SWD)
De Aar WSK	Rainbow Chicken Farms Athletic Club -KZN
De Beers Athletic Club	Rainbow Road Runners (Machadodorp)
De Rust Striders	Rakwada Athletic Club
Debid Athletic Club	Rand Athletic Club
Deelkraal G M (Eagles)	Rand Road Warriors
Deetlefs Wine Estate	Rand Water Athletic Club (A.V.T.)
Defence (WP) Athletic Club	Rand Water Athletic Club (CGA)
Delareyville Road Runners	Rand Water Athletics Club
Delmas Athletic Club	Randburg Harriers
Delwers Marathon Club	Randfontein Estates Gold Mine AC
Denel Athletics Club	Randfontein Sports Academy
Deon Moller	Randmark Athletic Club
Department of Public Works	Randpark Golf Club
Department of Sports and Culture Cradock AC	Randpark Youth Runners

Dept of Transport & Traffic (Limpopo)	Ratanda - Heidelberg
Diabetes S.A.	Ratanda Eagles Athletic Club
Diamant Marathon Club	RAU Athletic Club
Diamond Dash	Ravensmead Athletic Club
Diamond Striders	Ravensmead Junior Athletic Club
Diepkloof Athletic Club	Rawsonville Athletic Club
Diepsloot Athletic Club	RBS Athletic Club
Diggers Athletic Club	RCS Gugulethu Athletic Club
Dikgalaopeng Athletic Club	Re-a-Kgona Atletiekklub
DIRCO	Real Gijimas
Dirt Trekkers	Real Hearts Athletic Club
Dirtopia	Real Lions Athletic Club
DLA	Re-a-leka Athletics Club
Dobsonville Athletic Club	RedHub Multisport
Dolphin Coast Striders	Redro Harriers
Dolphins Athletic Club (Border)	Reigerpark Athletic Club
Dome Athletics Club	Reitvallei Athletic Club
Donne van der Walt	REMMOGO ATHLETICS CLUB
Dorperland Atletiekklub	Rentmeester (CNW)
Dosco E.T.S. Gijimas	Rentmeester (KZN)
Douglas Athletic Club	Rentmeester Athletic Club - MPL
Dower College Athletic Club	Rentmeester Athletic Club CG
Drafstap Marathon Club	Rentmeester Lichtenburg
Dream Team Athletic Club	Rentmeester Tuks Athletic Club - (GN)
Drostdy Harriers	Rentmeester Tuks Marathon Club
Druggist Striders	Rentmeester/Reparil-Gel Running Club

Dryland Event Management	Resbank Athletic Club
DST SUMBANDILA AC	Resbank Marathon Club
Duduza Marley Athletic Club	Reservoir Hills Athletic Club
Duguza Athletic Club	RFL Athletic Club
Durban Athletic Club	RFLAC
Durban Collegians Athletic Club	RFLAC Rollers
Durban Deep Athletic Club	Rhodes University Athletics Club
Durban Defence Athletic Club	Riana Vorster
Durban Green Corridor	Richard Acheson
Durban Heroes Athletic Club	Richmond Athletic Club
Durban High School Old Boys AC	Ricoh Athletics club
Durban Ramblers Athletic Club	Ridgeway Independent School
Durbanville Athletic Club	Riebeek Valley Athletic Club
Dusty Sprocket Adventure Sport	Rietspruit Marathon Club
Duzi Athletic Club	Rise Athletic Club
DWA Tsutsumani Athletics Club	Riverside Trail
Dwaalboom Athletics Club	RMP Properties Athletic Club
Dwars River Valley Athletic Club	Roadmasters Athletic Club
Dynamic Athletic Club	Robertson Athletic Club
Dzanani Athletic Club	Robertson Children’s Home
E.L. Spoornet Athletics Club	Rocky Road Runners
Eagle Christian Church	Roodekrans Athletic Club
Eagle Running Club	Roodeport Athletic Club
East Driefontein Road Runners	Roodies Athletic Club
East Griqualand Striders	Rooibos Athletic Club
East London Athletic Club	Rooies Atletiek Klub

East London Pacers	Rooiwal Athletic Club
East Rand Kayak, Athletic Section	Roos Reaction Security Road Runners
Eastern Cape Academy of Sport	Rosslyn Main Industries Athletic Club
Eastern Cape Parks	Rotary Club - Ladybrand
Eastern Province Athletics	Rotary Clubs of Cycad Middelburg & Witbank
Easterns Kraaifontein Athletic Club (WP)	Rotek Road Runners
Ebenezer Athletic Club	Round Table - Kei
Ebony Athletic Club	Roy Sparg
Edendale Hawkes	RPM Marathon Club
Edenvale Rand Road Warriors	RPM Union Section
Edgemead Runners	RPM Union Section Marathon Club
Edgewood Athletic Club	RTB Grenswag
EDS Athletic Club	RTT Athletic Club
Education Athletics Club	Rubusana TTC
Eersterivier Athletic Club	Rumbo Marker Athletic Club
EG Kerk - Phalaborwa	Run 4 Life Marathon Club
Ekangala	Run for Christ Athletic Club
EL 23 Miles Athletic Club	Run for Fun Athletic Club
Elandskraal Athletic Club	Run To The Beat
Elgin Grabouw Athletic Club	Run Walk for Life WP
Elite Athletic Club	Run/Walk for Life - Nelspruit
Elsies River Athletic Club	Run/walk for Life - Soweto
Emfuleni Athletics Club	Run/walk for Life (CNW)
Emnambithi Striders	Run/Walk for Life Athletic Club (Bela-Bela)
Empangeni Athletic Club	Run/Walk for Life Athletic Club (GN)
Enduro Club	Run/Walk for Life Athletic Club (KZN)

Energy Events	Run/Walk for Life Athletic Club (Limpopo)
Engen Athletic Club - KZN	Run/Walk for Life Athletic Club(SWD)
Engen RAU Athletic Club	Run/Walk for Life Athletics Club (EP)
Ennerdale Road Runners	Run/walk for Life Club
Entabeni Nature Conservancy	Run/Walk for Life Phalaborwa
EP Coaches	Run/Walk For Life Polokwane
EP Command Marathon Club	Running Free Mpumalanga
EP Masters Athletics Association	Running Inn - Gauteng North
EP Primary Schools	Running Inn/Aerosud
EP Prisons Athletic Club	Running The Cape Event Company
EP Veterans Association	Runtheberg Trail Run
EPAU Track and Field	Rustenburg Athletic Club
EPAUCC	Rustenburg Marathon Club
Epilepsy Dullstroom	Rustenburg Masters Athletic Club
Erfenisdammyl en Osfees (Event Company)	Rustenburg Multi Sport Club
Ergo Athletic Club	Ryde Events
Erica Walker	S.A. Post Office A C (NWN)
Erik Schipper	S.A.N.D.F. - Far North
Erika Kotze	S.A.P. Lowveld Atletiekklub
Ermelo Marathon Club	SA Airways Athletic Club
Eselfontein Festival	SA Breweries Athletic Club
Eshowe Runners	SA National Blood Service (Border)
Eskom Athletic Club (WP)	SA National Blood Services (Kzn)
Eskom Athletic Club Free State	SA National Defence Athletic Club
Eskom Athletic Club Mpl	SA Police – Gauteng Athletic Club
Eskom Gijimas (Border)	SA Police AC (Pietermaritzburg)

Eskom Gijimas (CNW)	**SA Police Amateur Athletic Club (EP)**
Eskom Gijimas (G.W.)	**SA Police Athletic Club**
Eskom Gijimas (Limpopo)	**SA Police Athletic Club (Durban)**
Eskom Gijimas (NP)	**SA Police EP**
Eskom Gijimas (SWD)	**SA Police Marathonklub (FS)**
Eskom Gijimas KZN	**SA Police Northern Free State**
Eskom PTM Gijimas	**SA Police Southern Free State**
Eskom PTM Gijimas (CGA)	**SA Poskantoor Atletiekklub**
Eskom Ptm Gijimas (GN)	**SA Reserve Bank Marathon Club**
Esselen Park Athletic Club	**SA Sports School Foundation (SASSFO)**
Estcourt Athletic Club	**SA Vroue Leerkollege**
Estcourt Vultures Athletic Club	**SA Weermag (Suid-Kaap) Sportklub**
Etana Insurance	**Saasveld Atletiekklub**
Etawa Athletic Club	**SABC Running Club**
EUGEN MARAIS	**Sabie Shufflers**
Evander Gold Mines	**SABS Striders**
Event Active	**Sace Lions Athletic Club**
Extreme Marathons - NWC	**SACS Old Boys Running Club**
Extreme Marathons EP	**SAD Athletic Club**
Exxaro Marathon Club (AGN)	**Saints Athletic Club**
Ezakheni Athletic Club	**Sakhisizwe**
Fairmount Athletic Club	**Saldanha Athletic Club**
Falcon Athletics Club (AVT)	**Samancor Chrome Marathon Club**
Falcons Athletic Club (CGA)	**SAMCOR Athletic Club (EP)**
Faranani Athletic Club - (GN)	**Samcor Marathon Club (GN)**
Farnese Athletic Club	**SANDF (FS)**

Fat Cats	**SANDF Athletic Club - 15 SAI Battalion**
Femme de Femme	**SANDF Athletic Club - Free State**
Ferrometals Road Runners	**SANDF Athletic Club - Limpopo**
Fezela Athletic Club	**SANDF Athletic Club - Western Province**
Ficksburg Marathon Club	**SANDF Athletic Club Makhado**
Finlime Harriers	**SANDF Athletic Club Polokwane**
Fire Athletic Club	**Sani Athletic Club**
First National Runners (K.Z.N.)	**Sanlam Atletiekklub (GN)**
First Step Road & Track Walking Club	**Sanlam Road Running Club**
Fish Hoek A.C	**Santos Athletic Club**
Fit 2 Run Athletic Club	**SANW Athletic Club (CNW)**
Fit 2000 (KZN)	**SANW SWD Atletiekklub**
Fit 2000 (MPL)	**SAP Bloemfontein Club**
Fit 2000 (WP) A.C	**SAPD Northern Free State**
Fit 2000 Athletic Club (CGA)	**SAPD Suid- Kaap Marathon Klub**
Fit Pretoria	**SAPG Athletic Club**
Fitcal	**Sappi Sports Club Executive**
Fitness from Africa	**SAPS Limpopo**
Flames Athletic Club	**SAPS Mafikeng Molopo Athletic Club**
Flora Chatsworth Athletic Club	**SAPS South Cape AC**
Florida Hoerskool Athletic Club	**SAPS Striders**
Florida Lake Canoe Club	**SARS Athletic Club (SAC)**
Florida Running Club	**Sascol Athletics Club**
Flower of the Desert	**SASKO Aeroton Athletic Club**
FNB Runners (CGA)	**Sasol Athletics Club**
Fochville Marathon Club	**Sasol Marathon Club**

