UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF THERAPEUTIC SCIENCES

DEPARTMENT OF PHYSIOTHERAPY

RESEARCH REPORT: MSc PHYSIOTHERAPY

RUNNING-RELATED INJURIES AND RISK FACTORS AMONG RUNNERS IN SOWETO TOWNSHIP CLUBS, JOHANNESBURG

RESEARCHER'S DETAILS

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A Research Report submitted to the Faculty of Health Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy.

Ethics number: M220234

06 June 2024

DECLARATION

I, Masocha Vusi Masilana, declare that this research report is my unaided work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Name of Candidate Signature of Candidate

______06________day of__June_________2024____ in__Johannesburg___

ABSTRACT

The surge in running's popularity globally has brought about an increase in running-related injuries (RRIs), particularly prevalent in sub-Saharan Africa, including South Africa's urban township of Soweto, where physical inactivity and non-communicable diseases pose significant public health challenges. This necessitates targeted research on RRIs in the region to understand the specific external and internal risk factors. The study aimed to determine the prevalence and risk factors for RRIs among recreational and professional runners in Soweto, Johannesburg. The study utilised a cross-sectional design to determine the prevalence and risk factors associated with RRIs, allowing for an efficient one-time data collection from a large sample. Runners from Soweto township was included in the study. A data collection tool in the form of a self-administered questionnaire was employed, utilising the RedCap online platform for administration. A structured analysis plan was implemented using STATA software, with an additional data processing phase in Excel to enhance the clarity and readability of results, including the customisation of charts and graphs to communicate the findings effectively. Descriptive and inferential statistics were obtained. Demographic analysis revealed a higher prevalence of female runners at the beginner level (55%, n=17), with a significant association between advancing age and injury risk. Among professional runners, the distance covered emerged as a significant risk factor, particularly for medium and long-distance runners (odds=2.07, p=0.05 and odd = 3.01, p =0.03, respectively). The frequency of training sessions demonstrated varying degrees of risk for both novice and professional runners.

Additionally, terrain-specific analysis highlighted the elevated risk of injuries for beginners on varied terrain relative to professional runners. Statistical findings included significant odds ratios for female runners (odds = 0.75, p =0.05), age over 25 among beginners (odds = 1.56, p = 0.031), medium distance running among professionals (odds = 2.07, p = 0.050), and varied terrain among beginners (odds = 1.76, p = 0.006). This study provides critical insights for tailoring injury prevention and management techniques, particularly for runners of various levels. It emphasises the importance of individualised treatments by stressing nuanced damage patterns between beginners and professionals. The heightened risk on varied terrain for beginners and the unique implications of sports engagement on injury risk for professionals are noteworthy findings. These findings guide tailored prevention strategies, recognising the varied character of RRIs and addressing unique needs at various career stages, with possible policy and future research implications.

Keywords: *Prevalence; Risk Factors; Runners; South Africa*

ACKNOWLEDGEMENT

I would like to begin by expressing my heartfelt gratitude to my supervisor, Dr Siyabonga Kunene, whose extensive knowledge, invaluable insights, and unwavering support were pivotal throughout the entirety of this research endeavour.

I extend my sincere appreciation to the participants in this study, whose willingness to dedicate their time and share their insights played a crucial role in the success of this research. My gratitude also goes out to Kumbi Mudziwa and the entire team for their invaluable assistance with the statistical analysis of this research report.

I am deeply thankful to my family and colleagues for their unwavering understanding, encouragement, and continuous support during the research process. Your steadfast belief in me served as a constant source of motivation and focus.

Lastly, I would like to convey my deepest appreciation to all individuals who, while not explicitly mentioned here, have contributed in diverse ways to this research effort. Your assistance, engaging discussions, and encouragement have been immeasurable.

Furthermore, finally, I offer my gratitude to the Almighty, thanking the Lord for His guidance and blessings throughout this journey.

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Abbreviations

RRIs: Running-Related Injuries

PFPS: Patellofemoral Pain Syndrome

BMI: Body Mass Index

WHO: World Health Organisation

NDCs: Non-Communicable Diseases

NSRP: National Sport and Recreational Plan

SSA: Sub-Saharan Africa

HR: Hazard Ratio

KM: Kilometres

US: United States

DFROM: Dorsiflexion Range of Motion

CGA: Central Gauteng Athletic

HREC: Human Research Ethics Committee

ASA: Athletics South Africa

SASCOC: South African Sports Confederation and Olympic Committee

SAMA: South African Medicine Association

POPIA: Protection of Personal Information Act

HREC: Human Research Ethics Committee

SMS: Short Message Services

CHAPTER 1: INTRODUCTION

1.1. BACKGROUND

An estimated 225 million individuals engage in regular running or jogging globally (World Health Organisation [WHO], 2021). Numerous health benefits, including improvements to cardiovascular health, weight management, mental health, and overall well-being, have been associated with running, hence its popularity in contemporary times (Loprinzi & Cardinal, 2013). Physical activity levels have improved over time, with the number of people who engage in regular physical activity, notably running, estimated to have increased by nearly 17% between 2001 and 2016 globally (Guthold *et al.,* 2018). The prevalence of running-related injuries (RRIs) has increased in many parts of the world in tandem with the sport's growing popularity. In the United States, around 73.5% of runners report sustaining an injury annually (Fields *et a*l., 2010). According to WHO projections, physical activity levels will continue to climb globally in the future years, emphasising the need to an improved understanding to prevent RRIs (WHO, 2021).

While there is no clear definition of RRIs, they are commonly understood to be injuries that develop while or because of running (van der Worp *et al.,* 2015). The most prevalent RRIs are shin splints, Illiotibial Band Syndrome (ITBS), plantar fasciitis, Achilles tendinopathy and Patellofemoral Pain Syndrome (PFPS). Shin splints are shin pain resulting from inflammation of the muscles, tendons, and bone tissue. Iliotibial band syndrome is external knee pain caused by inflammation of the Iliotibial band, a thick tissue band that runs from the hip to the knee. Plantar fasciitis is inflammation of the plantar fascia, a thick band of tissue that runs along the bottom of the foot, causing pain in the heel and sole.

Achilles tendinopathy is back heel pain caused by inflammation of the Achilles tendon, which connects the calf muscles and heel bone (Cardiso et al., 2019). Patellofemoral pain syndrome is a knee pain caused by irritation of the cartilage on the underside of the kneecap (Hreljac, 2004; Nielsen *et al.,* 2012). These injuries can have a substantial impact on runners' quality of life, their ability to engage in work and leisure activities, and their long-term health outcomes (van Gent *et al.,* 2007). In addition, RRIs can contribute to significant medical costs, both in terms of treatment and lost productivity (van der Worp *et al*., 2015). For instance, according to a 2012 study, the medical costs associated with RRIs in the United States totalled over $2.5 billion (Longo *et al*., 2015).

Sub-Saharan Africa is not an exception to the global trend of running's popularity, as participation in the sport has increased in recent years (Muir *et al*., 2019). Countries such as

Kenya, Ethiopia, and South Africa have produced some of the best long-distance runners in the world, and running is inculcated in the culture of many African communities (Muir *et al*., 2019). In keeping with global trends, RRIs are widespread.

Runners in sub-Saharan Africa may be especially prone to RRIs due to several factors, including improper running form, inadequate footwear, and running on uneven surfaces, according to studies (Junge *et al*., 2012). One study in Tanzania found that 29% of runners had experienced RRIs within the previous year (Goodwin *et al*., 2017). Another study in Kenya found that the lifetime prevalence of RRIs among recreational runners was approximately 50% (van der Worp *et al.,* 2015). Despite the purported benefits of running for people of all ages and fitness levels, many runners face possible hazards (Loprinzi & Cardinal, 2013). Understanding the risk factors and causes of RRIs, as well as taking actions to prevent and manage these injuries, is essential for continuing to enjoy the benefits of running.

Like other countries, South Africa has seen a substantial increase in the number of runners over the past several decades, with an estimated 3.5 million runners in the nation (Muir *et al*., 2019). Still, in comparison to its neighbours, South Africa has one of the highest rates of physical inactivity, with over 60% of the population failing to meet the recommended levels of physical activity (WHO, 2021). This is especially problematic given the high prevalence of non-communicable diseases (NCDs) in the country, which are strongly associated with physical inactivity. Consequently, promoting physical activity, such as running, has become a South African public health priority, including in highly populated areas such as Soweto, a township in Johannesburg (Taunton *et al*., 2014; Knobloch *et al*., 2019).

Despite the efforts to promote safe and effective running, there is little research on RRIs in the country, and unfortunately, this alone seems to impede such efforts (Goodwin *et al*., 2017). Other studies elsewhere have discovered that certain factors, such as advancing age, a higher BMI, and a history of injury, may increase the risk of RRIs (Nielsen *et al.,* 2012). However, it is still unclear which of these factors apply to the South African population, highlighting the need for additional research in this field.

Over a million people reside in Soweto, a township in Johannesburg, South Africa, which is renowned for its rich history and culture. Soweto, like many urban areas in South Africa, faces numerous health challenges, including a high prevalence of non-communicable diseases such as diabetes and cardiovascular disease (McCabe & Collins, 2013). Running has become a popular form of exercise in Soweto, with numerous running clubs and events throughout the township, including the Comrades Marathon, one of the largest and oldest ultramarathons in the world (Lichtenstein, 2018).

However, the community is under-resourced and faces numerous obstacles, such as a lack of access to safe running routes and adequate medical care, which may increase the likelihood of RRIs (Motala, Pirie, & Yakoob, 2019). There is limited research on running and RRIs in Soweto despite the sport's popularity. This study seeks to fill this knowledge gap by examining the prevalence and risk factors of RRIs among Soweto runners.

1.2. PROBLEM STATEMENT

The core problem investigated in this study is the epidemiology and risk factors associated with RRIs, which pose significant health concerns due to their potential to cause severe pain, disability, and lost productivity (Hreljac, 2004; Van Gent et al., 2007). The existing literature on RRIs exhibits several limitations, including imprecise injury data collection methods and varied definitions of RRIs (van der Worp et al., 2015; Lopes et al., 2012). Consequently, previous research has yielded inconclusive results, hindered a comprehensive understanding of this public health issue and impeded the development of effective injury prevention strategies.

Factors affecting this problem include both intrinsic and extrinsic risk factors such as age, body mass index (BMI), gender, training volume and intensity, footwear, and running surface (Hreljac, 2004; Knobloch et al., 2019). However, there is a lack of consensus on these risk factors among studies, with some reporting significant associations while others finding contradictory results. Moreover, previous research has primarily focused on specific populations, such as elite or professional runners, potentially limiting the generalizability of findings to the broader population of recreational runners.

To address these gaps in knowledge, this study aimed to conduct a cross-sectional analysis of both amateur and professional runners in a specific geographic area. By investigating demographic profiles, sports-specific histories, prevalence, treatment histories, and extrinsic risk factors associated with RRIs, the study intended to provide a more comprehensive understanding of the epidemiology and risk factors for these injuries. Additionally, the study sought to overcome previous limitations by employing standardized definitions of RRIs, optimizing sample size, follow-up period, and statistical power, thereby enhancing the reliability and generalizability of the findings.

1.3. RESEARCH QUESTIONS

What were the prevalence and risk factors for runner-related injuries among recreational and professional runners in Soweto, Johannesburg?

1.4. AIM

The study aimed to determine the prevalence and risk factors for RRIs among recreational and professional runners in Soweto, Johannesburg.

1.5. OBJECTIVES

The objectives of the study were to:

- Determine the demographic characteristics of recreational and professional runners.
- Determine the sport-specific background of recreational and professional runners.
- Determine the prevalence of running-related injuries (RRIs) among participants.
- Identify intrinsic and extrinsic risk factors for running-related injuries (RRIs) among participants.
- To find a relationship between demographic characteristics, sports background, prevalence, and risk factors.

1.6. SIGNIFICANCE OF THE STUDY

The findings of this study have the potential to benefit a wide range of stakeholders involved in promoting safe and healthy physical activity, including runners, coaches and trainers, medical and public health professionals, and policymakers. The study could help develop evidence-based prevention and treatment strategies by identifying the prevalence and risk factors linked to RRIs among recreational and competitive runners in Soweto. Prior research has highlighted the importance of implementing injury prevention programs in sports, and several guidelines for specific sports, including running, have been developed (Lopes *et al.,* 2019). However, these guidelines may not always be exhaustive or based on evidence, and they may not account for the unique risk factors present in various populations. In addition, this research has the potential to contribute to the academic community by shedding new light on the epidemiology and risk factors associated with RRIs in both amateur and professional runners.