Folweni Athletics Club	**Sasol Sasolburg Athletic Club**
Fondwe Athletic Club	**SASS Athletic Club**
Forest Hills Athletic Club	**SASSU**
Foresters Running Club	**Satori Athletic Club**
Formula 1 Athletic Club	**Saulsville Atteridgeville Dev. Club**
Fort Hare University Athletic Club	**Savages Athletic Club**
Fort Schanskop Historical Runs Association (FSHWA)	**Save the Children SA**
FORTIS NOORD	**SBR Sport**
Foskor Athletics Club	**Scaw Harriers Athletic Club**
Four by Four Athletic Club	**Schweizer Athletic Club**
Four Fire Colour Crazy	**Schweizer-Reneke Marathonklub**
Fourways Road Runners	**Scottburgh Athletic Club**
Franco Sports Events	**Seaward Estate**
Frank Wright	**SECSAA**
Frans du Toit Hoerskool Athletic Club	**Secunda Athletic Club**
Fred Norman Athletic Club	**Secunda Marathon & Harmony Athletics**
Free Gold Athletics Club	**Secunda Marathon Club**
Free Spirit Adventures	**Security Bureau Road Running Club**
Freebody Sports	**Sedgefield Striders**
Friends of St Francis (FOSTER)	**Seef Athletic Club**
Friends of Zeekoevlei & Rondevlei (FoZR)	**Sekunjalo Athletic Club**
Frontiers Sport and Entertainment	**Selborne College**
FSB	**Senekal Road Runners**
Funky Fynbos Festival	**Sepedi Athletic Club**
Future Olympians Athletic Club	**Seritarita Athletic Club**
	Sernick Running Club

G + D Werke Athletics Club	Sesheng Atletiekklub
Galeshewe Athletics Club	SET Athletic Club
Gallopers Athletic Club	Setsing SuperSpar Athletic Club
Gamble Athletic Club	Shallcross Athletic Club
Gandhi Walk Committee	Sharks Athletic Club
Gansbaai Lions Club	Sheshego Athletic Club
Garden Route Trail Running Group	Shift Sport and Marketing
GATfees Race Committee, Zastron	Shongwe Athletic Club
Gauteng North Development	Shosholoza
Gauteng Sports Challenge	Siemens Atletiekklub
Gauteng Striders	Sisonke Athletic Club
Gauteng Vaulting Committee	Sisters with Blisters
Gavin Bazely	Siyaphambili Athletic Club
GBP Runners	Siyaphila Athletics Club
Geju Athletics Club	Siyaya Sports
Gengold Harriers	Siza Vitality
Genius Athletic Club	Sky
Germiston Callies Harriers	Slurry PPC Road Runners
Germiston Reef Road Runners	Social Striders Marathon Club
Giant Athletic Club	Sol Plaatjie Athletic Club
Giyani Gallopers Athletic Club	Solidarity
Glencoe Development	Somerset East Athletic Club
Glenwood Harriers	Somerset Striders A.C
Global Athletic Club & Great Run Association	Sondela Events
Goedehoop Atletiekklub	Sonja du Toit
Goedemoed Atletiekklub	Soshanguve Athletic Club

Goedemoed Marathon Club	Soul City Sports Club
Gold Fields Training Services	South African Air Force Association NHQ
Golden Eagles Athletic Club	South Coast Striders
Golden Leopard Athletic Club	South Peninsula AC
Golden Star Athletic Club	South Region Athletic Club
Goldfields Striders	Southee AC
Gonubie Harriers	Southern Free State Police Athletic Club
Goodie Educators Athletic Club	Southern Life Athletic Club
Goodwood Harriers Running Club	Southern Striders A.C
Goudveld Multisport	Southern Trails
Graaf-Reneit Running Club	Soutpansberg Athletic Club
Grasshoppers Outeniqua Harriers	Soweto Athletic Club
Gravel Travel	Soweto Cabal Athletic Club
Great East Athletic Club	Soweto Hearts Athletic Club
Great Run Africa (GRA)	Spar Gauteng Athletic Club
Greater Elim Athletic Club	Spar Gauteng North A.C.
Greenside Road Running	Spartan Athletic Club
Greenstone Hill Running Club	Spartan Athletics Club (KZN)
Grey College	Spartan Harriers
Greyton MTB Club	Spectrum Atletiekklub
Greytown Development	Spectrum Sport
Groenpunt Marathonklub	Speedquest Athletic Club
Groot Constantia	Spirit Wind Athletic Club
Grootvlei Korrektiewe Dienste MK	Spoornet (SWD) Athletic Club
Groove Athletic Club	Spoornet Athletic Club
Group 5 Striders	Spoornet Kimberley Athletics Club

Groutville Athletic Club	**Sport Science Institute**
Guestro Athletic Club	**Sport Union Univ of Durban Westv**
Gym Venezia Athletic Club	**Sport-Farm**
H.H. Robertson Athletic Club	**Sports Connection Striders**
HAA-KOTIE Athletic Club	**Sports4u**
Haenertsburg Rotary Club	**Sportsvendo**
Halfway Athletic Club	**Sportsvendo CGA**
Hamiltons Athletic Club	**SPRAC**
Hammanskraal Police Marathon Club	**Springbok Athletics Academy (NWC)**
Hams Tech	**Springfield Coll of Ed AC**
Hangklip Athletic Club	**Springs Amateur Athletic Club**
Hantam Athletic Club	**SS Wellness**
Harambe Athletic Club	**St Albans Athletic Club**
Harfield Harriers	**St Francis Sport**
Harford Sports Promotions	**St Peter's Race Committee**
Harlequin Harriers (GN)	**St Vincent School for the Deaf**
Harlequin Harriers (KZN)	**St. Luke's Hospice**
Harmony Athletic Club	**Stadsraad van Pretoria Maratonklub**
Harmony Athletic Club (AVT)	**Standard Bank Athletic Club**
Harmony Athletic Club (GN)	**Standerton Marathon Club**
Harmony Athletic Club (KZN)	**Stanford Lake College**
Harmony Athletic Club (WP)	**Stap Club**
Harmony Athletic Club Mpumalanga	**Star Motor Group running club**
Harmony Athletic Club PE	**Steadville Athletic Club**
Harmony Athletics Club (CNW)	**Steel Striders**
Harmony Striders Virginia	**Steelpoort Marathon Club**

Harrismith Marathon Club	Stella Amateur Atletiekklub
Hartbeespoort Marathon Club	Stella Athletic Club
Hartebeesfontein AAK	Stellenbosch Athletic Club
Hartenbos Drawwers	Sterling
Hazyview Sprinters	Stillwater Sports
Heidelberg Marathon Club	Stonebridge Athletic Club
Helderberg Harriers	Stragglers Athletic Club
Helderkruin Primary School	Strand Athletic Club
Henley Road Runners	Strathvaal Striders
Herbalife Sports Club	Striders Athletic Club
Hermanus Adventures	Students Athletics Association
Hervormde Kerk Marikana	Stutterheim Marathonklub
Hewat Athletic Club	Stutterheim Round Table 103
Highveld Steel Road Runners	Success Athletics Club
Highway Athletic Club	Summerstrand Surf Road Runners
Hillcrest Villagers Athletics Club	Sun City Striders
Hilton Harriers	Sundays River Athletic Club
Hiltonians Athletic Club	Sunlight Flora Athletics Club
Hi-Performance Midas Road Runners	Sunninghill Striders Running Club
Hluhluwe Athletic Club	Sunrise Christian Joggers
Hoedspruit Air Force Marathon Club	Sunrise Run Series Billy Harker
Hoedspruit Gevleuldes A C	Sunshine H M P Sports Club
Hoedspruit Hollers Atletiekklub	Sunward Athletics Club
Hoerskool Ben Viljoen	Super Cycling Running Club
Hoerskool Ben Vorster	Super Web Athletics Club
Hoerskool Hans Strijdom	SuperSport Health & Adventure Running

Hoerskool Merensky	Swartland and Wellington Athletic Club
Hoerskool Noordheuwel	Swartland Athletic Club
Hoerskool Nylstroom	Swartland Endurance Riding Club
Hoerskool Randburg Athletics Club	Swartruggens Road Runners
Hogsback CPF	SWD Endurance Union
Holcim AC	SWD Road Running
HoneyGuides	Swiss-Re Athletic Club
Hospice Wits Events Department	Sydenham Sports Club
Hotazel Athletics Club	Synerchi Organics
Hout Bay Harriers	Syngenta Komatipoort Athletic Club
Howick Athletic Club	Syngenta Kroonstad College
HS Roodepoort	Syngenta Kroonstad Collegians
HSFSA	Talaria Atletics Club
HSRC Running Club	Tanya Verhoef/Janine Strydom
Hulamin Athletic Club	Tasol Kroonstad Marathon Club
Hulett Aluminium Athletic Club (CGA)	Team Brooks Athletic Club (CGA)
Hulett Aluminium Athletic Club (KZN)	Team Oche Road Runners
Hulett-Hydro Extrusions Athletic Club	Team Running Free
Humansdorp Atletiekklub	Team Runningfree Athletic Club (GN)
Hyde Park High School	Team Vitality - Gauteng
Hyundai Joggers	Team Vitality - KZN
IDC	Technikon Natal Athletic Club
Ikageng Marathon Club	Technikon Pretoria Athletics Club
Ikhamva Athletics and Motherwell Athletic Club	Technikon SA Athletic Club (CGA)
Ikhwezi Athletic Club	Technikon VS Atletiekklub
Ilanga Athletic Club (MPL)	Telkom Athletic Club

Ilanga Trails	Telkom Athletic Club (Cape Town)
Illumin8 Events	Telkom Athletic Club (GN)
Imamba Athletic Club	Telkom Athletics Club (Vaal)
Immaculata Secondary School	Temba Sunrise Athletic Club
Impala Marathon Club	Tembisa Athletic Club
Impendle Athletic Club	Temple Israel
Impi Challenge	Thabazimbi Athletics Club
Impulelo Athletic Club	Thabazimbi Marathon Club
In Touch Sport and ASG Events	The 369 Communications
In Touch Walk / Run	The Best Me Running Club
Indumiso Athletic Club	The Buffalo Volunteer Rifles
Infantry School Military Sports Club	The Cows
Ingwe Marathon Club	The Giant Cup
Injabulo Athletics Club	The Goons
Inner City AC	The Leverage Corporation
iNsingizi Lodge	The MUTTERS
Intellectually Impaired	The Num-Num Trails
Invent	Thohoyandou Athletic Club
Ipelegeng Athletic Club	Thohoyandou Correctional Services
Irene Athletic Club	Thohoyandou D C S
Irene Primary School	Thokoza Athletic Club
Isigidi Print	Thokoza Rockets Athletic Club
Itumeleng Athletics Club	Thomas Mbiza Athletic Club
Ivory and Ebony runners	Thwala Athletic Club
Ixopo Athletic Club	Thwala Bolebedu Athletic Club
Izingolweni Development	Tiger Trails

J S Athletic Club	TIRFU Raiders Rugby Club
Jabulani Athletic Club	Titan Athletic Club (KZN)
Jabulani Pace Athletic Club	Titanic Aces Amateur Athletic Club
Jacaranda Athletic Club	Toekomsrus Athletic Club
Jackal Creek Gym	Togs Frontrunners
Jacky Grassman	Tongaat Panthers
Jaguars Athletic Club	Top Events
Jannas Atletiekklub	Top Events (CGA)
Jason du Toit	Top Events (KZN)
JCR Walking and Running Club	Top Events EPA
Jeppe Quondam Athletic Club	Top Form Athletic Club
Jeug Athletic Club	Total Athletic Club
Jive Big Walk Committee	Toti Athletic Club
JMPD	Touwsrivier Primary School
Joburg Dynamics AC	Toyota Athletic Club
Jock Trust (Lowveld Clubs)	Track & Field
Johannesburg Canoe Club	Trail Magazine
Johannesburg College of Education	Trail Running South Africa
Johannesburg Football Referee AC	Trail Series (CGA)
Johannesburg Harriers Athletic Club	Trail Series (GN)
Johannesburg Market Agents	Trail Series (KZN)
Johannesburg Syndrome Road Runners	Trail Series (WP)
Johannesburg Zoo	Transformation Development Committee
Jouberton Coca Cola Athletic Club	Transnet A C (GN)
Joy Athletic Club	Transnet AAC - Natal
Jozi X Training	Transnet AC - G.W.

Jules Athletic Club	**Transnet AC - Komatipoort**
Juluka Diggers Road Running Club	**Transnet AC - Kroonstad**
K.A.D.C.	**Transnet AC - N W C**
Kagiso Striders	**Transnet AC - NP**
Kakamas Marathonklub	**Transnet AC - SWD**
Karee Road Runners	**Transnet AC (CNW)**
Karoo Road Runners	**Transnet AC Bloemfontein**
Kasona	**Transnet Athletic Club (WP)**
KAT Leisure Group	**Transnet Rail Engineering Athletic Club**
KAT Leisure Group (EP)	**Transnet Rail Engineering Athletics Club (GW)**
Katlehong Athletic Club	**Transnet Rail Engineering Atletiek Bloemfontein**
Katlehong Athletic Development Committee	**Transnet Sport (MPL)**
Kearsney Striders	**Transwerk Athletic Club - GN**
Kelloggs Striders	**Transwerk Stonebridge Athletic Club**
Kellys Athletic Club	**Transwerkatletiek & Fietsry Klub Bloem**
Kempton Road Runners	**Transwerkatletiek Bloemfontein**
KENFAC SAC	**Traumeel NWU-PUK Athletic Club**
Kenhardt Dorperland Athletic Club	**Treble Group**
Kenton Road Runners	**Tribe**
Kentron Athletics Club	**Trichardt Marathonklub**
Kgatsheng Athletics Club	**Trinity Athletic Club**
Khara Hais Harriers	**Triple-M Metering**
Khayelitsha Athletic Club	**Trisport**
KHOSA Road Runners	**Trisport - Gauteng**
Khuma Athletic Club	**Troisport Sports Club**
Khuphukani Athletic Club	**Trojane Baan & Veld Atletiekklub**

Khutala Marathon Club

Kimberley Central Athletic Club

Kimberley Defence

Kimberley Harriers

Kimberley Military Marathon Club

Kimberley Newton/Pirates Athletics Clubs

Kimberley Pirates Marathon Club

Kimberley Road Runners

Kinetics Athletic Club

King’s School West Rand and Panarama Runners Club

Kingfisher Athletic Club

Kings Court School

Klein Letaba Athletic Club

Klerksdorp Marathon Club

Klerksdorp Pretsport Hardloop Klub

Klerksdorp Sport Council

Kloof Marathonklub

Knysna Marathon Club

Koepel Marathonklub

Kohler Unity Athletic Club

Komatipoort Athletics Club

Komga Amateur Road Runners

Komga Road Runners

Koornfontein Marathon Club

Kopano Athletic Club (CNW)

Tsakane Athletic Club

Tshakhuma Athletic Club

Tshakhuma Marathon Club

Tshiendeulu Athletic Club

Tshilidzini Athletics Club

Tshisaulu Athletics Club

Tshiya College of Education

Tshwane Athletic Club

Tshwane University of Technology Marathon Club

Tsitsikamma Athletic Club

Tsutsumani Athletics Club

Tuks Alumni Road Runners

Tuks Marathon Club

Tuks Sports

Tuks Waterberg Athletic Club

Tulbach Athletic Club

Tumela Athletic Club

Turn 2 10 Club

Turn 2 God

Turn 2 God/ Nico vd Westhuizen

Tusa Tusano NRC

TV Set-Piece S.A.

Twini Athletic Club

Two Oceans Marathon Association

TWR Athletic Club (Wits Tech)

Tygerberg Athletics Club (Road)

Korma Chameleons	Tygerberg NLK Athletics Club (Track and Field)
Korrektiewe Dienste Marathonklub - FS	Tygerpoort Marathonklub
Korrektiewe Dienste Stallions Atletiekkl	Tzaneen Marathon Club
Kosi Bay Athletic Club	Ubuhle Athletic Club
Kosmosdal Athletic Club (KAC)	Ubunye Athletic Club
Koster Marathon Club	Udumo Athletic Club
Kouga Multisport Club	Ugie Athletic Club
Kovsie Athletics	Uitenhage Athletic Club
Kowie Striders	Ukhozi Athletic Club
Kruger Park Marathon Club	Ultimate Events
Krugersdorp Athletic Club	Ultra Athletics Club
Krugersdorp Road Runners	Ulundi Athletics Club
Kruisfontein AC	Umbumbulu Coll AC
KTWK Atletiekklub	uMhlathuze Athletic Club
Kumba Marathon Club	uMlazi Athletic Club
Kumba Marathon Club (Limpopo)	UMqulusi Athletic Club
Kuruman Road Runners	Umtiza Runners
Kwamadlala Development	Umvoti Athletic Club
Kwa-Mashu Athletic Club	Umzinto Athletic Club
Kwandengezi Athletic Club	Unbranded Events
Kwanobuhle	Underberg Development
Kwa-Thema Arsenals	Unisa Marathonklub
Kwa-Thema Athletic Club	United Athletic Club
Kwa-Thema Striders	Universal Road Runners
Kwa-Thema Unified Athletic Club	University of Cape Town A.C
K-WAY VOB Running Club	University of Limpopo

Kwazikhali Trading and Entertainment	**University of Natal (Pmb) Athletics**
KwaZulu-Natal Athletics	**University of PE Athletic Club**
KwaZulu-Natal Department of Sport & Recreation	**University of Pretoria (Tuks)**
KZN Ezemvelo Honorary Officers	**University of Pretoria Veterinary Science Faculty**
KZN Military A C	**University of Stellenbosch Mr Price athletics Club**
KZN Trail Running	**University of the Free State Athletic Club**
Lady Grey	**University Of Western Cape ac**
Ladysmith Athletic Club	**UPE**
Laerskool Horison	**UPE Athletic Club and Youth for Christ**
Laerskool Worcester-Oos	**Upington Crusaders**
Laingsburg Atletiekklub	**Urban Fitness Outdoor Athletics Club**
Lake Eland Classic	**USSASA**
Lammergeyer Road Runners	**UVE Athletic Club**
Lamontville Athletic Club	**Vaal Athletic Club**
Langebaan Strandlopers	**Vaal Reefs Marathon Club**
Langeberg A.C. (Swellendam)	**Vaal Triangle Police Athletics Club**
Langeberg Athletic Club	**Vaal Triangle Premier Milling Athletics**
Langeberg Atletiekklub - Riversdal	**Vaalharts Athletic Club**
Lante Investment Holdings	**VaalTech Atletiekklub**
Larries Platina	**Valsrivier Athletic Club**
Le Club	**Vanderbijlpark Collegians A C**
Lebone II Athletic Club	**Varsity Kudus Athletic Club**
Lebowa Police Athletics Club	**Varsity Sports Athletic Club**
Legacy Athletics Club	**Vasbyt Endurance Walk Association of SA**
Legends Athletic Club	**Velocity Athletic Club**
Legends Golf & Safari Resort	**Venda Defence Marathon Club**

Legogote Villagers	**Venda Prisons Athletic Club**
Lekoa Athletics Club	**Venezia Athletic Club**
Lenasia Athletic Club	**Vertical Horison Adventure Sport**
Lesedi – Katlehong Athletic Club	**Verulam Athletic Club**
Lesedi Athletics Club	**Veterane Atletiekklub (SWD)**
Letaba Athletics Club	**Veterans Athletics (Natal)**
Letaba Road Runners	**Victoria Lake Athletic Club**
Letaba Rotary Club	**Victory Athletic Club**
Lethabong Athletic Club	**Virginia Athletics (KZN)**
Letsie Primary Athletic Club	**Virginia Striders**
Lewensentrum Athletic Club	**Vision Athletic Club**
Liberty Club (Mpl)	**Vision FET Athletic Club**
Liberty Health Rhodes Trail Run	**Vodacom Kimberley Road Runners**
Liberty Life Athletic Club (CGA)	**Vodacom Striders (CG)**
Liberty Life Athletic Club (GN)	**Vodacom Striders W.P**
Liberty Life Athletic Club (KZN)	**Volksrust Marathon Club**
Liberty Life Vaal Triangle Athletic Club	**Volkswagen Amateur Athletic Club**
Liberty Nike Athletic Club (CGA)	**Voltaren Tuks Sportburo**
Liberty Nike Athletic Club (CNW)	**Voltex Running Club**
Liberty Nike Athletic Club (GN)	**Volunteer Wildfire Services Jonkershoek**
Liberty Nike Athletic Club (KZN)	**Voorberg Athletic Club**
Liberty Nike Athletics Club - FS	**Voortrekker Monument Draf en Stap Klub**
Liberty Nike Beaufort West Athletic Club	**Vosloorus Puma Athletic Club**
Liberty Own Your Life A.C	**Vosloorus Striders Athletic Club**
Lichtenburg Marathon Club	**Vryberg Marathon Club**
LifeCare	**Vryheid Athletic Club**

Lima & Harmony Athletic Club	Vultures Athletic Club - KZN
Lima & Phalaborwa Road Runners	Vultures Athletic Club - VT
Limpopo Academy of Sport	Vutha
Limpopo Schools	WAGM Athletic Club
Lion of Africa Itheko S.A.C	Wagpos Athletics Club
Lion River Club	Walmer Athletic Club
Lisa de Speville	Wanderers Athletic Club
Living Free Athletic Club	Ward Events
Longtom Marathon Club	Warden Marathon Club
Longtom Steering Committee	Warmbad Laerskool
Loop-en-Val Motshwarateu Athletics	Warmbaths Bela-Bela Marathon Club
Lord Milner School	Warriors Running Club
Loskop Valley Cycling Club	Waterberg School Athletic Club
Loskop Valley Marathon Club	Waterfront Spar
Love Running	Wattville Athletic Club
Lowveld Canoe Club	Way2Wine
Lowveld Country Club	Weermag Potchefstroom AC
Luka High School	Wellington Athletic Club
Lukhona Running Club	WERAH Athletic Club
Lusa Community Chest	Wesselsbron Atletiekklub
Lwandle AC	West Coast Athletic Club
Lydenburg Marathonklub	West Coast Community HIV-AIDS Initiative
Lynford School	West Coast Defence Marathon Club
M L Sultan Athletic Club	West Gold Athletic Club
M.T. Bakery Athletic Club	Westeria Athletic Club
MABOPANE AC	Western Cape Land Service

Mabopane Athletic Club	Western Cape Sport School
Macassar Athletic Club	Western Platinum Mines Athletic Club
Madadeni Athletic Club	Western Province Athletics
Madiba Bay Athletic Club	Western Province Cricket Club
Madibeng Athletic Club	Western Striders
Madkwe Mambas Athletic Club	Westville Athletic Club
Mafika Athletic Club	Whalers Athletic Club
Mafikeng Road Runners	White City Athletic Club
Mafikeng RR-Tusk Resorts-Mafikeng Lions	Wild Runner Athletic Club
Mafube Sport Management	Wild Series
Magalies Atletiekklub	Wild Trail SA
Magaliesberg Country Classic Festival	Wild Trail SA (NWN)
Magana Athletic Club	Wildebeest Run
Magnetic South Events	WildJoburg Trail Run
Magnolia Road Runners	Wildseries (FS)
Makadima	Wilge Marathonklub
Makoya AC	Willard Batteries Athletic Club
Makro Athletic Club (CGA)	Willie Mtolo Athletic Club
Malabar Athletics Club	Winberg Athletic Club
Malcolm X Athletic Club	Wingate Road Runners
Maluti-A-Phofung Water Athletic Club	Wings Athletic Club
Mamba Athletic Club	Witbank Marathon Club
Mamelodi AC & Global AC	Wits Alumni Relations/Wits AC and Varsity Kudus
Mamelodi Athletic Club	Wits Athletic Club
Mamre Athletic Club	WMW Athletic Club
Mandene Park Club	Wonderboom AC