Consequently, the study may have significant implications for South African policymakers and public health officials. This study seeks to address the knowledge gaps and limitations of policy initiatives such as the National Sport and Recreation Plan and the Healthy Lifestyle Campaign by providing a thorough understanding of the prevalence and risk factors associated with RRIs among recreational and professional runners in Soweto, Johannesburg. By identifying the factors that contribute to these injuries, policymakers can develop targeted interventions to reduce the incidence and severity of RRIs and ultimately promote safe and healthy physical activity among South Africans. The findings of this study also align with the Sustainable Development Goals of the United Nations, particularly Goal 3, which seeks to ensure healthy lives and promote well-being for all people of all ages. The findings of this study will contribute to the achievement of this objective by informing evidence-based interventions to reduce the incidence of RRIs and improve the health and well-being of the South African population (National Sport & Recreation Plan, 2011; United Nations, 2015; Healthy Lifestyle Campaign, 2018).

In addition, the study could contribute to the existing literature on injury prevention and treatment methods. This would strengthen the framework for the investigation of other sports-related injuries and their associated risk factors that are still in development. Furthermore, this study could contribute to the education and training of students and researchers in the fields of physiology and sports medicine by enhancing their knowledge of the epidemiology and risk factors associated with running-related injuries. By integrating real-world data into curricula, graduates can better address the complex challenges associated with running-related injuries, ultimately leading to more effective injury prevention and rehabilitation efforts and promoting physical activity as a safe and sustainable component of a healthy lifestyle.

CHAPTER 2: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter is a literature review that identifies gaps in what other studies have established regarding running-related injuries (RRIs). Following the study's objectives, this chapter discusses the global, regional, and local prevalence of RRIs, as well as the measurement techniques employed. The chapter proceeds to identify the extrinsic and intrinsic risk factors associated with RRIs, as identified in other studies. In addition to focusing on these factors, the subsections seek to highlight the characteristics and sport-specific profiles of runners participating in different studies. The chapter concludes with a discussion of the biopsychosocial model, the framework from which this study is conceptualised.

2.2. LITERATURE SEARCH STRATEGY

A literature review was systematically undertaken to examine RRIs, and the risk factors associated with them. The investigation commenced with an initial search of scholarly databases, including PubMed, Scopus, and Google Scholar, utilising Boolean operators and keywords. "Running-related injuries," "running injury risk factors," and "running injury prevalence" were the principal search terms utilised. An essential criterion was the restriction of outputs to materials that were published exclusively in the past decade.

The high number of retrieved results necessitated a multi-step selection process. Initially, titles and abstracts were screened to exclude irrelevant studies. Subsequently, a full-text evaluation was conducted to assess the relevance and quality of the remaining articles. In addition, the references of selected articles were examined to guarantee a thorough coverage of relevant studies. Following the initial search and elimination of duplicate entries, a comprehensive screening process was carried out. Priority was given to studies that examined the prevalence, risk factors, and methodologies pertaining to RRIs in South Africa and Sub-Saharan Africa as a whole, according to the inclusion criteria.

To supplement the initial database search with pertinent studies that may have been overlooked, an examination was conducted on the references and bibliographies of the chosen articles. The ultimate compilation examined in the present study comprises an extensive array of research studies, encompassing cross-sectional surveys, prospective and retrospective cohort studies, systematic reviews, and more. As a result, it is anticipated that these studies will augment the overall comprehension of the terrain of RRIs in Soweto, South Africa. Figure 2.1 presents the results from PubMed, illustrating one of the databases used for the search and retrieval of relevant literature in this study. This figure, along with the review of additional sources, provides a thorough foundation for understanding the prevalence and risk factors of RRIs within the specified region.

Database: PubMed Date: 10-07-2023	Search Words	Limit (filter, limits, refine)	Number of Records
#1	Running -related injuries		1530
#2	Running related injuries OR Running Injury Risk Factors* OR Running Injury Prevalence*		1649
#3	Running related injuries OR Running Injury Risk Factors* OR Running Injury Prevalence*	Years: 2013-2023 *Publication Language*: English *Article Type*: Meta-analysis, Clinical Trial, Systematic Reviews, Randomized Control Trials *Duplication Status*: Duplicates Removed	209
	#1 & #2	Years: 2013-2023 *Publication Language*: English *Article Type*: Meta-analysis, Clinical Trial, Systematic Reviews, Randomized Control Trials *Duplication Status*: Duplicates Removed	101
#4	Running injuries AND (Sub Saharan Africa)	Years: 2013-2023 *Publication Language*: English *Article Type*: Meta-analysis, Clinical Trial, Systematic Reviews, Randomized Control Trials *Duplication Status*: Duplicates Removed	89
#5	Running injuries AND (South Africa)	Years: 2013-2023 *Publication Language*: English *Article Type*: Meta-analysis, Clinical Trial, Systematic Reviews, Randomized Control Trials *Duplication Status*: Duplicates Removed	77

Figure 2.1: PubMed Database Engine Search Criteria and Results

2.3. PREVALENCE AND INCIDENCE OF RUNNING-RELATED INJURIES

An immediate problem in the study of RRIs is the lack of global, regional, or, preferably, local estimates to ascertain the extent and magnitude of the problem. The lack of standardised methods for measuring and reporting injuries makes it difficult to corroborate and scale findings from different studies and locations. The excessive reliance on athletes' self-reporting of injuries, which is highly subjective and frequently associated with inaccuracies, has also emerged as a significant obstacle to the accurate measurement of the prevalence and incidence of RRIs. However, recent efforts have been made to resolve these obstacles and improve estimates of the prevalence and incidence of RRIs (Koech *et al.,* 2021).

A systematic review and meta-analysis study by Lopes *et al.* (2019), for instance, estimated the global incidence of RRIs at 15.9%, which is approximately one in every six runners experiencing an injury every year. In the study involving over half a million participants from 25 countries and 197 studies analysed, knee injuries were found to be the most common, constituting 42.2% of the total reported injuries. The study also estimated the prevalence of RRIs at 52.8%, implying that more than half of the runners had experienced an injury at some point in their running career. A more recent systematic review involving 100,000 runners from around the world sampled from 23 studies by Saragiotto *et al*. (2020) estimated the overall incidence of RRIs at 23.5%, while prevalence was estimated at 67%.

In Sub-Saharan Africa (SSA), due to the limited number of studies that have been carried out, the prevalence and incidence of RRIs may be underestimated. Though this may be true, existing estimates indicate that they are higher than worldwide estimates. Calculating the prevalence of RRIs as the proportion of runners who reported experiencing an injury during their activities over a specific period (1 year), Lopes *et al.* (2019) estimated the overall prevalence of RRIs in SSA at 34.4%.

A cross-sectional survey by Koech *et al.* (2021) among 167 professional athletes in the Rift Valley, Kenya, found the prevalence of running injuries to be 63%. The prevalence among males (n = 64; 69%) was higher in comparison with that of females (n = 42; 57%). The posterior thigh (n = 87; 52%) was the most common site for injuries among the athletes, followed by the lower back (n = 78; 47%) and ankle (n = 63; 38%).

One of the few local studies on common running musculoskeletal injuries among recreational half-marathon runners in KwaZulu-Natal found that 90% (n = 180) of runners reported having sustained RRIs between February and June 2012 (Ellapen *et al.*, 2013). The lower back and hip (16%), tibia and fibula (22%), and knee (26%) were the anatomical sites most prone to injury. The intrinsic factors predisposing runners to musculoskeletal injuries were deviant quadriceps and hip flexion angles.

However, as mentioned above, much of the information available in most of these studies is a result of self-reported or self-administered questionnaires rather than medical diagnoses. The lack of local estimates massively underestimates the prevalence of RRIs. A systematic review by van Der Worp *et al.* (2015) of 400 articles on running injuries reported that less than 15% of these studies were SSA articles, of which only 1% could be classified as high-quality studies.

2.4. FACTORS ASSOCIATED WITH RUNNING-RELATED INJURIES

Several studies have concluded that RRIs are the product of multiple risk factors. RRIs have generally been categorised into two main categories: intrinsic and extrinsic factors. This section explores intrinsic and extrinsic factors in detail and how they are associated with RRIs.

2.2.1 Extrinsic Factors

Extrinsic factors refer to outside-the-body elements that are associated with RRIs. Such factors may include running surface, running shoe type, running frequency, and running duration, among others.

Running Surface

Recent studies have identified the running surface as an extrinsic factor that may significantly contribute to the risk of RRIs. Saragiotto *et al.'s* (2015) study among a sample of Canadian runners found that those who trained on harder surfaces such as asphalt and concrete had up to three times the elevated risk of injury relative to those who trained on grass trails. Similarly, a study by Shumbusho *et al.* (2022) in Rwanda aiming to determine the incidence and risk factors of RRIs found that those frequently running on dirt roads were at higher risk of developing RRIs such as ankle sprains and Achilles tendinitis relative to those running on asphalt roads. Like other studies conducted elsewhere, the study is limited in that it only focused on professional runners participating in organised events, which is not representative of all the runners in the country. Additionally, the reliance on self-reported data has also led to questions about the reliability of the study's findings.

While there are a handful of studies that confirm the association between the running surface and RRIs, there are also a significant number that arrive at a different conclusion. Schwellenus *et al.* (2011), in a prospective study among ultra-marathon runners, found that those who ran on uneven surfaces were associated with an increased risk (relative risk = 1.3, 95% CI = 1.0–1.7) of lower limb injuries. Interestingly, while making a point about the significance of uneven surfaces, the study did not find any statistically significant relationship between the hardness of surfaces and RRIs. In a prospective study involving 929 marathon runners in South Africa, the overall incidence of RRIs was as high as 20.7%, with knee injuries (27.9%) and angle injuries (23.3%) being the most common types of injuries. However, no significant association was found between the running surface and injuries.

Elsewhere, in a cross-sectional study among recreational runners in Brazil, Almeida *et al.* (2015) concluded that running itself was a risk factor for injury. Those who used asphalt as a running surface had an elevated risk of knee injuries. In contrast, those running on grass or dirt, presumably softer surfaces, were more prone to experiencing ankle injuries. These contradictory findings imply that the association between running surface and injury risk is likely complex and based on various factors, including surface type, biomechanics, and individual differences in running technique and training.

Running shoe type

The type of running shoe has also been identified as one of the extrinsic factors potentially related to RRIs. Several studies have been conducted to determine how different types of shoes, including minimalist, neutral, stability, motion control, and trail running shoes, contribute to the incidence of running injuries. Interestingly, in some cases, while one shoe type in one study is viewed as having a protective effect, in another, it is identified as increasing the risk of injuries.

For example, while neutral shoes are thought to provide adequate cushioning and are thus associated with lower injury rates (Tauton *et al*., 2003), elsewhere, the same shoe type is suggested to be inadequate in controlling the inward motion of the foot, thus increasing the injury risk among runners (Ryan *et al.,* 2015).

In their prospective study among recreational runners in the Netherlands, Malisoux *et al.* (2015) found a lower (hazard ratio [HR] = 0.61; CI: 0.39–0.96) injury risk among those running with motion control shoes relative to those with neutral shoes. In this and other studies, the authors concluded that motion shoes were associated with a lower risk of injuries due to their anti-pronation design, which resulted in a reduction of foot motion, causing tension on the lower leg muscles and tendons. However, Nielsen *et al.* (2014) found no association between motion-control shoes and a reduced incidence of RRIs.

Even with minimalist shoes, there is no conclusive evidence regarding the direction of the association with RRIs. In a meta-analytical study involving 10 randomised control trials among 183 participants, minimalist shoes were associated with an increased risk (Odds Ratio = 1.54, 95% CI = 1.20–1.98) of ankle and foot injuries among runners (Hsu *et al.,* 2017). Similarly, a study in Italy concluded that runners who wore minimalist shoes were more likely to develop injuries such as Achilles tendonitis and fasciitis. In contrast, an Australian study involving 61 runners examined over 12 weeks found that those who wore minimalist shoes had fewer injuries (0.49 per 1,000 km) compared to those wearing traditional shoes (0.69 per 1,000 km). In another US study involving 568 runners followed over one year, those who wore minimalist shoes had a reduced (6.3%) injury rate relative to those who used traditional shoes (9.3%). In both studies, the authors argued that relative to other shoe types, minimalist shoes encouraged a natural running gait or a fair forefoot strike pattern, which in turn reduced the impact forces on the lower extremities.

While reflecting on this difference, it is noteworthy to point out that the studies were carried out under varying circumstances and conditions among different populations, which ultimately led to different results. In addition, the contradictory findings also suggest the complexity of the relationship between running shoe type and injuries, thus the need for further investigation.

Running shoe age and wear

Studies have also investigated the effects of shoe age and wear on RRIs. Running shoe age and wear refer to the amount of time the shoe has been used and the level of deterioration it has incurred because of use. The argument among proponents of this causal link, in general, is that the older the shoe, the more likely it is to be associated with running injuries (Malisoux *et al.,* 2016; Cheung, 2015). As shoes age and are worn out, some of the materials used to create them, such as mesh, synthetic leather, carbon fibre, rubber, and gore-tex, also break down. This, in turn, can lead to reduced support and cushioning that the runner requires to avoid injuries. In their prospective cohort study among 264 recreational runners in Luxembourg, Malisoux *et al.* (2016) found that those who ran in shoes that were older than six months old were associated with a 2.2 times elevated risk of RRIs relative to those who had shoes less than six months old. In addition, runners who ran more frequently and had higher weekly mileage had a higher incidence of RRIs when wearing older shoes compared to those with new shoes.

Cheung *et al.* (2015) substantiate the above findings by arguing that the shoe wear pattern provides an idea of how the runner's foot strikes the ground and whether there is excessive pronation or supination. In this study, those who had shoes considered old, that is, “shoes whose outer sole on the lateral heel was worn down to the level with the midsole or more than 50% wear,” were up to three times more likely to have knee injuries than those with even wear patterns.

However, there is also evidence suggesting that older shoes have a protective effect on injuries relative to newer shoes. In their retrospective cohort study, Ruder *et al*. (2016) found that runners who had shoes with higher mileage had a 2.5% (per every 100 miles) decreased risk of developing injuries relative to those with newer shoes. The study concluded that shoes had a “break-in” period during which the materials became better adapted and more comfortable for the runner’s foot. Similarly, Bonnaci *et al.* (2017) found that runners with shoes classified as “worn” had a 39% lower risk of injury compared to those who had shoes classifieds as "new." Like Cheung *et al. (*2015), the “break-in” hypothesis of Bonnaci *et al.* (2017) concluded that older shoes had better shock absorption and a natural flex pattern, which reduces the load and pressure on the feet and limbs during running. This, in turn, results in a decreased risk of RRIs among runners.

Running frequency and duration

The relationship between running frequency, duration, and RRIs is again complex, with researchers arriving at different conclusions. In a meta-analysis involving 115,018 runners pooled from 25 studies, Lopes *et al*. (2012) established that increased running frequency (more than three times a week) was associated with elevated levels of running injuries. Increased running frequency led to injuries such as shin splints because of repetitive stress on the bones and muscles due to prolonged and frequent running. In terms of duration, the study also found that those who ran more than 60 minutes per session had significantly higher odds of having injuries relative to those who ran less. Similar findings were also generated among 532 Brazilian novice runners followed for over a year (Buist *et al.,* 2015). On the other hand, ankle sprains and knee injuries, which were common among runners, were also indirectly attributed to prolonged and frequent running.

Relative to novice runners who ran less than 10 kilometres (km) a week, Videbaek *et al.* (2015) found that those who ran more than 10 km reported a higher incidence of injuries (31.4% versus 1.8.8%). In addition, the study concluded that increasing running distance too quickly was a significant risk factor for injury, thus recommending novice runners to increase their running distance gradually.

In contrast, Saragiotto *et al.* (2014) found no statistically significant relationship between running duration and RRIs among 534 recreational runners in Brazil. Another study in Taiwan involving 55,137 participants, followed between 1996 and 2006 by Wen *et al. (2014),* found that running at least five times a week was associated with a lower risk of cardiovascular disease and all-cause mortality but without increasing the risk of injury.

Previous Injury

Overall, the literature suggests that previous injuries are a strong predictor of future RRIs. While Hespanhol Junior *et al.* (2020) did not mention specific injuries in their systematic review and meta-analysis, they concluded that runners with a history of injury were 2.5 times more likely to sustain RRIs relative to those without a history of injury. A study in Ethiopia among 89 runners by Tesfaye *et al.* (2019) concluded that runners with a previous injury were more than twice as likely to sustain new injuries compared to those without injury history. Owoeye *et al.* (2018), in Nigeria, among 142 runners followed for a year, also found ankle sprains and knee injuries common among runners who had sustained injuries before.

Other studies have taken a step further to focus on which past injuries specific injuries are associated with. Nielsen *et al.* (2014) established that runners with a history of knee injuries were more likely to develop patellofemoral pain syndrome (PFPS) in the future. Meanwhile, runners with a history of Achilles tendon injuries were 1.5 times more likely to develop Achilles tendinopathy in the future. Another one-year prospective cohort study by van de Worp *et al*. (2015) established that runners with a history of lower leg injuries were more likely to develop new leg injuries in the future (adjusted hazard ratio of 2.03, 95% CI 1.19–3.36). Runners with a history of knee injury, on the other hand, were also more likely to develop new knee injuries (adjusted hazard ratio of 2.23, 95% CI 1.29–3.86) compared to those without a history of injury.

A few studies, however, have found no association between previous injuries and newer injuries among runners.

Other extrinsic factors

There are, however, other extrinsic factors that may cause RRIs in addition to the ones stated above. These may include training-related factors such as training volume, load, intensity, and type of training. Although there are a few cases reported due to these factors, Owoeye *et al.* (2018) note that such cases are mostly associated with more serious injuries, such as muscle strains and groin injuries.

A qualitative study conducted by Saragiotto *et al*. (2014), which interviewed 95 recreational runners, concluded that most of the runners interviewed seemed “to have beliefs" about what could have caused RRIs. Thus, lack of information may be regarded as another risk factor related to running injuries, which may be remedied by educating more runners, as several of the beliefs are not supported by current evidence.

2.2.2 Intrinsic Factors

Intrinsic factors refer to internal risk factors that may predispose an individual to RRIs, which may include but are not limited to sex differences, age, and BMI.

Sex Differences

Several studies have argued that injury risk profiles also vary by sex. Specifically, most studies have identified female runners as being more at risk of injury compared to their male counterparts. In their 12-week prospective cohort study involving 71 female and 61 male novice runners, Worp *et al.* (2015) established that female runners had an elevated risk of developing injuries compared to their male compatriots. Specifically, female runners had a 2.2 relative risk of developing patellofemoral pain syndrome relative to their male counterparts. Differences in lower limb alignment and muscle strength between males and females were identified as possible reasons for variations in risk profiles. Other studies have identified the sex differences in risk levels as attributable to anatomical and biomechanical factors that make males and females more susceptible to injury. According to Ferber *et al.* (2010),’ females' wider hips and larger Q-angle contribute to the increased stress on the knee and joint during running, which in turn may lead to the development of injuries such as patellofemoral pain syndrome. In addition, estrogen and progesterone hormones, which play crucial roles in the regulation of the menstrual cycles in females, have also been suggested to affect the strength and flexibility of ligaments and tendons in the body. According to Heitz and Micklewright (2014), the fluctuation of hormones during the menstrual cycle could potentially put females at a higher risk of injury due to changes in joint stability, muscle strength, and neuromuscular control.

Stanhewicz *et al.* (2017) found that while female runners were more likely to report RRIs, the severity of injuries varied significantly between sexes. While 74% of females reported having an injury in the previous year compared to 61% of males, on assessing the severity using a scale ranging from 0 (no pain) to 10 (severe pain), the average for both sexes was 5.5. The authors contend that while severity is unaffected by sex, the incidence may vary due to anatomical differences between males and females. Meanwhile, Nielsen *et al.* (2013) established that while female runners had a higher incidence of knee injuries, their male counterparts had, on the other hand, a higher incidence of leg and ankle injuries. The study shows that individuals of both genders have a likelihood of experiencing injuries, and the risk of injury to certain body parts varies depending on sex. Studies elsewhere found no significant association between sex and RRIs when adjusting for training volume and history (Lopes *et al.,* 2019). From this perspective, there may be other factors that are more important in determining injury risk.

Age

Age is a well-established intrinsic factor associated with RRIs. A systematic review and meta-analysis, including 109,906 participants from 23 studies by Lopes *et al.* (2019), examined the association between age and injury risk in runners. They found that older age (40 years and older) was associated with a higher (1.5–2.0 times higher) injury risk. Lopes *et al.* (2019) concluded that increased age factors such as decreased muscle strength, slower reaction times, and reduced joint mobility also came into play, thus contributing to higher injury rates. The risk profile of older runners also varied when other factors were included in the analysis. For example, older runners who also engaged in long-distance running had a higher risk of injury relative to those who ran shorter distances. Elsewhere, in a study involving 569 runners with a mean age of 32.7 years [range 18–65 years] in Saudi Arabia, El-Metwally *et al.* (2015) again found age to be a significant predictor of RRIs. In this study, the odds of injury increased by 1.3 for every one-year increase in age. While emphasising the importance of age in profiling one's injury risk, the study also emphasised the need to consider its interactivity with other variables such as sex, height, body mass index (BMI), and running on hard surfaces. Other studies also emphasised the strong positive association between age and RRIs, including Owoeye *et al.* (2018) in Nigeria and Yamato *et al.* (2015) in Japan.

Only a few studies have established an inverse or no relationship between age and RRIs. These include a study in Spain by Bonnaci *et al.* (2017) that established that older runners over 50 years of age had a 46% lower risk of injury compared to runners between the ages of 18 and 29. While Bonnaci *et al.* (2017) attempted to control for the confounding effects of other variables such as sex, previous injury history, and weekly mileage, like other studies arriving at a similar conclusion (van Gent *et al.,* 2007; Taunton *et al.,* 2003), their study has been flagged for selection bias and inadequate controls. To support their findings in their study among 532 novice runners in the Netherlands, van Gen *et al*. (2007) suggested the older runners' lower risk of injury be associated with their better understanding of their physical limitations, hence the increased likelihood of adhering to injury prevention precautions when running, including warming up and gradually increasing mileage and intensity. Ferber *et al.* (2019) also argued in their study that, compared to younger runners, older runners had better musculoskeletal health and conditioning, which helped protect against injury. In their study of the incidence and characteristics of RRIs in runners of different ages, genders, and ethnicities in the United States, Krabak *et al.* (2020) concluded that relative to younger runners, older runners had better muscle strength and joint stability, which helped prevent injuries.

While examining the influence of age on RRIs, it is interesting to note that several scholarships recognise the complexity of the relationship. A variety of factors potentially impacting the relationship, such as genetics, lifestyle factors, and training habits, have hardly been interrogated.

Body Mass Index (BMI)

Findings on the relationship between BMI and RRIs are mixed. While other studies have identified a positive relationship between BMI and RRIs, others have found no statistically significant association. In their systematic review study, Saragiotto *et al.* (2014), for example, established that for every 1 unit increase in BMI, there was a 6% increase in the risk of injury, including overuse and traumatic injuries. The authors suggested that a higher BMI led to increased loading on the lower extremities, altered biomechanics, and reduced joint range and motion, hence the increased risk of injury. Using standard BMI measurement procedures, Bonnaci *et al.* (2017) found that "overweight" runners (greater than 25 kg/m2) had a 30% higher risk of injury relative to those classified as "normal" (less than 25 kg/m2). Meanwhile, those classified as "obese" (30 kg/m2) had a 50% higher risk of RRIs relative to those who had a "normal" BMI. In their conclusion, the authors suggested that a higher BMI led to greater impact forces on the lower limbs and joints during running, thereby increasing the risk of injury.

However, several studies have contrasting findings. After adjusting for age, running experience, and other potential confounding factors, Buist *et al.* (2015), for example, found no statistically significant relationship between BMI and RRIs. Reflecting on the findings, the authors suggested that the absence of an association may have been because the study population consisted of female recreational runners who overall had lower BMI values relative to the more competitive elite runners. Similarly, Videbaek *et al.* (2015) found no association between BMI and RRIs among novice female runners. In addition to the fact that most of their participants had a lower BMI, the authors also suggested that their study may have been underpowered to detect a significant association. While their sample size of 930 may be comparably higher than samples elsewhere, it is plausible that it may not have been large enough to detect a significant effect. The study also noted that novice runners could have gradually increased their training volume and intensity, which allowed their bodies to adapt and reduce the risk of injury. Finally, with a longer follow-up period, they also suggested that their 14-week study could have yielded different results.

Psychosocial Factors

Several studies have attributed RRIs to psychosocial factors. Psychosocial factors are a combination of psychological and social factors that are thought to influence the runner's thoughts, emotions, and behaviours. Other psychosocial factors that have been studied concerning RRIs include anxiety, stress, depression, perfectionism, and coping strategies.