Mandeville Fit 2000	Wonderpark AC
Mangosuthu Tech	Woodview Athletic Club
Manguang Development Athletics Club	Worcester Athletic Club
Mankwe Athletic Club	Worcester Athletic Club & Vryburgers of De Doorns
Manoni AC	Worcester Athletics/Hex Vallei Athletics
Maphumulo Development	WRSquared Multisport
Marais Viljoen Athletics Club	X - Treme
Maranatha Athletics Club	X-Cel Athletics Club
Marico Bosveld Myl Committee	XDIRT Events
Maritimo Marathon Club	Yebo Striders (WP)
Maritzburg Striders	Yellowwood Park Athletic Club
Marken Boerevereniging Athletic Club	York Sabie Running Club
Marks Sports Therapy AC	YSKOR Pretoria Atletiekklub
Mascot Active Running Club	Zamdela Athletic Club
Masedi Sport, Arts and Culture Development	Zamimpilo Athletic Club
Masters	Zastron A.C.
Mates Mountain & Trail Enthusiasts	Zebediela Athletic Club
Mathule Athletic Club	Zebediela Progressive Athletic Club
Maties Stellenbosch Athletic Club	Zeerust Marathon Klub
Matla Marathon Club	Zoetendal Academy
Matule Athletic Club	Zombie Run SA
Maungani Athletics Club	Zondereinde Athletic Club
Maverickmadness	Zonkizizwe Athletic Club
Max Cluer Sports Marketing	Zsports Events NPC
Maxed Elite Athletics	Zululand Multisport Club
Maxi Atletiekklub	

Mazda Athletic Club (GN)	**Zululand Triathlon Club**
MB Promark & Events	**Zwakala Athletic Club**
McArthur Marathonklub	**Zwartberg Runners**
Mdantsane Athletic Club	

Of the 1811 running clubs, 57 were excluded due to lack of contact details.

Appendix B - Recruitment

Figure 48. Recruitment advertisement

Appendix C – Letter of information to participant

RHODES UNIVERSITY
Where leaders learn

Master of Science study: Running related injury risk factors in South African long-distance runners

Dear participant

Thank you for your interest in my study, your participation is highly appreciated. In this letter, you will find a brief overview of the background to this study and the procedures that you will be following. The requirements of this study involve completing a questionnaire. Please read through everything thoroughly and ensure that you understand what is to be expected of you. If you are unsure of anything or have any further questions regarding this study and your participation in it, please feel free to contact me (Chloë Jäger) at runningstudysa@gmail.com.

OVERVIEW

Long-distance runners are susceptible to running related injuries which often interfere with their training and performance. Although we know that certain factors contribute to the risk of developing a running related injury, we are unsure of how these factors affect the South African population of long-distance runners. Additionally, the interaction between specific intrinsic (non-modifiable) and extrinsic (modifiable) factors, for example age and running experience, and running injury risk, is unknown. Therefore the purpose of this study is to find out what effect the combination of these factors has on injury risks, as well as to broaden the knowledge relating to the South African population of long-distance runners specifically.

In order to participate in this study, you must be currently participating in long-distance running and have been running a minimum of 20 km per week for at least 3 months unless you are currently injured. If this is the case, you can still participate in the study as long as you were running for at least 3 months prior to your injury. If you are currently injured, you can only participate in the study if you have not been out of training for longer than 6 months. You must be a South African citizen to participate in this study as we are specifically investigating South African runners. Additionally, you must be of 18 years of age or older.

PROCEDURES

The questionnaire is web based and can be found by clicking on this link: http://goo.gl/forms/iWHDwRC8Xd. The questionnaire will take approximately 15 minutes to complete. Please attempt to complete the questionnaire in one sitting, however if this is not possible, your progress will be saved and you may complete the questionnaire at a later stage provided you have a Google account.

When answering the questionnaire, ensure that you have read and understood each question properly. If you do not understand what the question is asking, please contact me at runningstudysa@gmail.com. Do not leave any answers blank unless otherwise indicated. Please think clearly before answering a question and answer honestly. Your honesty is important as each answer will influence the outcomes of the current study. Your personal information will remain completely anonymous and will be used only for research purposes. Your participation in this questionnaire will assist in determining the relationships between extrinsic and intrinsic factors in long-distance runners, thus adding to the knowledge of running-related injuries. This knowledge may help to reduce injury rates in the South African population of long-distance runners and may additionally help to inform future research. You are under no obligation to fill in or complete this questionnaire however your participation would be highly appreciated.

RISKS AND BENEFITS

The risks associated with this study are minimal and include the possibility of being offended by a question, however this is highly unlikely. If you do not feel comfortable answering a question remember that you are not in any way obliged to complete the questionnaire.

Contributing to this study by completing a questionnaire will help to enrich the knowledge relating to the factors that increase injury risk. This information may inform future studies and help to decrease the incidence of running related injuries in South African long-distance runners. On a personal level, this study may prove to be beneficial to your own understanding of running injuries and could help you to avoid or at least reduce the likelihood of future injuries. In addition to these benefits, once the study has been completed, each running club will receive feedback regarding the findings of the study which will hopefully be valuable in terms of your own running training and experience.

All data collected will remain anonymous and will be used strictly for statistical analyses. Thank you again for taking the time to participate in this study. If you have any enquiries, please feel free to contact me or my supervisor, Andrew Todd, on the details below.

Yours sincerely,

Chloë Jäger

(Human Kinetics and Ergonomics Master of Science student)

runningstudysa@gmail.com

072 130 5282

Supervisor: Andrew Todd (a.todd@ru.ac.za)

Appendix D – Letter of Consent

RHODES UNIVERSITY
Where leaders learn

PARTICIPANT CONSENT FORM

I, ____, have been fully informed of the current study titled:

Running related injury risk factors in South African long-distance runners

I have read and understood all the information provided regarding the procedures of the experiment, as well as the risks and benefits associated with the study. I am aware of what is expected of me, as a participant, throughout the duration of the experiment. I give my permission to the investigator to use my answers to the questionnaire for data collection purposes. I understand that all my information shall be kept anonymous. I give my permission for my data to be kept for three years in Microsoft Excel documents to potentially be used confidentially for future scientific research.

In agreement to participate in this research project, I agree to waive any legal recourse against the researchers of Rhodes University. I agree to immediately report anything of uncomfortable or offensive nature to the investigator, should this occur at any stage throughout the duration of the experiment. I am fully aware that I may withdraw from the study at any point.

I have read and understood the above information and the accompanying letter.

I therefore consent to voluntarily participate in the current study.

Participant:

(Name) (Signature) (Date)

Researcher:

Chloë Jäger Jäger 1 July 2015

(Name) (Signature) (Date)

Appendix E – Email sent to running clubs

To whom it may concern

My name is Chloë Jäger and I am currently completing my Masters in Human Kinetics and Ergonomics at Rhodes University in Grahamstown, Eastern Cape. My thesis is titled, "Running related injury risk factors in South African long-distance runners". For more information on my study, I've attached a "Letter of information". In order to investigate the possible injury risk factors of running, I am conducting a questionnaire. For the questionnaire to be valid, I am in need of a minimum of 200 participants who fit the following criteria:

- South African citizens of 18 years or older
- Running a minimum of 20 kilometres per week for at least the last 3 months
- Both non-injured and injured runners will be included, as long as the injured runners were running for at least 3 months prior to the injury
- Injured runners must not be out of training for longer than 6 months

Please could you forward this email to all of the members of your running club and if they are interested in participating in my study, have them read the attached letter of information and follow this link to complete the questionnaire: http://goo.gl/forms/iWHDwRC8Xd. The questionnaire is internet based and should only take approximately 15 minutes to complete. Thank you in advance for your help!

Regards,

Chloë Jäger

Appendix F – Questionnaire

Questionnaire: Running related injury risk factors in South African long-distance runners

Please ensure that you have read all the information below before completing this questionnaire. Please read each question clearly and answer honestly. You may leave questions blank if they do not apply to you.

Master of Science study: Running related injury risk factors in South African long-distance runners

Thank you for your interest in my study, your participation is highly appreciated. Below, you will find a brief overview of the background to this study and the procedures that you will be following. The requirements of this study involve completing a questionnaire. Please read through everything thoroughly and ensure that you understand what is to be expected of you. If you are unsure of anything or have any further questions regarding this study and your participation in it, please feel free to contact the investigator, Chloë Jäger, at runningstudysa@gmail.com.

OVERVIEW

Long-distance runners are susceptible to running related injuries which often interfere with their training and performance. Although we know that certain factors contribute to the risk of developing a running related injury, we are unsure of how these factors affect the South African population of long-distance runners. Additionally, the interaction between specific intrinsic (nonmodifiable) and extrinsic (modifiable) factors, for example age and running experience, and running injury risk, is unknown. Therefore the purpose of this study is to find out what effect the combination of these factors has on injury risks, as well as to broaden the knowledge relating to the South African population of long-distance runners specifically.

In order to participate in this study, you must be:

· South African citizens of 18 years or older

· Running a minimum of 20 kilometres per week for at least the last 3 months

· Both noninjured and injured runners will be included, as long as the injured runners were running for at least 3 months prior to the injury

· Injured runners must not be out of training for longer than 6 months

PROCEDURES

Upon your consent to participate in this study, you may start the questionnaire below. The questionnaire will take approximately 15 minutes to complete. Please attempt to complete the questionnaire in one sitting, however if this is not possible, your progress will be saved and you may complete the questionnaire at a later stage provided you have a Google account.

When answering the questionnaire, ensure that you have read and understood each question properly. If you do not understand what the question is asking, please contact me at runningstudysa@gmail.com. Do not leave any answers blank unless otherwise indicated. Please think clearly before answering a question and answer honestly. Your honesty is important as each answer will influence the outcomes of the current study. Your personal information will remain completely anonymous and will be used only for research purposes. Your participation in this questionnaire will assist in determining the relationships between extrinsic and intrinsic factors in long-distance runners, thus adding to the knowledge of running related injuries. This knowledge may help to reduce injury rates in the South African population of long-distance runners and may additionally help to inform future research. You are under no obligation to fill in or complete this questionnaire however your participation would be highly appreciated.

RISKS AND BENEFITS

The risks associated with this study are minimal and include the possibility of being offended by a question, however this is highly unlikely. If you do not feel comfortable answering a question remember that you are not in any way obliged to complete the questionnaire.

Contributing to this study by completing a questionnaire will help to enrich the knowledge relating to the factors that increase injury risk. This information may inform future studies and help to decrease the incidence of running related injuries in South African long-distance runners. On a personal level, this study may prove to be beneficial to your own understanding of running injuries and could help you to avoid or at least reduce the likelihood of future injuries. In addition to these benefits, once the study has been completed, each running club will receive feedback regarding the findings of the study which will hopefully be valuable in terms of your own running training and experience.

All data collected will remain anonymous and will be used strictly for statistical analyses. Thank you again for taking the time to participate in this study. If you have any enquiries, please feel free to contact me or my supervisor, Andrew Todd, on the details below.