High levels of stress, for instance, were found to be associated with greater injury risk among 185 collegiate cross-country runners in the US (Raglin *et al.,* 2017). Relative to runners who had low levels of stress, those who reported being stressed were nearly three times more likely to incur injuries. The study established impaired cognitive function and decision-making, reduced muscle function, and altered hormonal responses as possible mechanisms through which the relationship between stress and running-related injury was mediated. Wolgat *et al.'s* (2015) study also established a similar detrimental effect stress had on runners. In this study, athletes with higher anxiety scores were more likely to experience overuse injuries, while those with higher depression scores were more likely to experience acute injuries. The authors suggested that psychological factors such as stress were likely to lead to athletes' poor decision-making and training choices, such as pushing too hard and ignoring pain, which all elevate injury risk. Additionally, these factors were suggested to impact individual performance by disrupting sleep patterns, causing fatigue, and reducing motivation. Koutakis *et al*. (2015) also suggested that higher levels of stress increase levels of cortisol, a hormone that, if released in excess, can impair the body's ability to heal and recover from injuries.

"Perfectionism," the tendency to engage in excessive and compulsive behaviour, is another psychosocial factor that has been examined closely concerning the incidence of RRIs. According to Hill *et al.* (2019), perfectionists tend to have an unrelenting desire to achieve their goals, which can lead to inflexibility in adjusting training schedules whenever required and a tendency to overcommit. In their study among 50 elite runners in Sweden, Ivarsson *et al.* (2015) found that runners with high levels of perfectionism were more likely to set overly ambitious goals and engage in excessive training, which led to physical and psychological stress. Ronkainen *et al*. (2020) discovered similar results among Finnish runners, who were more likely to burn out and suffer injuries because of their high levels of perfectionism.

Elsewhere, studies have focused on how specific stress or emotion-copying mechanisms can contribute to RRIs. Johnson *et al.* (2017) found that runners who used "avoidance" as a stress-copying mechanism were more likely to experience RRIs compared to those who were emotion-focused. Avoidance was noted as a stress coping mechanism in which a runner either frequently engaged in wishful thinking or denied the existence of a problem when faced with one. Emotion-focused responses, on the other hand, involved acknowledging the existence of problems and managing the emotional response to the stressor, such as using relaxation techniques or actively pursuing emotional support.

Overall, there appears to be a consensus among studies that an individual's response to stress, and injury-related situations influences their injury risk and ability to rehabilitate. Most of the research appears to encourage problem-focused coping strategies, such as pursuing resources to address the issue.

Foot arch height, pronation, and supination

Foot arch height, pronation, and supination are biomechanical factors that can influence running mechanics and increase the risk of RRIs. In general, research suggests that the arch of the foot is an important determinant of injury as it is made up of bones, ligaments, and tendons that form a natural shock absorber during running. On the one hand, having flat feet (classified as low arches) is suggested to increase ankle stress and knee joint stress, which makes the runner susceptible to injury (Sousa *et al*., 2019). According to Buldt *et al.* (2015), flat-footed athletes had a higher risk of developing plantar fasciitis and medial tibial stress relative to athletes with different foot types. According to the study, overpronation, a condition in which the foot rolls too far inward, often results from flat feet, which are characterised by a very low or no arch at all, causing the entire sole to touch the ground and raising the risk of injuries.

Having cavus feet (classified as high arches), on the other hand, has been associated with poor shock absorption and an increased risk of stress fractures (Ribeiro *et al.,* 2017). In this systematic review, high-arched individuals were more likely to experience injuries to the lateral (outer) side of the foot and ankle, such as lateral ankle sprains and perineal tendonitis, relative to those with neutral or normal foot arches. High-arched participants' high risk of injury was attributed to their feet' limited flexibility, which made them more prone to twisting and rolling during running *(supination).* In their study involving 5,272 military recruits followed up over 3 months, high-arched recruits were more than twice as likely to develop stress fractures in the lower leg bones compared to those with normal arches. The study suggests that high arches may lead to increased loading of the bones and muscles in the lower leg, which can increase the risk of stress fractures.

Other intrinsic factors

There are other intrinsic factors associated with RRIs. These include leg length discrepancy, joint mobility and stability, ankle dorsiflexion range of motion, genetic predisposition, and muscle imbalance. This section briefly discusses studies on the factors mentioned and how they may lead to musculoskeletal injuries.

A study by Lopes *et al.* (2019) found that leg length discrepancy is also another risk factor associated with RRIs. Leg length discrepancy occurs when one side of the opposing muscles is stronger than the other. It usually occurs when muscles on one side are used a lot more than those on the other. Eventually, muscles on the other side grow weaker, longer, and looser. Studies show that rigorous physical activities, including running, often lead to injuries such as hip flexor tendonitis, knee and ankle issues, quadriceps, hamstring, and calf strains, and Achilles tendonitis, amongst others.

Genetic predispositions may also lead to RRIs. Genetic predispositions refer to an increased chance or likelihood of developing a particular disease based on the presence of one or more genetic variants and family history suggestive of an increased risk of the disease. In a study by McCabe and Collins (2018) on the association of genes and injury in professional and semi-professional athletes, four genes were assessed in relation to injury. The TT (nucleobase) genotype of the GDF5 gene, the TT and CT (nucleobase) genotypes of the AMP gene, the TT (nucleobase) genotype of CO5A1, and the GG (nucleobase) genotype of the IGF2 gene were all found to be linked to injury. These genes are mostly associated with knee and ankle injuries. A study by Small and Relph (2017) hypothesised a connection between anatomy and physical fitness because genetics (genotype) heavily influences' the body's development and formation (phenotype). Results from this study indicated that individuals with a weak musculoskeletal makeup are most likely to have reduced physical fitness and, consequently, are most likely to suffer from injuries after rigorous physical activities.

Additionally, Lopes *et al.* (2019) noted that muscle imbalances can lead to some RRIs. Muscle imbalance occurs when one side of the opposing muscles is stronger than the other. It usually occurs when muscles on one side are used a lot more than those on the other. Eventually, muscles on the other side grow weaker, longer, and looser. Lopes *et al.* (2019) found that rigorous physical activities, including running, often lead to injuries such as hip flexor tendonitis, knee and ankle issues, quadriceps, hamstring, and calf strains, and Achilles tendonitis, amongst others.

Some RRIs are also a result of other intrinsic factors, such as joint range of motion and stability. Joint stability is the ability of a joint to remain in a fixed position and resist unwanted movement. Mobility, on the other hand, is the ability of a joint to move freely through its range of motion. A systematic review carried out by Smith *et al*. (2019) predicted lower extremity injuries in recreational runners and found that strong hip abductors were significantly associated with RRIs. The study also found that optimal muscle strength, flexibility, range of motion, and alignment were linked with physical fitness. At the same time, extremes on either end were associated with musculoskeletal injuries in recreational runners.

Dorsiflexion is also another intrinsic factor that may be associated with RRIs. Dorsiflexion range of motion (DFROM) is the movement of the foot upwards so that the foot is closer to the shin. The American Academy of Orthopaedic Surgeons and the American Medical Association generally accept the normal range of motion for ankle dorsiflexion as 20 degrees. Taylor *et al.* (2021) concluded that lower levels of both ankle DFROM and DF%USED are associated with biomechanics considered to be associated with a high risk of sustaining injury. However, the study could not establish whether reduced DFROM from dynamic movements is due to restrictions in joint motion or underutilisation of available ankle DFROM.

2.5. TOOLS USED TO SCREEN FOR RUNNING-RELATED INJURIES AND RISK FACTORS.

To understand the prevalence and determinants of RRIs, it is imperative to understand the different methodologies and instruments that are utilised. A routinely used approach is the implementation of surveys and questionnaires, as illustrated in the study of Smith *et al.* (2019). Their survey approach, distributed to a diverse group of recreational runners, allowed for the collection of a wide range of information on running habits and injury occurrences. However, the reliance on self-reports raises issues regarding recall accuracy, a challenge noted in the Saragiotto *et al*. (2016) study. Participants in this study were asked to recall specifics about their training regimens and injury history, highlighting potential limitations in the quality of such retrospective data collection.

Elsewhere, prospective cohort studies have been noted as offering an additional effective method for evaluating injuries connected to running. In a prospective study, Lopes *et al.* (2019) tracked a group of marathon runners for six months, documenting their training activities and any injuries they experienced. This method allows for the identification of chronological relationships between training parameters and instances of damage. Nevertheless, prospective studies, like the one conducted by Small and Relph (2017), are prone to dropout rates, particularly among those who sustain injuries, which might introduce possible bias to the results.

Critical to the evaluation of instruments utilised for determining prevalence and risk is the validity and dependability of findings. To strengthen the credibility of their findings, Bonnaci *et al.* (2017) utilised a triangulation strategy that combined clinical evaluations and participant surveys. However, contradictions between participant self-reports and clinical assessments suggest possible constraints on the reliability of the data. on the other hand, assessed the correlation between running form and injury through the utilization of biomechanical analysis in conjunction with objective measurements, including force plates and motion capture systems. These findings underscored the necessity for more objective evaluations in comprehending injury mechanisms, as they uncovered feeble correlations between subjective reports and objective measures. The detailed enumeration and interpretation of data pertaining to RRIs are complicated tasks, as these methodological considerations underscore.

On another hand, qualitative techniques are also employed and are crucial in gaining a deeper comprehension of the subjective experiences and environmental elements linked to RRIs. Smith *et al.* (2018) conducted in-depth interviews with injured runners to investigate the psychosocial dimensions of their injury experiences. This qualitative methodology facilitated the detection of subtle elements, such as obstacles related to motivation, emotional reactions, and the dynamics of social support, which quantitative techniques could disregard. Nevertheless, it is crucial to acknowledge that qualitative research frequently includes smaller sample sizes, hence restricting the extent to which the findings may be applied to a broader population.

Aside from interviews, narrative analysis has been utilised to extract comprehensive narratives from injured runners, providing insights into their understanding of causes, rehabilitation procedures, and the influence of injuries on their running identity (Johnston *et al.,* 2020). These qualitative insights enhance our comprehensive understanding of the injury experience, but they are essentially subjective and dependent on the specific situation.

Mixed methods approach, on the other hand, which integrate qualitative insights with quantitative measures, are also expected to offer a comprehensive understanding of RRIs, as illustrated by the research of van der Worp *et al*. (2016). In this study, injury data for this study were gathered through the administration of a survey; subsequent interviews delved into the contextual factors and individual experiences. In addition to augmenting comprehension, the integration of methodologies enables the verification and triangulation of findings, thereby mitigating potential biases that may arise from the use of isolated approaches.

Despite the acknowledged strengths, qualitative methodologies also pose difficulties concerning replicability, standardisation, and the possibility of researcher bias. To address these apprehensions, scholars, including Nielsen *et al.* (2021), have implemented stringent qualitative approaches, such as member-checking and inter-rater reliability evaluations, to bolster the credibility of their qualitative results. In summary, the incorporation of qualitative methodologies provides a comprehensive understanding of the intricate characteristics of RRIs, thereby augmenting the current corpus of knowledge with significant contributions.

2.6. THEORETICAL FRAMEWORK: THE BIOPSYCHOSOCIAL MODEL

The biopsychosocial model is a theoretical framework that has been widely used in health and medicine to explain and treat a wide range of health issues, including injuries. The model proposes that health and disease result from complex interactions between biological, psychological, and social factors. In the case of RRIs, the model shows that a comprehensive approach is needed to understand and deal with multiple arrays of factors that affect injury risk, occurrence, and recovery. Multiple interacting factors, including biomechanical, psychological, and social factors, are frequently responsible for RRIs, according to research (Gijon-Nogueron & Meeusen, 2021; Saragiotto *et al.,* 2016).

The significance of examining both physical and psychological variables in injury prevention and treatment is a crucial feature of the biopsychosocial paradigm as it relates to RRIs. While biomechanical aspects like foot mechanics and running form have long been recognised as major factors in injury risk, research has also revealed that psychological factors such as stress and anxiety can play a role in the persistence of injuries. Psychological factors have been demonstrated in studies to increase injury risk by modifying running mechanics and raising muscle tension, and addressing psychological issues with therapies such as cognitive-behavioural therapy can be beneficial in reducing injury risk.

In the context of RRIs, the recognition that social and environmental factors can contribute to injury risk is a crucial aspect of the biopsychosocial model. For example, studies have shown that training volume, running surface, and social support all play a role in injury risk and that addressing these factors through interventions such as training modifications and social support programmes can be effective in reducing injury risk and promoting recovery.

Overall, the biopsychosocial model offers an ideal framework for comprehending the complex and multifaceted nature of RRIs, as well as devising more comprehensive approaches to injury prevention and treatment. Researchers and clinicians can develop more effective techniques for lowering injury risk, boosting recovery, and improving general health and well-being in runners by considering the interplay of biological, psychological, and social components.

2.7. CONCEPTUAL FRAMEWORK: THE BIOPSYCHOSOCIAL MODEL

This study defines RRIs because of the interplay between socio-demographic, physical, and environmental factors, based on the biopsychosocial model of health. The prevailing literature identifies gender, age, level of competitiveness, leg dominance, and body mass index as significant socio-demographic characteristics. Conversely, physical, and environmental elements encompass the state of the shoes, the incline of the running path, the type of running, the type of surface, and the frequency of weekly runs. The occurrence or non-occurrence of any combination of the elements may result in the development or prevention of RRIs as illustrated in Figure 2.2. This study aimed to investigate the relationship and mechanisms by which these variables combine to cause running-induced injuries among athletes in Soweto.

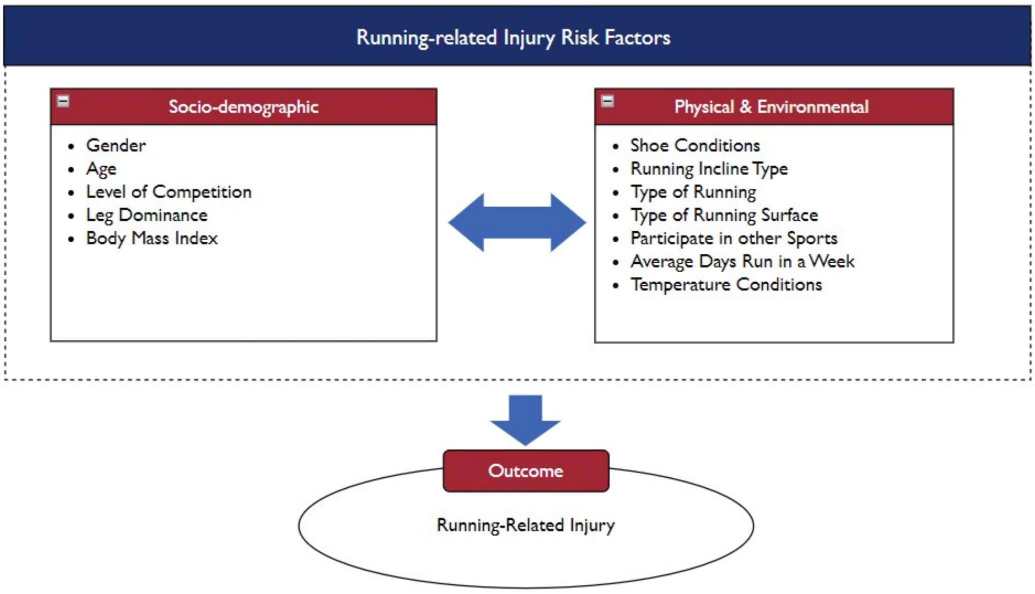

Figure 2.2: Conceptual Framework for running-related injuries (Adapted from the Biopsychosocial Model of Health, 2010)

2.8. CHAPTER CONCLUSION

This chapter has provided a literature review on the prevalence of RRIs on a global, regional, and local scale. In addition, the chapter discussed the risk factors for RRIs. The chapter specifically discussed the extrinsic and intrinsic factors identified in the literature as being associated with RRIs in professional and recreational runners. The chapter concluded with a discussion of the biopsychosocial model and a listing of the model's factors that may be relevant to the study.

CHAPTER 3: METHODOLOGY

3.1. INTRODUCTION

This chapter focuses on the methodology employed in investigating the extrinsic and intrinsic factors associated with running-related injuries (RRIs) among recreational and professional runners in Soweto, South Africa. It outlines the cross-sectional study design followed and provides justification for why the study design was used. The chapter also provides a detailed description of the study area, study population, data source, and analysis plan, among other methodical processes. Finally, the chapter explores the ethical considerations that were followed primarily in the data collection phase of this research.

3.2. DESCRIPTION OF THE STUDY AREA

Soweto, a sprawling township in South Africa's Gauteng province, is renowned for its rich heritage and diverse population (Wilmot *et al*., 2014; Maharaj, 2018). Numerous South African ethnic groups, including Zulu, Xhosa, Sotho, and Tswana, are represented in the township, resulting in a culturally diverse tapestry. The socioeconomic status of the population varies widely, with some areas characterised by informal settlements and destitution and others by middle-class neighbourhoods and affluent areas (Gordon, 2019; Le Roux, 2013). This diversity provides a chance to investigate the impact of socio-cultural influences on health-related outcomes, including RRIs. Figure 3.1 displays a general map of Soweto, highlighting its location within the Gauteng Province of South Africa, along with its main features, including major roads and residential areas.

Geographically, Soweto is in an urban environment containing a variety of residential areas, commercial districts, and open spaces. The varied terrain in Soweto, which includes both flat and mountainous sections, offers runners a variety of challenges and training opportunities. Running on inclines or irregular surfaces can place additional stress on the muscles and joints, which can have a significant impact on running performance and injury risk. Moreover, Soweto features a unique combination of urban and natural elements. Runners in Soweto can explore a variety of running routes that traverse not only the township's streets but also parks, recreational areas, and scenic landscapes (Shaw *et al.,* 2004). These routes may include paved highways, gravel paths, and even dirt trails, adding an element of adventure and variety to the experience of running. The type of terrain and surface can affect foot strike patterns, impact forces, and overall running biomechanics.

According to Chikoko *et al.* (2016), Soweto is also a culturally rich and ethnically diverse community, with residents of various ethnicities and traditions. The cultural diversity of Soweto affords the opportunity to investigate the impact of cultural factors on health-related outcomes, such as RRIs. In addition, the historical significance of Soweto during the apartheid era has been extensively studied in the context of health and well-being. Mabaso and Madiba (2018) emphasised the impact of historical factors on health disparities and access to healthcare services in Soweto.

Numerous studies have also acknowledged Soweto’s strong sense of community engagement and sporting culture. Steyn *et al.* (2015) have also referenced the availability of athletics and sporting facilities as ideal for studying specific risk factors associated with injuries among professional and amateur runners. In this context, Soweto is well-known for its association with numerous athletic competitions, including the world-famous Comrades Marathon. The ultramarathon, which attracts thousands of runners across the globe, is one of the most famous and prestigious long-distance races.

In addition, Soweto also hosts several other significant athletic clubs’ competitions and activities throughout the year. These events, such as the Soweto Marathon, also attract a wide spectrum of participants, from elite athletes to recreational runners, demonstrating the region's thriving running culture.

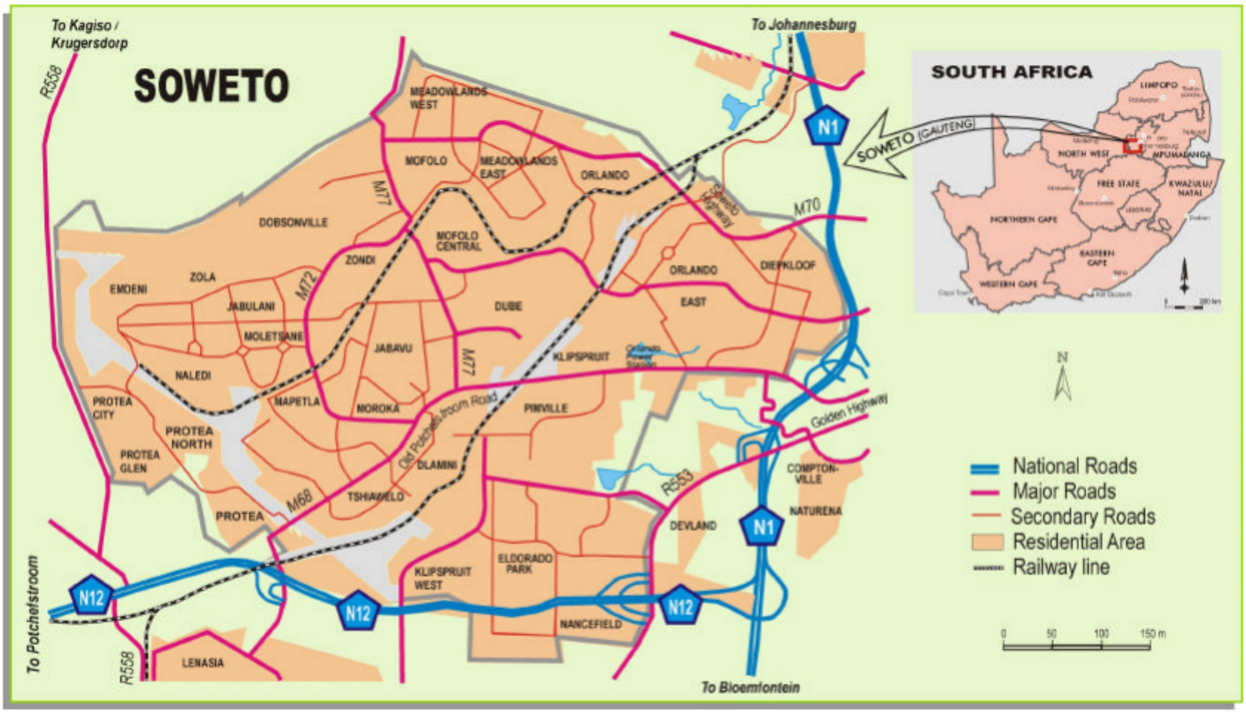

Figure 3.1: Map of Soweto Township and Main Areas; Source: South Africa Maps Co, 2018.

3.3. STUDY DESIGN

To determine the prevalence and risk factors associated with RRIs, a cross-sectional design was utilised in this study. In a cross-sectional study, data are collected at a specific time point from a sample of participants, allowing for the evaluation of various variables and their prevalence or distribution within the study population (Hulme *et al., 2017*). Employing a cross-sectional study design provided several benefits for the present study. First, it provided a snapshot of the demographic profile, sports-specific history, and RRIs of participants at a particular moment, enabling a comprehensive comprehension of these factors within the given timeframe (Hulme *et al.,* 2017; Szklo & Nieto, 2014).

In addition, a cross-sectional design allowed for the efficient capture of data, as it only required a one-time evaluation of participants without the need for long-term follow-up. This made it possible to collect data from a comparatively large sample within a reasonable amount of time and financial resources (Hulme *et al.,* 2017). Additionally, a cross-sectional design facilitated the investigation of relationships between variables by simultaneously collecting data on potential risk factors and their association with RRIs. This allowed for data analysis and examination of the relationships without the need for extended follow-up periods or additional data collection cycles (Hulme *et al.,* 2017; Szko & Nielson, 2014).

In summary, the use of a cross-sectional study design in this investigation yielded insightful information regarding the demographic profile, sports-specific history, and prevalence of RRIs among the participants. It provided efficiency in data collection, enabling an exhaustive assessment of multiple variables and their associations within a specific time frame (Hulme *et al.,* 2017; Szklo & Nieto, 2014).

3.4. STUDY POPULATION

The population of interest for this study were adult males and females who were engaged in professional and recreational running activities. It consisted of individuals of various ages, ethnicities, and socioeconomic circumstances who participated in running events and activities in the Soweto neighbourhood.

Specifically, the study targeted six athletic clubs in Soweto. Members of these clubs were both male and female runners between the ages of 18 and 60 who participated in different types of running activities and competed at different levels. According to the Central Gauteng Athletic Association (CGA) (a professional association in charge of running in the area), there were 585 athletes registered, but 220 were active members in 2022.

Table 3. 1 Distribution of the target population

#	Clubs	Total Number of Runners (Population)	Active Number of Runners
1	Soweto Athletic Club	120	40
2	Orlando Athletic Club	200	70
3	Soweto Cabal Club	60	27
4	Diepkloof Athletics Club	150	60
5	Soweto Hearts Athletics Club	25	11
6	Meadowlands Athletics Club	30	12

Table 3. 2 Inclusion and Exclusion criteria of the study

Inclusion Criteria	Exclusion Criteria
- Active Soweto club runners registered with Central Gauteng Athletic (CGA). - Runners aged between the ages of 18 and 60. - Runners engaged in running activities professionally or recreationally.	- Participants with pre-existing conditions or injuries (degenerative conditions or traumatic) that could have had a substantial effect on their RRIs or confounded the results. - Also excluded runners with less than three months after surgery.

3.5. SAMPLING AND SAMPLE SIZE

Participants in this study were recruited using a purposive sampling method. Purposeful sampling, which is the deliberate selection of participants who meet specific criteria, allows for the achievement of a final sample size of 84 participants out of 233 population, according to the Raosoft tool. Purposeful sampling allowed for the selection of participants based on specific criteria, ensuring the representation of subgroups within the target population (Creswell, 2014). Given the difficulties encountered in recruiting a larger sample size, it was determined that participants would be purposefully selected to satisfy the study's requirements and objectives.