Yours sincerely,

Chloë Jäger

(Human Kinetics and Ergonomics Master of Science student)

runningstudysa@gmail.com

072 130 5282

Supervisor: Andrew Todd (a.todd@ru.ac.za)

* Required

1. Participant consent *

I have been fully informed of the current study titled: Running related injury risk factors in South African long-distance runners. I have read and understood all the information provided regarding the procedures of the experiment, as well as the risks and benefits associated with the study. I am aware of what is expected of me, as a participant, throughout the duration of the experiment. I give my permission to the investigator to use my answers to the questionnaire for data collection purposes. I understand that all my information shall be kept anonymous. I give my permission for my data to be kept for three years in Microsoft Excel documents to potentially be used confidentially for future scientific research. In agreement to participate in this research project, I agree to waive any legal recourse against the researchers of Rhodes University. I agree to immediately report anything of uncomfortable or offensive nature to the investigator, should this occur at any stage throughout the duration of the experiment. I am fully aware that I may withdraw from the study at any point. I have read and understood the above information and the information provided regarding the study. I therefore consent to voluntarily participate in the current study.

Mark only one.

Agree

Do not agree

Intrinsic Factors

2. Name and surname

3. Email address

4. Current province *

Which province in South Africa are you currently living in?

Mark only one.

Eastern Cape

Free State

Gauteng

KwaZulu Natal

Limpopo

Mpumalanga

Northern Cape

North West Province

Western Cape

5. Running club

Which running club are you a part of?

6. Date of birth *

Example: December 15, 2012

7. Sex *

Mark only one.

Male

Female

8. Race *

It is known that various races have different body compositions and therefore may be susceptible to different types of injury. For this reason, it is important to know the race of each participant.

Mark only one.

Black African

Caucasian (White)

Coloured

East Asian

Indian

Other:

9. Race of mother *

Please indicate the race of your mother if known. The details of your parents' race, language and country of origin are important as they help to confirm the details of your own origin.

Mark only one.

Black African

Caucasian (White)

Coloured

East Asian

Indian

Unknown

Other:

10. Race of father *

Please indicate the race of your father if known

Mark only one.

Black African

Caucasian (White)

Coloured

East Asian

Indian

Unknown

Other:

11. Country of origin - Mother *

Which country does your mother originate from? If unknown, please specify

12. Country of origin - Father *

Which country does your father originate from? If unknown, please specify

13. Home language *

It is important to know the home language of the participant, as this further confirms the genetic origin or each runner

Mark only one.

Afrikaans

English

Ndebele

Northern Sotho/Sepedi

Southern Sotho/Sesotho

Swati

Tsonga

Tswana

Venda

Xhosa

Zulu

Other:

14. Home language - Mother *

Please indicate the home language of your mother if known

Mark only one.

Afrikaans

English

Ndebele

Northern Sotho/Sepedi

Southern Sotho/Sesotho

Swati

Tsonga

Tswana

Venda

Xhosa

Zulu

Unknown

Other:

15. Home language - Father *

Please indicate the home language of your father if known

Mark only one.

Afrikaans

English

Ndebele

Northern Sotho/Sepedi

Southern Sotho/Sesotho

Swati

Tsonga

Tswana

Venda

Xhosa

Zulu

Unknown

Other:

16. Stature (Height) *

Please indicate your height in centimetres (cm)

17. Mass (Weight) *

Please indicate your weight in kilograms (kg)

Socioeconomic Factors

This section is important as it gives us an idea of your living conditions which has been shown to have an impact of the likelihood of developing an injury.

18. Socioeconomic background - Monthly income

Please indicate which monthly income bracket your household falls under.

Mark only one.

Less than R 1 000

R 1 000 – R 5 000

R 5 000 – R 10 000

R 10 000 – R 15 000

R 15 000 – R 30 000

More than R 30 000

Training Factors

19. Training characteristics - Training frequency per week. *

How often do you run every week?

Mark only one.

Once (1)

Twice (2)

Three times (3)

Four times (4)

Five times (5)

Six times (6)

Seven times (7) (everyday)

More than 7 times per week. Please specify below, under "Other"

Other:

20. Training characteristics - Training distance per week. *

On average, how far do you run every week? Remember, you must run a minimum of 20 km to be included in this study.

Mark only one.

20 – 30 km

30 – 40 km

40 – 50 km

50 – 60 km

More than 60 km

21. Training characteristics - Training duration per week. *

How many hours per week, approximately, do you spend running?

Mark only one.

Less than 1 hour

1 hour

2 hours

3 hours

4 hours

5 hours

6 hours

7 hours

8 hours

9 hours

10 hours

More than 10 hours

22. Training characteristics - Number of training months per year *

Approximately, how many months per year do you run regularly? The months do NOT have to be consecutive (following each other).

23. Training characteristics - Training type *

What type of terrain (ground) do you train on?

Check all that apply.

Road/Tar/Asphalt

Cross country/Trail

Treadmill

Track/Tartan

Grass

Cement

Other:

24. Training characteristics: Training type *

Please indicate the approximate time spent training per week on each type of terrain

(ground) in the box below. E.g. Road: 2 hours; Grass: 1 hour; Treadmill: 20 min

25. Training characteristics *

Have you recently (in the past year) changed anything about your training?

Mark only one.

Yes

No *Skip to question 27.*

26. Training characteristics

Please specify what you have changed about your training characteristics in the past year, if you have changed them at all. Skip question if this does not apply to you. E.g. Increased duration from 20 minute runs to 1 hour runs and started running on the road as opposed to just the treadmill.

27. Training characteristics *

Are you currently training for a long-distance race?

Mark only one.

Yes

No

Running Experience

28. Running experience *

How long have you been participating in long-distance running for?

Mark only one.

Less than a year

1 – 5 years

5 – 15 years

More than 15 years

29. Running experience *

What is your preferred race distance?

Check all that apply.

Less than 10 km

10 km – 21 km

Half marathon (21 km)

Marathon (42 km)

Ultramarathon (More than 42 km)

Other:

30. Running experience *

How many races of approximately 21 km have you competed in, in the past 12 months?

Mark only one.

0

1

2

3

4

5

More than 5

31. Running experience *

How many races of approximately 42 km have you competed in, in the past 12 months?

Mark only one.

0

1

2

3

4

5

More than 5

32. Running experience *

How many races of approximately 80 km or more, have you competed in, in the past 12 months?

Mark only one.

0

1

2

3

4

5

More than 5

33. Running experience *

At what level do you participate at in long-distance races (10 km or more)? What is your current seeding for most of races that you run?

Mark only one.

Social runner only

No seeding

A

B

C

CC

D

E

F

G

H

Other:

34. Running experience *

Are you a sponsored or professional athlete?

Mark only one.

Yes

No

Footwear

35. Footwear - Type*

What type of footwear do you predominantly run with? If "Other", please specify brand.

Click on the links provided next to each answer option to see the indicated footwear.

Mark only one.

Normal running shoes which are closed shoes with a tapered heel, rigid sole and cushioned support. (Click link to see image https://blownrubbersole.files.wordpress.com/2013/08/mizunowaverider16350x263.jpg)

Trail running shoes. (Click link to see image http://fashionbazinga.com/wpcontent/uploads/2014/07/salomonspeedcrosscsgreenyellowtrailruningshoes14053032094k8gn.jpg)

Socks (without shoes)

Racing flats close shoe with a flat sole. (Click link to see image http://cdn.runblogger.com/images/2013/03/mizunowaveekidenracingflatreviewbycoachcaleb4.jpg)

Minimalist shoes Vibram FiveFingers. (Click link to see image http://topclassactionscom.c.presscdn.com/wpcontent/uploads/2012/04/vibram%20fivefingers.jpg)

Minimalist shoes Earth Runners. (Click link to see image http://www.intuitionphysician.com/wpcontent/uploads/2013/06/Ultralight2.jpeg.gif)

Barefoot

Other:

36. Footwear - Type*

How long have you been training in this predominant footwear type (normal running shoes, trail running shoes, socks, racing flats, Vibram FiveFingers, Earth runners or barefoot) that you are currently using?

Mark only one.

Less than one month

1 – 6 months

6 months – 1 year

More than 1 year but not since I started running

Since I started running

37. Footwear - Type*

How many different types of the above mentioned footwear (normal running shoes, racing flats, etc.) do you run with? NOTE: This question is NOT addressing the number of different brands of one type of footwear you run with, but rather whether you run with more than one type of completely different footwear (eg. trail running shoes as well as normal running shoes).

Mark only one.

1

2

3

4

5

More than 5

Other:

38. Footwear - Type*

Have you recently (in the past 12 months) changed or added to your running footwear type?

Mark only one.

Yes

No *Skip to question 41.*

39. Footwear - Type

Which footwear type did you change to or add to your running footwear type?

Check all that apply.

Normal running shoes

Trail running shoes

Socks (without shoes)

Racing flats

Vibram FiveFingers

Earth Runners

Barefoot running

Other:

40. Footwear - Type

Why did you change footwear types or add to your footwear?

Check all that apply.

To reduce chances of injury

To improve performance

Curiosity

Other:

41. Footwear - Total number of footwear items *

How many pairs of running footwear do you alternate between? E.g. 2 pairs of trail running shoes and 1 pair of racing flats therefore you alternate between 3 pairs of shoes. NOTE: Barefoot counts as 1 pair.

Mark only one.

1 pair

2 pairs

3 pairs

4 pairs

5 pairs

More than 5 pairs

42. Footwear – Remedial considerations *

Do you use inserts or orthotics when running?

Mark only one.

Yes

No *Skip to question 45.*

43. Footwear – Remedial considerations

For what reasons do you use inserts or orthotics?

44. Footwear – Remedial considerations

How long have you been using inserts or orthotics for?

Cross Training

45. Cross training *

Do you play other sports or do other exercise (other than long-distance running) every week?

Mark only one.

Yes

No *Skip to question 49.*

46. Cross training

If you do any other exercise or sports, how many different types of these sports and exercises, EXCLUDING running, do you participate in every week?

Mark only one.

1

2

3

4

5

6

7

More than 7

47. Cross training

If you do participate in other sports and exercises, please check all the boxes of the other sports or activities that you participate in.

Check all that apply.

Aerobics

Athletics

Badminton

Basketball

Canoeing

Climbing

Cricket

Crossfit

Cycling

Dancing

Field hockey

Gymnastics

Horse riding

Martial arts

Netball

Pilates

Resistance training (Lifting weights)

Rowing

Rugby

Soccer

Squash

Surfing

Swimming

Tennis

Yoga

Other:

48. Cross training

If applicable, please indicate the duration of time spent each week on other sports and exercise (EXCLUDING running).

Mark only one.

1 hour

2 hours

3 hours

4 hours

5 hours

6 hours

7 hours

8 hours

9 hours

10 hours

More than 10 hours

Running Related Injuries and Pain

49. Current running related injury and pain *

Are you currently suffering from a running injury or pain associated with running?

Mark only one.

Yes

No

50. Previous running related injury and pain *

How many running related injuries or pain (including any current ones) have you had in the past 12 months?

Mark only one.

0 *Skip to question 90.*

1

2

3

4

5

6

7

8

9

10

More than 10

Running Related Injuries and Pain

All questions in this section are related to injuries and pain that have been caused by running.

51. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months. If you have had running related pain or injury in the past 12 months, please indicate the anatomical location. The injury must be a result of running.

Mark only one.

Shoulder

Upper arm

Lower arm

Wrist

Hand

Hip or groin

Buttock

Upper thigh behind

Upper thigh in

front

Knee

Calf

Shin

Ankle

Foot

Pelvis

Back

Head

Neck

Torso

Other:

52. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the nature of the running related injury or pain. Leave this question out if you have not been injured as a result of running in the past 12 months.

Check all that apply.