This method allowed for a concentrated and in-depth examination of the research questions while still ensuring the diversity of the sample. The purpose of this study was to collect a variety of perspectives and experiences regarding RRIs among recreational and professional athletes. While the sample size may be smaller than initially recommended, the strategy of purposive sampling ensured the inclusion of relevant participants. It made a comprehensive analysis of the study's objectives possible. This was achieved by having predetermined inclusion and exclusion criteria based on age, running activity, and residence.

3.6. DATA COLLECTION TOOL

The researcher designed a self-administered questionnaire to collect the data for this study. The questionnaire was developed based on extant literature and validated instruments commonly employed in research studies (Brunet *et al.*, 1990; Van Der Worp *et al.,* 2015; Kunene *et al.,* 2018).

There were four sections in the questionnaire. Section A focused on collecting demographic information from the participants, such as age, gender, race, hand dominance, height, and weight. Section B focused on the sports-specific background of the participants, including running mode, participation level, and years of running experience. Section C consisted of questions regarding the prevalence of RRIs and treatment history for various body regions, including the foot, ankle, shin, knee, thigh, hip, groin, buttocks, iliotibial band (ITB), and low back. Section D explored the risk factors associated with RRIs, including running load, participation frequency, environmental conditions, equipment used, and running methodologies.

To ensure the questionnaire's validity and quality, a rigorous procedure was followed. Three experts in sports rehabilitation evaluated the initial questionnaire draft to evaluate its content and face validity. Their comments and suggestions were incorporated into the questionnaire to enhance its clarity and applicability.

3.7. PILOT STUDY

A pilot study was conducted to evaluate the questionnaire's suitability and readability among participants. Inviting approximately 10% (n=9) of the total sample size from the target population to participate in the pilot study helped determine the time required for respondents to complete the questionnaire efficiently. This pilot size was chosen to provide a manageable yet representative subset of the target population, allowing any problems with the questionnaire to be recognised and resolved prior to the full-scale study. Following the pilot study, the collected data were analysed to evaluate the performance of the questionnaire and identify any necessary revisions.

It is noteworthy to emphasise that there were no significant alterations made to the original questionnaire. The modifications implemented mostly aimed at rectifying potential typographical and grammatical errors, as well as consolidating two analogous questions identified in separate sections of the questionnaire into a single question. Also, the initial edition of the questionnaire had demographic components, such as information regarding the respondents' marriage status, occupation data, and marital status. The pilot analysis revealed that certain non-essential demographic factors were causing unneeded elongation. Consequently, these less important demographic factors were eliminated following the initial study, making the questionnaire more efficient.

The final version of the questionnaire comprised 27 closed-ended questions across various sections, as well as four auto-generated questions, such as the survey's start and end times.

3.8. DATA COLLECTION PROCEDURE

The researcher obtained ethical clearance from the Witwatersrand Human Research Ethics Committee (HREC) prior to collecting data. The committee played a crucial role in assuring the ethical integrity of the collection of primary data for this study by evaluating the research protocol and ensuring that the participant's rights and welfare were safeguarded. The credibility of the committee was essential for establishing ethical standards and ensuring that all research involving human subjects is conducted without risk (World Medical Association, 2013).

The Central Gauteng Athletic (CGA), an organisation that represents athletes in the Soweto area, granted permission to conduct the study among Soweto running clubs. This approval not only helped increase the study's credibility and legitimacy within the athletic community but also provided access to a targeted group of participants. The administrators and coaches of the GCA played a crucial role in assisting the researcher with the database for contact details of the Soweto running clubs.

Subsequently, the researcher reached out to the identified participants via various channels of communication, such as phone calls, emails, and in-person meetings. During these interactions, the purpose of the study, the data collection procedure, and the voluntary nature of participation were explained. In addition, the researcher addressed any concerns or queries the participants had and obtained their informed consent to participate.

The questionnaire was administered utilising the RedCap online platform to ease data capture and provide quality assurance. RedCap provided a safe and easy-to-use interface for participants to complete the questionnaire, as well as effective data storage and monitoring during the study. For example, at one stage, a problem was observed in which some participants had difficulty completing a specific component of Section B of the questionnaire. A previously unanticipated glitch was detected, which resulted in specific participants encountering challenges when attempting to provide precise responses in this section. The problem was promptly rectified by disseminating focused information, which included a comprehensive manual, to the individuals who were impacted. The provision of explanation and support materials facilitated the smooth navigation of this portion by participants, hence preserving the integrity of their responses. The ability to address difficulties demonstrates the importance of real-time monitoring tools quickly and effectively in improving the quality of data and the experience of participants during data collection.

Overall comprehensive strategy was implemented to improve participant engagement and data quality during the data-gathering process. To encourage timely completion of the questionnaire, reminders were issued to participants via several methods, including email, WhatsApp, and Short Message Services (SMS). The questionnaire was made available to participants for two weeks, allowing them the flexibility to complete it at their convenience. To establish clear expectations, participants were notified during the initial communication that, on average, the questionnaire would require roughly 15-20 minutes to finish. Nevertheless, it was noted that certain participants finished the questionnaire in considerably less time, suggesting the possibility of rushed responses. To tackle this problem, a subsequent correspondence was dispatched to those who had very brief durations for task completion. The participants were prompted to consider the significance of well-considered and precise answers and were motivated to review the questionnaire if needed. This proactive strategy was implemented to guarantee the integrity and dependability of the collected data.

In contrast, a comparable follow-up was undertaken for participants who took an exceptionally extended period to complete the questionnaire. The participants were contacted to inquire about any difficulties encountered during the completion procedure. This individualised interaction facilitated the identification and resolution of problems, guaranteeing a more nuanced comprehension of the participants' perspectives. Furthermore, the comments received from participants who took a longer time have offered useful insights that can be used to enhance future studies, thus contributing to the continuous improvement of data-gathering procedures. The objective of this interactive and responsive strategy was to maximise the accuracy of the data collected and improve the overall experience for participants.

3.9. DATA ANALYSIS

The analysis plan for this study followed a systematic and structured approach to address the research objectives. STATA, a licensed software programme chosen for its ability to assure reproducibility through code-based analysis, was primarily used to conduct the analyses. The following table shows how data was analysed per objectives:

Table 3. 3 Analysis plan

Objectives	Variables	Type of data	Analysis
Determine the demographic characteristics of recreational and professional runners.	Independent variable: age, gender, race, running experience, hand dominance, weight, and height.	Numerical and Categorical	Descriptive statistics, e.g., frequencies mean standard deviations, etc.
Determine the sport-specific background of recreational and professional runners.	Independent variable: sports history	Numerical and Categorical	Descriptive statistics, e.g., frequencies mean standard deviations, etc.
Determine the prevalence of RRIs among participants.	Dependent variables: running injuries.	Numerical and Categorical	Descriptive statistics, e.g., frequencies mean standard deviations, etc.
Identify intrinsic and extrinsic risk factors for RRIs among participants.	Independent variable: risk factors.	Numerical and Categorical	Descriptive statistic: frequencies. Inferential statistics: Chi-square tests, odds ratios, and a logistic regression.
To find a relationship between demographic characteristics, sports background, prevalence, and risk factors.	Dependent variables: risk factors Independent variables: the level of competition, age, gender, race, running experience, hand dominance, weight, and height.	Numerical and Categorical	Inferential statistics, e.g., Pearson Chi-square, Person correlation coefficient & linear, logistic regression.

A secondary data processing phase was added to ensure the clarity and readability of the results.

STATA tabular outputs that were relevant were copied and pasted into Excel for data cleansing and customisation. Unnecessary fields were eliminated, and tables were structured to improve the display. Additionally, charts and graphs were customised in Excel to convey the findings effectively.

CHAPTER 4: RESULTS

4.1. INTRODUCTION

This chapter presents the results derived from the investigation of the risk factors associated with running-related injuries (RRIs) among beginners and professional-level runners in Soweto, South Africa. It is structured into three distinct sections. The initial section concentrates on the demographic profiling of the participants, including an examination of the sport-specific backgrounds of recreational and professional runners. The second section presents the prevalence and characteristics of RRIs among participants. Lastly, the third and final section of this chapter entails a comparative analysis of the risk factors for RRIs, disaggregating these by competition level.

4.2. DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS

The study's participant distribution exhibited a balanced gender split, with 51% (n=43) being female and 49% (n=41) male among the 84 participants. According to the analyses, 73% (n=61) of participants were 25 years of age and older, while 27% (n=23) were below the age of 25. Furthermore, 54% (n=47) of participants were classified as right-legged, whereas 44% (n=37) identified as left-legged.

Focusing on the demographic profiles of participants by competition level reveals a stark disparity between the proportion of female and male runners (Table 4.1). At the beginner level, there is a higher proportion of female runners (53.4%, n = 31) compared to beginner-level male runners (46.6%, n=12), indicating a greater female presence in this category. Conversely, at the professional level, the situation is reversed, with a higher percentage of male runners (53.8%, n=14) compared to female runners (46.1%, n=12). Notably, when looking at the total number of runners at each level, there are 31 female beginner runners and 12 female professionals. In contrast, at the beginner level, there were 27 male competitors, and at the professional level, there were 14 male competitors. This overall distribution demonstrates a greater total number of female runners, but their concentration is predominantly in the beginner category.

Table 4. 1 Profile of the demographic characteristics of participants by competition level (n=84).

	Beginner % (n)	Professional % (n)	Total	Chi2 p-value
Gender				
Male	46.6% (27)	53.8% (14)	41	
Female	53.4% (31)	46.1% (12)	43	0.53
Age				
25 and below	29.3% (17)	23% (6)	23	
Over 25 Years	70.7% (41)	76.9% (20)	61	0.55
Body Mass Index				
Underweight	13.7% (8)	7.6% (2)	10	
Normal	39.6% (23)	42.3% (11)	34	0.81
Overweight	20.6% (12)	26.9% (7)	19	
Obese	25.8% (15)	23% (6)	21	

At both the beginner (70.7%, n=41) and professional (76.9%, n=20) levels, a higher proportion of runners were aged 25 and above. Conversely, those aged 25 and under were more numerous and had a higher percentage representation among beginner-level runners (29%, n=17) compared to professional-level runners (23%, n=6). Notably, the difference in age distribution between these two groups approached statistical significance with a p-value of 0.55.

Turning to the Body Mass Index (BMI) category representation, normal-weighted runners consistently made up the largest percentage of both novice (39.5%, n=23) and professional (42.3%, n=11) runners (Table 4.1). Interestingly, although not statistically significant ($p = 0.81$), the combined proportional totals of overweight and obese athletes were higher for both beginner and professional-level runners (46.9%, n=27 and 49.1%, n=13respectively). Notably, the proportion of underweight runners was reduced in both the beginner and professional categories, indicating a lower prevalence in these groups.

4.3. SPORT-SPECIFIC CHARACTERISTICS OF PARTICIPANTS

Examining the sport-specific backgrounds of runners at various competition levels, as shown in Table 4.2, reveals notable differences. A greater proportion of beginner runners (86%, n=50) participated in short distance running than professional runners (32%, n=8). In contrast, a larger proportion of professional runners (68%, n=17) preferred long-distance running, whereas only 13.7% (n=8) of beginner runners participated in long-distance events. Notably, a chi-square test (p = 0.000*) revealed that these differences were statistically significant.

Table 4. 2 Profile of the sport-specific history of participants by competition level (n=84)

	Beginner % (n)	Professional % (n)	Chi2 p-value
Type of Running			
Long Distance	13.7% (8)	68% (17)	0.000*
Short Distance	86.2% (50)	32% (8)	
Average Number of Days Run in A Week			
1 Day/Week	20.6% (12)	3.8% (1)	0.002*
2-3 days/week	62.0% (36)	19.2% (5)	
4-5 days/week	17.2% (10)	46.1% (12)	
Participate In Other Sport			
No	67.2% (39)	50% (13)	0.021*
Yes	32.7% (19)	50% (13)	
Type Of Running Surface			
Natural Surfaces	9.6% (6)	14.3% (3)	0.445*
Man Made Surfaces	90.4% (56)	85.7% (18)	
Running Incline Type			
Flat Surface	45.6% (26)	44.0% (11)	0.635
Varied Surface	54.3% (31)	56.0% (14)	
Temperature Conditions			
Cold	10.3% (6)	11.5% (3)	0.870
Hot	89.7% (52)	88.5% (23)	
Sustained Injuries Previously			
No	48.2% (28)	12% (3)	0.041*
Yes	51.7% (30)	88% (22)	
Consulting for injuries			

	Beginner % (n)	Professional % (n)	Chi2 p-value
No	29% (9)	40.9 % (9)	0.368
Yes	70.9% (22)	59% (13)	

** Represents statistically significant result*

Regarding the average number of training days per week, at the beginner level, 20.6% (12) of participants reported running once per week, whereas the majority, 62.0% (36), reported running 2-3 times per week. In addition, 17.2% (10) of beginner-level runners maintained a schedule of running four to five days per week, while none reported running more than five days per week. In contrast, only 3.8% (1) of professional runners ran once per week, while 19.2% (5) ran three times per week. A staggering 46.1% (12) of professional runners trained 4-5 days per week, and a significant 30.7% (8) reported running more than 5 days per week. Also, to note, a chi-squared test (p = 0.000*) demonstrates that these differences in the average number of days run per week are statistically significant.

Examining participants' participation in other sports in addition to running reveals varying patterns at various levels of competition. At the beginner's level, the majority (67.2%, 39) reported no participation in other sports, while a substantial number (32.7%) reported participation in other sports. In comparison, 50% (13) of professional runners reported both participation and nonparticipation in other sports. The observed differences in participation in other sports between the two levels of competition, however, were not statistically significant (p = 0.1333), indicating a balanced distribution.

At the beginner level, 29% (9) reported not seeking consultation for injuries, whereas 70.9% (22) reported doing so. 40.9% (9) of professional-level runners did not seek consultation for injuries, while 59% (13) did so. The lack of statistical significance necessitates caution in interpreting these differences between the two competition levels in terms of injury consultation.

4.4. PREVALENCE AND CHARACTERISTICS OF RUNNING-RELATED INJURIES.

The overall prevalence of RRIs was estimated at 63% (n=53 (Figure 4.3), with no significant difference noted when disaggregated by gender (63% for females; 62% for males).

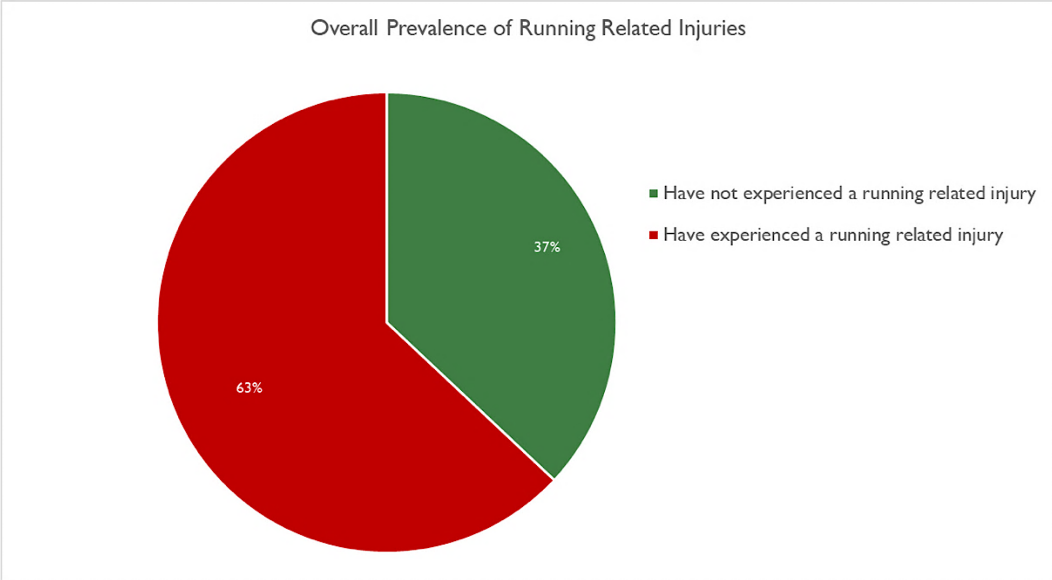

Figure 4.1: Showing the overall prevalence of running-related injuries (n=84)

Interestingly, when disaggregated by level of competition, professional runners had a relatively high prevalence of RRIs (88%, n=22) in comparison with runners who were characterised as "beginners" (52% n=30) (Figure 4.4).

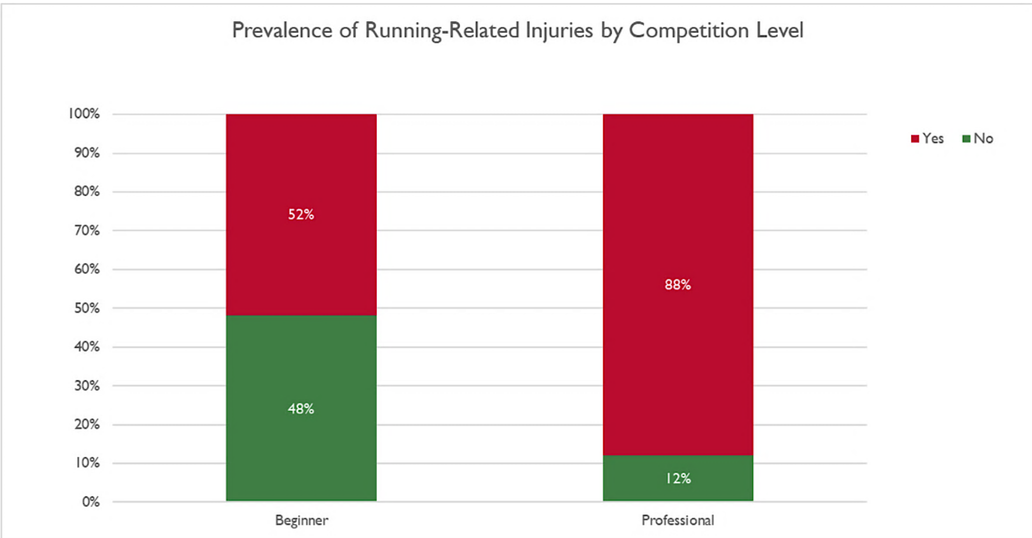

Figure 4.2: Showing the prevalence of running-related injuries by competition level (n=84)

Meanwhile, in terms of age, older runners over the age of 25 had a slightly higher prevalence (63%, n=14) relative to those who were 25 years and younger (61%, n=38).

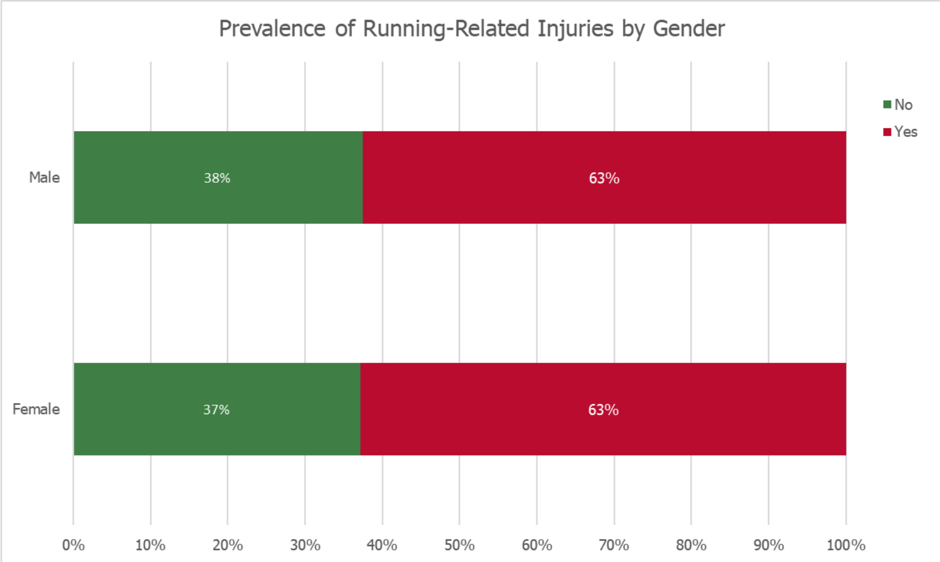

Figure 4.3: Showing the prevalence of running-related injuries by Gender(n=84)

When examined by type of running activity, those engaged in long-distance running had a 60% prevalence rate of RRIs. Those participating in other sports other than running seem to have had greater susceptibility (75%, n=24) to running related injuries, with those not participating in other sports having an estimated prevalence rate of 55% (n=28).

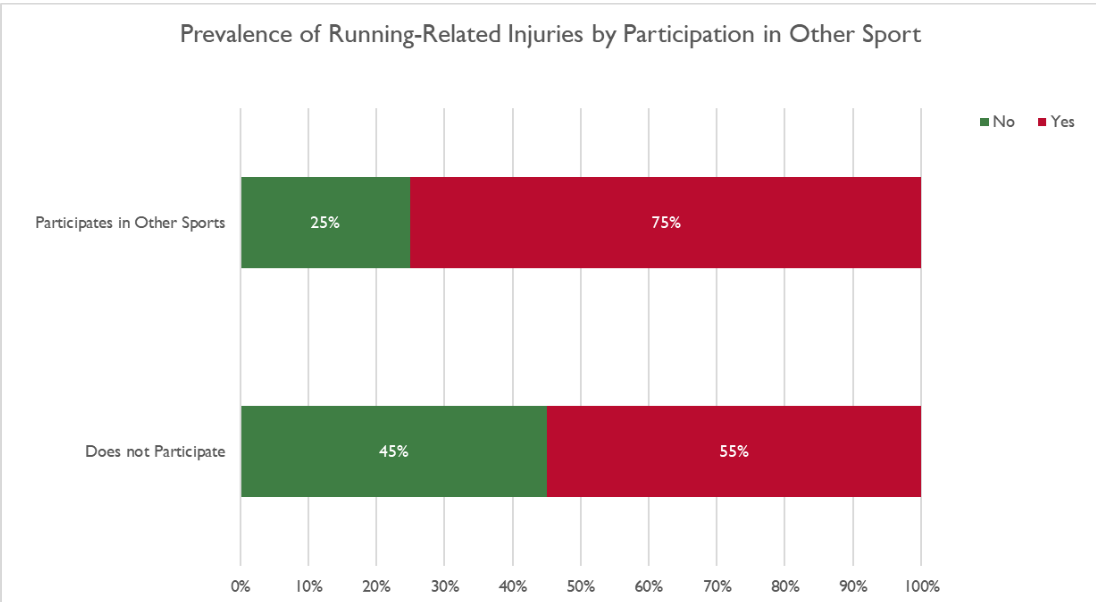

Figure 4.4: Showing the overall prevalence of running-related injuries by Participation in other sports (n=84)

The prevalence of RRIs seems to elevate with every unit increase in the number of days allocated by each participant to running (Figure 4.6). Those running at least once a week had, for instance, an estimated 31% (n=4 prevalence of RRIs, while those running 2-3 days a week had almost double the prevalence (58%, n=23) of RRIs. Meanwhile, dedicated runners committed between 4-5 days of running per week at a prevalence of 77% (n=17), while those running every day had a 100% prevalence.

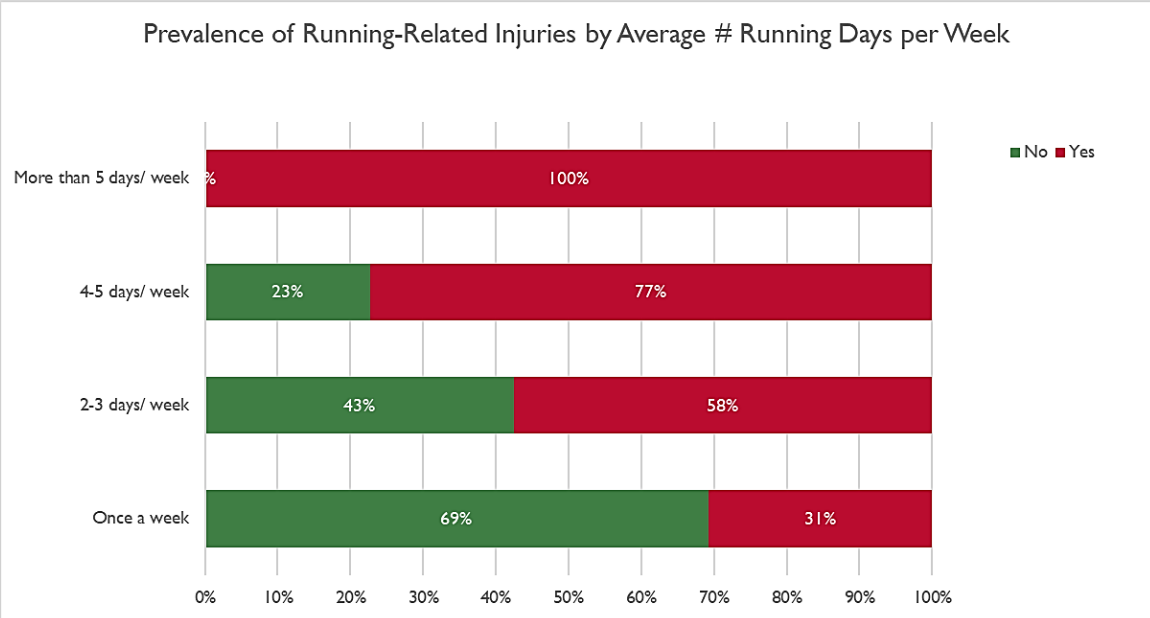

Figure 4.5: Showing the overall prevalence of running-related injuries by average running days per week (n=84)

Meanwhile, the type of running surface did seem to impact the prevalence of RRIs, with those indicating running on "wet surfaces" being more prone (78% prevalence) relative to those who indicated running on "dry" surfaces.