Sharp pain

Aching

Stiffness

Looseness, subluxation or dislocation

Tingling

Burning

Numbness

Swelling

Other:

53. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did this running related injury/pain occur gradually (overuse) or immediately (acute)? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Gradually (overuse)

Immediately (acute)

54. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Duration of the running related injury/pain. Approximately how long did it take you to recover from the running related injury/pain? If the injury or pain is current, indicate the estimated time of recovery. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

1 day – 3 days

4 – 7 days

1 – 2 weeks

2 – 4 weeks

1 – 3 months

3 – 6 months

More than 6 months

55. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you fully recover from this injury before you started running again? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

Still recovering

56. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Was/is this running related injury/pain recurrent? (Has this same injury happened before?)

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

57. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

If this running related injury/pain has been diagnosed by a professional, what was the diagnosis? E.g. Achilles tendinopathy, patellofemoral pain syndrome, tibial stress syndrome, etc. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

58. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you undergo surgery for this running related injury/pain? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No *Skip to question 60.*

59. 1st most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please elaborate on this surgery.

60. Have you had a second running related injury or pain in the past 12 months?

Mark only one.

Yes

No *Skip to question 90.*

61. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the anatomical location of the running related injury. The injury must be a result of running. Leave this question out if you have not been injured as a result of running in the past 12 months.

Mark only one.

Shoulder

Upper arm

Lower arm

Wrist

Hand

Hip or groin

Buttock

Upper thigh behind

Upper thigh in

front

Knee

Calf

Shin

Ankle

Foot

Pelvis

Back

Head

Neck

Torso

Other:

62. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the nature of the running related injury or pain. Leave this question out if you have not been injured as a result of running in the past 12 months.

Check all that apply.

Sharp pain

Aching

Stiffness

Looseness, subluxation or dislocation

Tingling

Burning

Numbness

Swelling

Other:

63. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did this running related injury/pain occur gradually (overuse) or immediately (acute)?

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Gradually (overuse)

Immediately (acute)

64. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Duration of the running related injury/pain. Approximately how long did it take you to recover from the running related injury/pain? If the injury or pain is current, indicate the estimated time of recovery. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

1 day – 3 days

4 – 7 days

1 – 2 weeks

2 – 4 weeks

1 – 3 months

3 – 6 months

More than 6 months

65. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you fully recover from this injury before you started running again?

Mark only one.

Yes

No

Still recovering

66. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Was/is this running related injury/pain recurrent? (Has this same injury happened before?)

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

67. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

If this running related injury/pain has been diagnosed by a professional, what was the diagnosis? E.g. Achilles tendinopathy, patellofemoral pain syndrome, tibial stress syndrome, etc. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

68. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you undergo surgery for this running related injury/pain? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No *Skip to question 70.*

69. 2nd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please elaborate on this surgery.

70. Have you had a third running related injury or pain in the past 12 months?

Mark only one.

Yes

No *Skip to question 90.*

71. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the anatomical location of the running related injury. The injury must be a result of running. Leave this question out if you have not been injured as a result of running in the past 12 months.

Mark only one.

Shoulder

Upper arm

Lower arm

Wrist

Hand

Hip or groin

Buttock

Upper thigh behind

Upper thigh in

front

Knee

Calf

Shin

Ankle

Foot

Pelvis

Back

Head

Neck

Torso

Other:

72. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the nature of the running related injury or pain. Leave this question out if you have not been injured as a result of running in the past 12 months.

Check all that apply.

Sharp pain

Aching

Stiffness

Looseness, subluxation or dislocation

Tingling

Burning

Numbness

Swelling

Other:

73. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did this running related injury/pain occur gradually (overuse) or immediately (acute)?

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Gradually (overuse)

Immediately (acute)

74. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Duration of the running related injury/pain. Approximately how long did it take you to recover from the running related injury/pain? If the injury or pain is current, indicate the estimated time of recovery. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

1 day – 3 days

4 – 7 days

1 – 2 weeks

2 – 4 weeks

1 – 3 months

3 – 6 months

More than 6 months

75. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you fully recover from this injury before you started running again? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

Still recovering

76. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Was/is this running related injury/pain recurrent? (Has this same injury happened before?)

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

77. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

If this running related injury/pain has been diagnosed by a professional, what was the diagnosis? E.g. Achilles tendinopathy, patellofemoral pain syndrome, tibial stress syndrome, etc. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

78. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you undergo surgery for this running related injury/pain? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No *Skip to question 80.*

79. 3rd most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain:

Please elaborate on this surgery.

80. Have you had a fourth running related injury or pain in the past 12 months?

Mark only one.

Yes

No *Skip to question 90.*

81. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the anatomical location of the running related injury. The injury must be a result of running. Leave this question out if you have not been injured as a result of running in the past 12 months.

Mark only one.

Shoulder

Upper arm

Lower arm

Wrist

Hand

Hip or groin

Buttock

Upper thigh behind

Upper thigh in front

Knee

Calf

Shin

Ankle

Foot

Pelvis

Back

Head

Neck

Torso

Other:

82. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please indicate the nature of the running related injury or pain. Leave this question out if you have not been injured as a result of running in the past 12 months.

Check all that apply.

Sharp pain

Aching

Stiffness

Looseness, subluxation or dislocation

Tingling

Burning

Numbness

Swelling

Other:

83. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did this running related injury/pain occur gradually (overuse) or immediately (acute)?

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Gradually (overuse)

Immediately (acute)

84. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Duration of the running related injury/pain. Approximately how long did it take you to recover from the running related injury/pain? If the injury or pain is current, indicate the estimated time of recovery. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

1 day – 3 days

4 – 7 days

1 – 2 weeks

2 – 4 weeks

1 – 3 months

3 – 6 months

More than 6 months

85. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you fully recover from this injury before you started running again? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

Still recovering

86. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Was/is this running related injury/pain recurrent? (Has this same injury happened before?)

Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No

87. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

If this running related injury/pain has been diagnosed by a professional, what was the diagnosis? E.g. Achilles tendinopathy, patellofemoral pain syndrome, tibial stress syndrome, etc. Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

88. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Did you undergo surgery for this running related injury/pain? Leave this question out if you have not had any pain or been injured as a result of running in the past 12 months.

Mark only one.

Yes

No *Skip to question 90.*

89. 4th most severe injury/pain: Current or previous (in the past 12 months) running related injury and pain

Please elaborate on this surgery.

90. Previous running related injury and pain

Please add any additional information regarding any previous running related injuries in the text box below.

91. Non-running related pain, injury and other health issues

Are there any other health issues or non-running related injuries that may affect your running? Please describe

92. Additional comments

Please add any other comments that you have regarding anything in the questionnaire, to the text box below

Appendix G – Supplementary data

POOLED DATA

Table LXI. Information regarding pooled variables

Variable	Details of pooled data
Running terrain	Beach was pooled with sand.
Running footwear type	Several participants listed their own type of footwear, which was then researched and placed into the appropriate category. The category "combination shoes" was created for any footwear that was described by participants but did not fit into a previously defined category.
Reasons for changing running footwear types	Reasons listed under "Other": to suit a new style of running, old shoes, multi-day trail races, running longer distances, increased comfort, running on different terrains.
Reasons for using orthotics	Reasons listed under "Other": cushioning, over-supination, recommendation, comfort and to prevent shoes from wearing out. The question relating to reasons for using orthotics was an open-ended question and therefore all participant responses had to be grouped using the investigator's discretion.
Anatomical location of RRI	Upper extremities: Head, neck, shoulder. "Other" injury locations: sciatica, illiotibial band and pain in the leg, buttocks and lower back. The "Achilles" category was created as many participants used it as a location. Injury descriptions that specified Achilles tendon injury, were changed to Achilles in the location.
Nature of RRI	Stiffness included cramps and knots. Burning included irritation. "Other" injury descriptions: stress fractures, tears, spasms and tendonitis.

SUPPLEMENTARY DATA

The following section comprises of results that were omitted from Chapter IV, for the following reasons: The sample sizes were less than 5 therefore the association did not hold enough significant statistical power; a significant association was found however it could not be seen where this association was; the results did not contribute to answering the main research question. The brevity and main purpose of the current study would be compromised, had these findings been included.

Table LXII. Frequency and percentage of home languages of participants

Language	%	n =
Afrikaans	29.14	111
English	61.42	234
Ndebele	0	0
Northern Sotho/Sepedi	0.26	1
Southern Sotho/Sesotho	0.26	1
Swati	0	0
Tsonga	0	0
Tswana	0.52	2
Venda	0.26	1
Xhosa	3.94	15
Zulu	1.05	4
Other	3.15	12
TOTAL	100	381

The predominant home language of the participants was English (61.42%), followed by Afrikaans (29.14%), with these two languages making up 90.56% of the total participants. The remaining 9.44% consist of Northern Sotho/Sepedi, Southern

Sotho/Sesotho, Tswana, Venda, Xhosa, Zulu and other non-South African languages. No participants spoke Tsonga, Swati and Ndebele as their home languages, although they are all official South African languages. 12 participants spoke "Other" home languages which comprised of eight European, two African, one Chinese and one Indian language.

Table LXIII. Frequency of various races and the races and origin of their parents (if not of South African origin)

Ethnicity	**Number (%)**	**Parents of different ethnicities**	**Origin of parents not of SA origin**	**Number of participants with no South African parents**	**Number of participants with one South African parent**	**Participants with both parents from SA**
Black African	26 (6.88%)	1 (Black African and Coloured)	2 – both from Southern Africa	2	0	24
Caucasian	313 (82.8%)		44 – Both European 1 – 1 from Australia 39 – 1 European 11 – 1 from Southern Africa 6 – Both from Southern Africa 2 – 1 from East Africa 2 – 1 from South America, 1 from Europe	56	53	204

			1 – 1 from Europe, 1 from Canada 1 – 1 from Europe, 1 from Madeira Islands 2 – unknown			
Coloured	30 (7.95%)	2 (Indian and Coloured parents)		0	0	30
East Asian	1 (0.26%)		From Taiwan	1	0	0
Indian	7 (1.85%)		1 – 1 from India 1 – 1 from Zambia/UK	0	2	5
Other	0					
Mixed	1 (0.26%)	1 (white and Indian parent)	1 from Ireland	0	1	0

Table LXIV. Frequency of participants and parents with the same home language

Home language	2 parents with same home language	1 parent with same home language	0 parents with same home language
Afrikaans	104	6	1
English	183	33	18
Northern Sotho/Sepedi	1	0	0

Southern Sotho/Sesotho	0	1	0
Tswana	1	1	0
Venda	1	0	0
Xhosa	15	0	0
Zulu	3	1	0
Other	12	0	0

Table LXV. Frequency of types of cross training activities

Cross training activities	**n =**	**%**
Aerobics	17	3.06
Athletics	18	3.24
Badminton	2	0.36
Basketball	1	0.18
Bowls	1	0.18
Boxing	5	0.90
Canoeing	11	1.98
Climbing	7	1.26
Cricket	5	0.90
Crossfit	22	3.96
Cycling	123	22.12
Dancing	6	1.08
Field hockey	9	1.62

Golf	3	0.54
Gymnastics	1	0.18
Hiking	3	0.54
Horse riding	2	0.36
Martial arts	3	0.54
Netball	1	0.18
Paddling	2	0.36
Pilates	30	5.40
Resistance training (Lifting weights and body weight exercises)	115	20.68
Rowing	12	2.16
Rugby	3	0.54
Sailing	1	0.18
Soccer	11	1.98
Squash	14	2.52
Surfing	3	0.54
Swimming	73	13.13
Tennis	12	2.16
Volleyball	1	0.18
Walking	5	0.90
Yoga	30	5.40
Other	4	0.72

TOTAL	556	100.00

Bootcamp, strength programs and core exercises were listed under resistance training. "Other" consisted of drafts, dog agility and jumping, cardio at the gym and stepper. Spinning and cycling were grouped together.

Table LXVI. Association between participants with RRIs and race distance preference of 10 – 21 km

Participants with RRI in the past 12 months	**Preference of 10 – 21 km race distance**		
	Yes	**No**	**p-value**
	68.07% (n=166)	78.77% (n=212)	0.02000

Participants who did not select 10 – 21 km as a favoured race distance, appeared to be more likely to have had an injury in the past 12 months, than participants who enjoyed races of 10 – 21 km

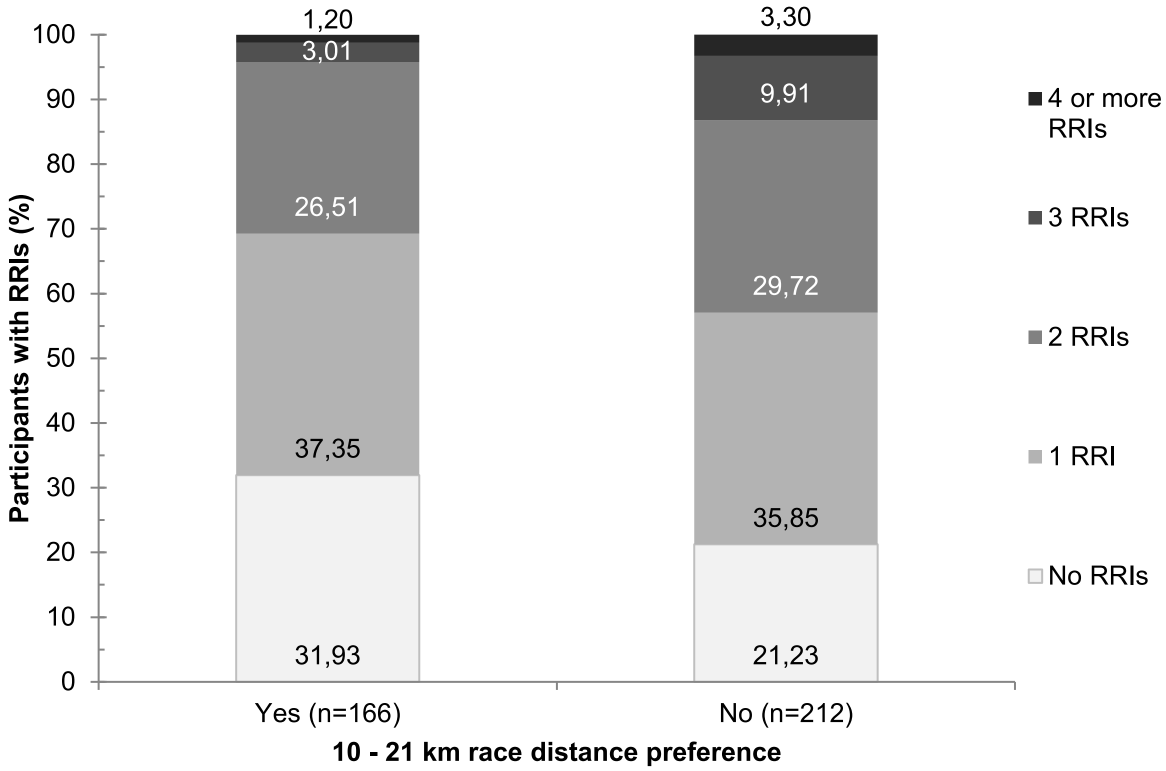

Figure 49. Association between the number of RRIs and 10 – 21 km race distance preference (p=0.01306)

Those who selected 10 – 21 km race distance as a favourite, were more likely to have one or no injuries in the past year, whereas two or more RRIs were more prevalent in participants who did not select this race distance.

Table LXVII. Associations between RRI location and running terrains

	Running terrain		
	Sand		
Participants with ankle RRIs	**Yes**	**No**	**p-value**
	66.67% (n=3)	8.80% (n=375)	0.02359
	Cement		
Participants with other RRIs	**Yes**	**No**	**p-value**
	11.76% (n=17)	0.55% (n=361)	0.01085

Two thirds of participants who ran on sand reported ankle RRIs however only 3 participants in the current study ran on grass and therefore the small sample size is likely to have impacted these results. A very small proportion of participants who did not run on sand (8.80%) developed ankle RRIs however the sample size was much larger than those who did run on grass and therefore the difference is likely due to this.

Out of 17 participants who ran on cement, 2 reported suffering from other types of RRIs apart from the ones mentioned. This is equal to 11.76% of these participants. The same number (n=2) of participants who did not include cement as a running terrain, suffered from other RRIs. However, because of the much larger sample size of this group (n=361), the percentage of injured participants was much lower than those who ran on cement.

Table LXVIII. Associations between RRIs location and running experience

	Running experience				p-value
	Less than a year	**1 - 5 years**	**5 - 15 years**	**More than 15 years**	
Participants with 'other' RRIs	0.00% (n=25)	0.00% (n=142)	3.36% (n=119)	0.00% (n=92)	0.03209

Table LXIX. Associations between RRI location and race distance preferences

	Preference of 21 km race distance		
Participants with knee RRIs	27.83% (n=212)	18.67% (n=166)	0.03948
Participants with posterior thigh RRIs	10.85% (n=212)	4.82% (n=166)	0.03808

Table LXX. Associations between RRI location and the number of ultramarathons run in the past 12 months

	Number of +42 km races run						**p-value**
	0	**1**	**2**	**3**	**4**	**5 or more**	
Participants with anterior thigh RRIs	0.45% (n=224)	1.72% (n=116)	0.00% (n=18)	7.60% (n=13)	50.00% (n=2)	0.00% (n=5)	0.00000
Participants with posterior thigh RRIs	4.46% (n=224)	14.66% (n=116)	5.56% (n=18)	23.08% (n=13)	0.00% (n=2)	0.00% (n=5)	0.00959

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Table LXXI. Association between RRI location and number of footwear pairs

	Number of footwear pairs					**p-value**
	1 pair (n=104)	**2 pairs (n=168)**	**3 pairs (n=61)**	**4 pairs (n=30)**	**5 or more pairs (n=15)**	
Participants with ‘other’ RRIs	3.85% (n=104)	0.00% (n=168)	0.00% (n=61)	0.00% (n=30)	0.00% (n=15)	0.03078

Table LXXII. Association between RRI location and weekly cross training duration

	Weekly cross training duration (hours)									**p-value**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 or more**	
Participants with other RRIs	0.00% (n=45)	0.00% (n=69)	1.82% (n=55)	0.00% (n=23)	0.00% (n=18)	0.00% (n=16)	0.00% (n=7)	12.50% (n=8)	0.00% (n=10)	0.04100

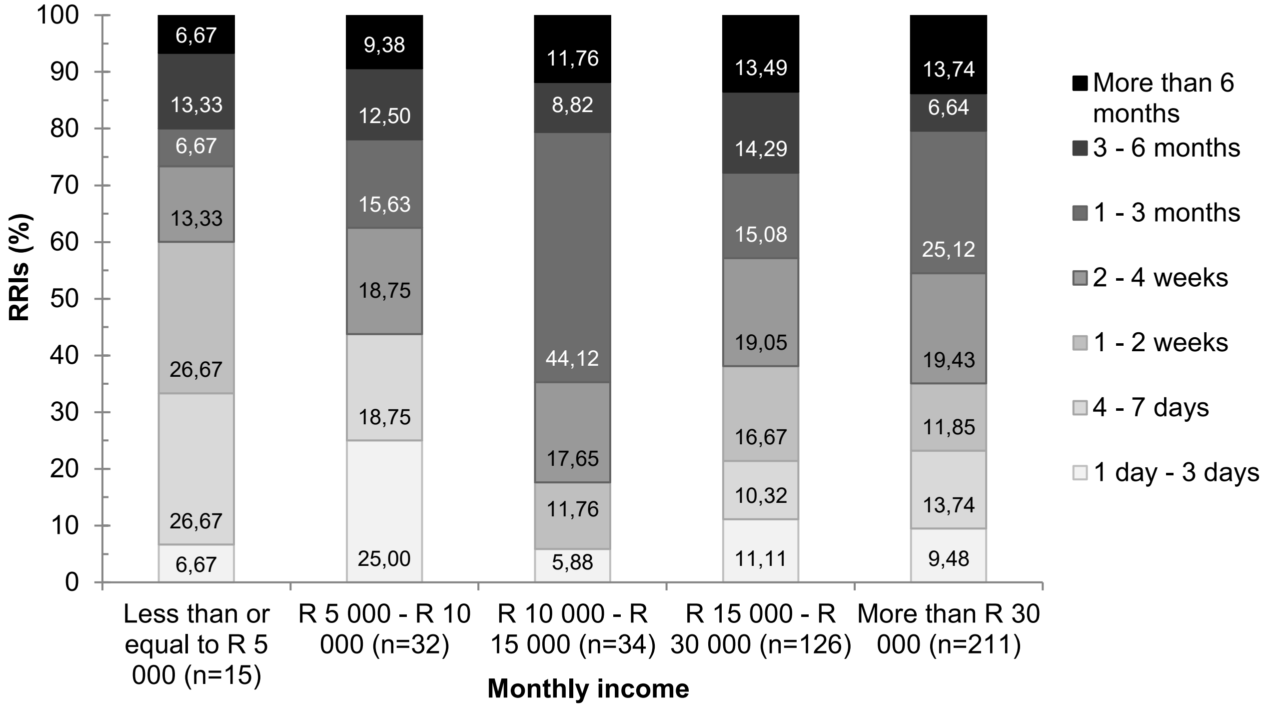
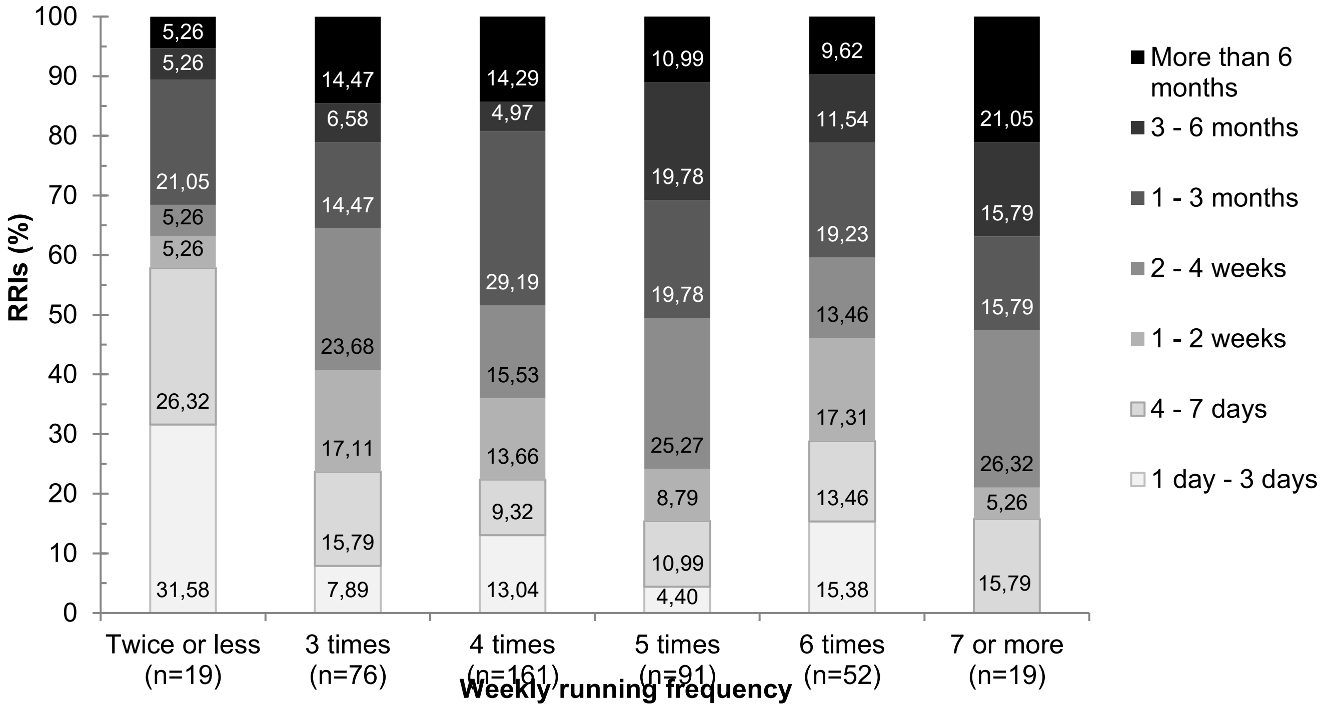


Figure 50. Association between RRI duration and monthly income (p=0.008883)



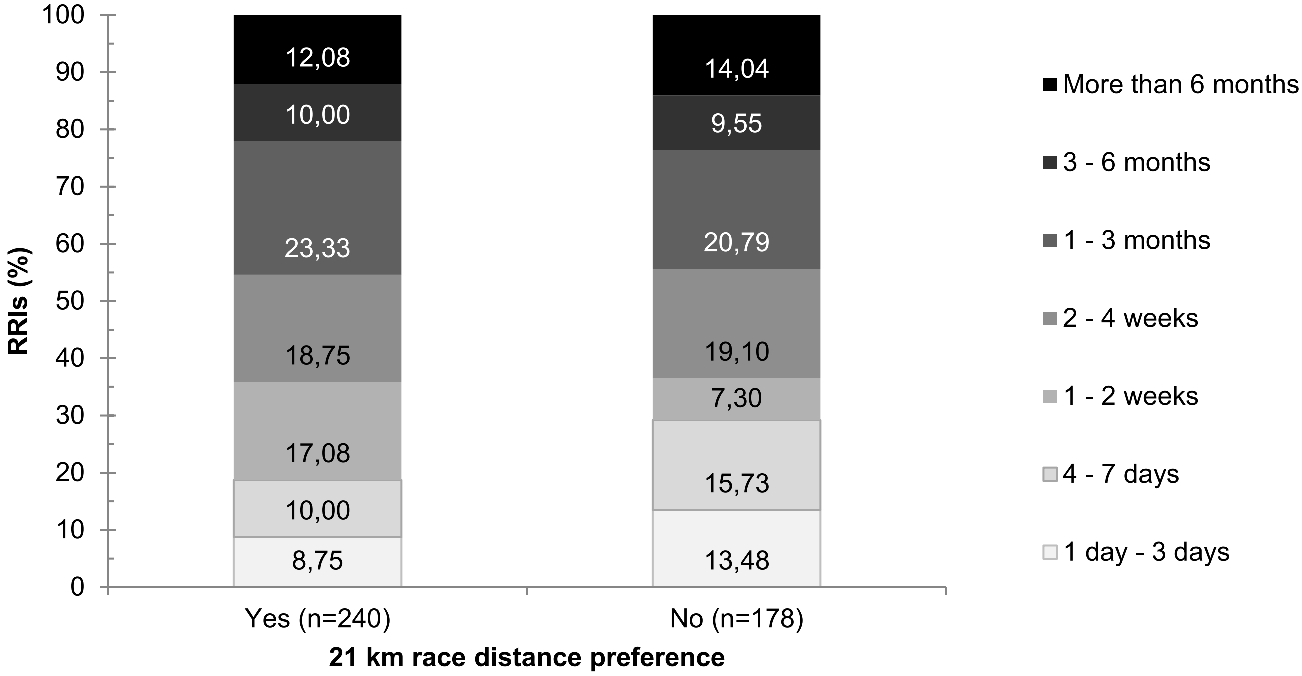


Figure 51. Association between RRI duration and 21 km race distance preference (p=0.042699)

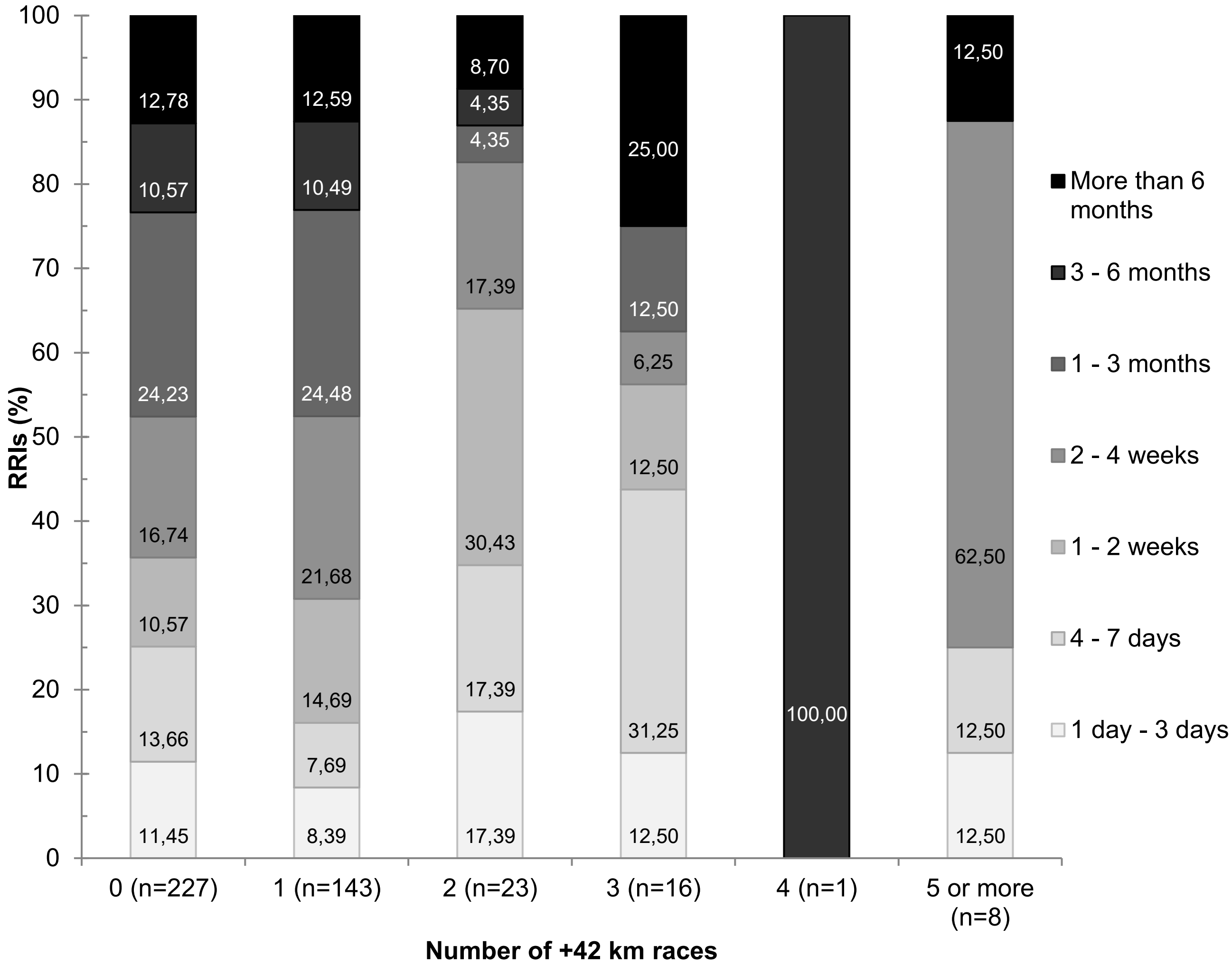


Figure 52. Association between RRI duration and number of +42 km races (p=0.015030)

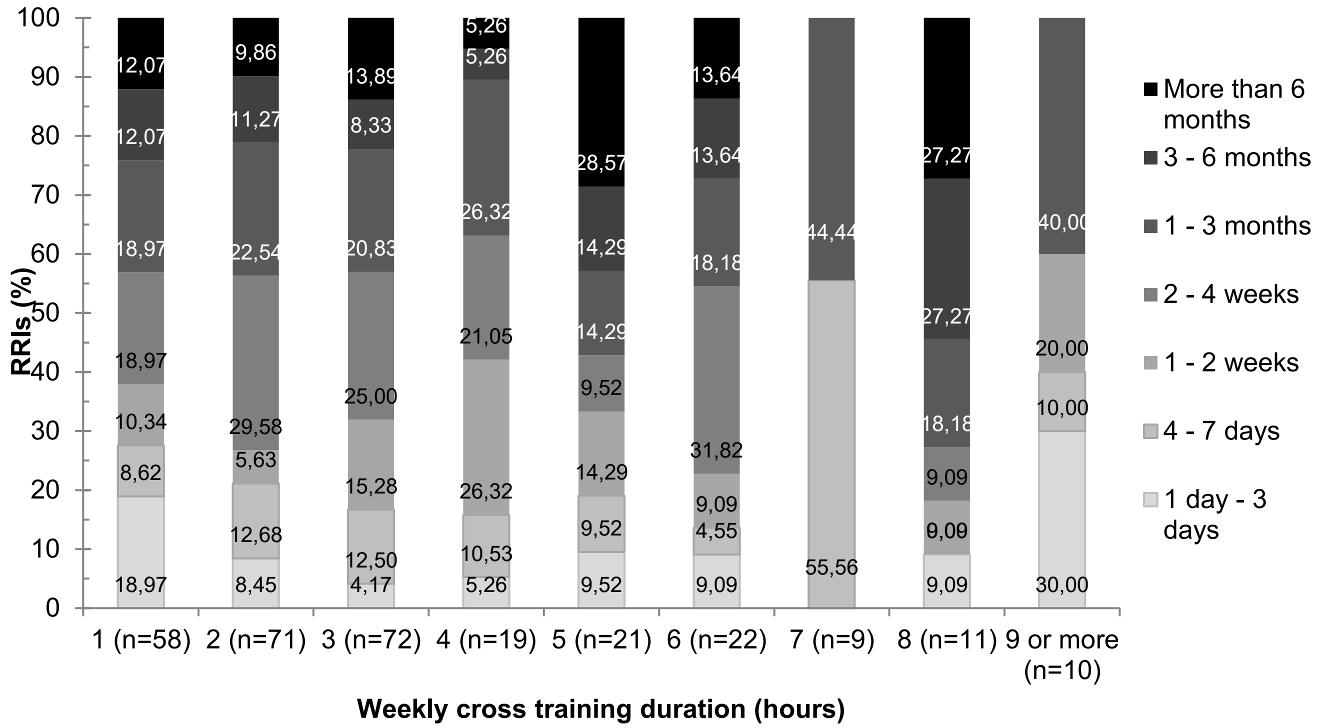


Figure 53. Association between RRI duration and weekly cross training duration (p=0.019836)

Table LXXIII. Association between recurrent RRIs and weekly running frequency (p=0.03338).

	Weekly running frequency						**p-value**
	Twice or less	**3 times**	**4 times**	**5 times**	**6 times**	**7 times or more**	
Recurrent RRIs	36.84% (n=19)	50.00% (n=76)	41.61% (n=161)	35.56% (n=90)	53.85% (n=52)	15.79% (n=19)	0.03338