4.5. RISK FACTORS FOR RUNNING-RELATED INJURIES.

The purpose of the third objective was to determine the impact of various factors on the likelihood of sustaining RRIs. The analysis of socio-demographic and environmental factors revealed that the frequency of running days per week increased the likelihood of RRIs (Table 4.3). Individuals who ran 2-3 times per week were 1.75 times more likely ($p = 0.003$) to sustain RRIs than those who ran only once per week. In addition, those who ran 4-5 times per week were nearly twice as likely (Odds = 1.87; $p = 0.021$) to sustain RRIs as those who ran once per week. Although the difference was not statistically significant ($p = 0.234$), individuals who ran virtually every day of the week were up to 2.35 times more likely to sustain injuries related to running.

Furthermore, a significant correlation was found between participation in other sports in addition to running and the risk of RRIs (p = 0.08). Participants who did not participate in other sports had a 0.35 times lower chance of developing RRIs.

Although these results were not statistically significant, the study examined the impact of variables such as temperature conditions during running. Runners in predominantly hot conditions were 1.25 times more likely to sustain a running-related injury than those who ran in temperatures spanning from cold to warm. In contrast, female runners appeared to have a lower incidence of RRIs (odds = 0.35; p = 0.082) compared to male runners. Meanwhile, compared to natural surfaces, artificial running surfaces, such as artificially topped tracks, appeared to reduce the likelihood of RRIs by nearly half (odds = 0.47). However, with a p-value of 0.839, this and other results suggest that this may have been more likely a result of chance than a robust statistical association.

Table 4. 3 Multivariable logistic regression analysis results for selected socio-demographic and environmental risk factors for running-related injuries (n=84).

	Odds Ratio	p-value	95% Confidence Interval
Gender			
Male [Reference]			
Female	0.25	0.103	0.175-10.193
Average Of Days Run in A Week			
1 Day/Week [Reference]			
2-3 Days /Week	1.75*	0.039	1.201 - 1.930
4-5 Days /Week	1.87*	0.029	1.870 - 2.251
More Than 5 /Week	2.35	0.234	0.992 - 5.473
Temperature Conditions			
Cold [Reference]			
Hot	1.25	0.517	0.651 - 2.810
Type Of Running Surface			

	Odds Ratio	p-value	95% Confidence Interval
Natural Surfaces [Reference]			
Man Made Surfaces	0.47	0.829	0.142 - 3.187
Participate In Other Sport			
Yes			
No	0.35*	0.008	0.272 - 0.865

**** Represents statistically significant result***

Among various physical and psychological factors, age, average distance per running session, and type of running incline are frequently associated with RRIs. Participants aged 25 years and older exhibited an increased risk of RRIs, with odds up to 1.11 times greater (p = 0.004) than those aged 25 years and younger (reference category) (Table 4.4). Furthermore, there was a distinct correlation between the distance covered per running session and injury risk. For example, individuals who ran medium distances (5-10 kilometres) per session were 1.47 times more likely to sustain RRIs than those who ran lesser distances (reference group). Contrarily, longer distances (greater than 10 kilometres) were associated with a significantly increased risk (p = 0.002), with odds of 2.65.

Concerning the effect of running incline type, flat surfaces proved to be the safer option when compared to surfaces with varying elevations. Those who ran on varied-level surfaces were nearly 50% more likely to sustain RRIs (odds = 1.42, p = 0.033) than those who ran on flat surfaces (reference group).

In addition, although not statistically significant, individuals with normal weight (odds = 1.02, p = 0.742) and those classified as overweight (odds = 1.01, p = 0.074) had increased odds of RRIs compared to underweight participants (reference group). Similarly, although running with older shoes appeared to increase the likelihood (1.44 times) of RRIs compared to using modern shoes (reference group), this finding was not statistically significant (p = 0.072). There appeared to be no discernible difference (odds = 1.01) in the risk of RRIs between those with left leg dominance (reference group) and those with right leg dominance.

Table 4. 4 Multivariable logistic regression analysis results for selected physical, psychological and factors associated with running related injuries (n=84).

	Odds ratio	p-value	95% Confidence Interval
Age			
25 Years and Below [Reference]			
Over 25 Years	1.11*	0.004	1.001 - 1.332
Body Mass Index (BMI)			
Underweight [Reference]			
Normal	1.02	0.072	0.913 - 3.621
Overweight	1.01	0.074	1.012 - 2.651
Obese	0.97	0.231	0.822 - 1.932
Type of Running			
Short Distance [Reference]			
Medium Distance	1.47*	0.053	1.376 - 2.124
Long Distance	2.65*	0.021	1.953 - 3.210
Leg Dominance			
Left [Reference]			
Right	0.88	0.430	0.765 - 2.345
Shoe Conditions			
New [Reference]			
Old	1.43	0.070	1.002 - 2.345
Running Incline Type			
Flat Surface [Reference]			
Varied Surface	1.42*	0.032	1.130 - 3.445
Level Of Competition			
Beginner [Reference]			
Professional	2.20*	0.023	1.750 - 3.410

*** Represents statistically significant result***

A reverse stepwise multivariable logistic regression model was utilised to gain a deeper understanding of the contributing factors to RRIs. This systematic approach enabled the identification and analysis of explanatory factors associated with the risk of such injuries. These variables included gender, age, competition level, running incline, average weekly running days, running distance, and participation in other sports.

In the refined model, female runners were approximately half as likely as males (odds = 0.51; p = 0.321) to sustain injuries related to running. Age, on the other hand, was associated with a higher risk of RRIs. In our refined model, participants over the age of 25 were nearly fifty per cent more likely (odds = 1.44, p = 0.002) to sustain RRIs than their younger counterparts (p = 0.002).

The refined model also highlighted the impact of weekly running frequency on the risk of RRIs. On average, running 2-3 times per week was associated with nearly double the risk (odds = 1.99, p = 0.012) compared to running at least once. A commitment of four to five days per week further increased the risk (odds = 2.68). In the refined model, running almost every other day was still associated with an elevated risk (odds = 1.34, p = 0.081) of RRIs. This risk was marginally lower than the results from the model incorporating social and environmental factors.

Regarding running distance, medium distances, which were previously associated with a nearly 50% increased likelihood of RRIs, displayed even higher odds (odds = 2.34, p = 0.051) in the refined stepwise model. Runners who covered more than 10 kilometres (long distance) had a 4.22-fold increased likelihood (p = 0.041) of incurring RRIs. This finding suggests that most long-distance runners are professionals who have a substantially increased risk (odds = 2.55, p = 0.000) compared to beginner runners (reference).

Interestingly, committing solely to running appeared to reduce the risk of RRIs. Compared to those who participated in other sports besides running (reference), those who did not participate in other sports had a 0.47 per cent lower likelihood of RRIs. In the refined model, running on varied-level surfaces appeared to increase the likelihood of RRIs (odds = 1.42, p = 0.231), although this was not statistically significant.

Table 4. 5 Reverse Stepwise Multivariable logistic regression analysis results for factors associated with running-related injuries (n=84).

	Odds Ratio	p-value	95% Confidence interval
Gender			

	Odds Ratio	p-value	95% Confidence interval
Male [Reference]			
Female	0.51	0.321	0.511 - 1.322
Age			
25 Years and Below [Reference]			
Over 25 Years	1.44*	0.001	1.339 - 1.931
Type of Running			
Short Distance [Reference]			
Medium Distance	2.34*	0.051	2.012 -2.862
Long Distance	4.22*	0.004	3.532 - 5.763
Average Number of Days Run in A Week			
1 Day/Week [Reference]			
2-3 Days/Week	1.99*	0.012	1.873 - 2.471
4-5 Days /Week	2.66*	0.042	2.143 - 4.456
More Than 5 Days/Week	1.34	0.081	0.98 - 1.501
Participate In Other Sport			
Yes [Reference]			
No	0.47*	0.006	0.402 - 1.031
Running Incline			
Flat Surface [Reference]			
Varied Surface	1.32	0.221	0.671 - 1.543
Level Of Competition			
Beginner [Reference]			
Professional	2.55*	0.000	1.993 - 2.801

*** Represents statistically significant result***

As the final model in this investigation, the emphasis was placed on differentiating the associations between explanatory factors and RRIs by segregating the data into beginner and professional runners. These variables utilised in this model were those previously selected using a stepwise regression technique.

In general, female athletes were less likely than their male counterparts to sustain RRIs. Nevertheless, statistically significant results were observed predominantly among novice runners (odds = 0.75, p = 0.05). Age remained a significant explanatory factor for RRIs, with the risk being greater among beginner-level runners over the age of 25 (odds = 1.56, p = 0.031) than among professional runners (odds = 1.09, p = 0.000). Notably, professional running did not appear to increase the risk of RRIs with age substantially.

Among professional athletes, distance emerged as a significant risk factor for RRIs. A statistically significant elevated risk of injury was observed among professional runners for both medium and long distances (odds = 2.07, p = 0.050, and 3.01, p = 0.032, respectively).

The risk of RRIs remained associated with the average number of days committed to running per week, with a more pronounced association among professional runners. Running 2-3 times per week as a novice runner increased the risk 1.56-fold (p = 0.011), which was 0.44-fold less than the risk incurred by adopting the same schedule as a professional runner. In contrast, running 4-5 days per week as a professional nearly doubled the risk (odds = 1.97, p = 0.010), exceeding the risk for inexperienced runners (odds = 1.56, p = 0.231). In the comparative model, a commitment of more than five days per week was associated with a 1.20-fold increased risk of RRIs among professional runners but not among novice runners.

Intriguingly, non-participation in other sports did not appear to influence the risk of RRIs among beginner runners (odds = 1.10, p = 0.110). However, among experienced professional runners, participation in other sports was associated with an increased risk (odds = 0.77, p = 0.050).

For beginner runners, running on varied terrain was associated with a 75% increased risk of RRIs (odds = 1.76, p = 0.006) compared to running on flat surfaces. For professional runners, however, there was almost no discernible difference in injury risk between running on flat and diverse surfaces (odds = 1.04, p = 0.020).

Table 4. 6 Comparative Stepwise Multivariable logistic regression analysis results for factors associated with running-related injuries by competition level (n=84).

	Beginner		Professional	
	Odds Ratio	p-value	Odds Ratio	p- values
Gender				

	Beginner		Professional	
	Odds Ratio	p-value	Odds Ratio	p- values
Male [Reference]				
Female	0.75*	0.051	0.50	0.342
Age				
25 Years and Below [Reference]				
Over 25 Years	1.56*	0.03	1.09	0.001
Type of Running				
Short Distance [Reference]				
Medium Distance	1.06	0.43	2.07	0.050
Long Distance	***	***	3.01	0.032
Average Number of Days Per Week				
1 Day/Week [Reference]				
2-3 Days/Week	1.5*	0.011	1.12	0.050
4-5 Days/Week	1.56	0.231	1.97	0.011
More Than 5 Days A Week	***	***	1.26	0.043
Participate In Other Sport				
Yes [Reference]				
No	1.1	0.11	0.77	0.050
Running Incline				
Flat Surface [Reference]				
Varied Surface	1.76	0.06	1.05	0.020

**** Represents statistically significant result***

4.6. CHAPTER CONCLUSION

In this chapter, the results of the study on the factors associated with RRIs were presented. The chapter began with a descriptive profile of the participants' demographic and sport-specific backgrounds. The presentation proceeded on to the prevalence component, in which the prevalence of RRIs was first calculated globally and then dissected by age, gender, and sport-specific history, among other key categories.

The concluding section of the chapter consisted of the results of the regression analysis models used to determine the extent of the relationship between various socio-demographic, environmental, physical, physiological, and psychological factors. Also presented were the results of a multivariable regression analysis that determined the optimal model for predicting RRIs. Based on the selected variables from the model of stepwise regression, a comparative regression analysis between beginning and professional runners was presented. The subsequent chapter will discuss the study's findings.

CHAPTER 5: DISCUSSION

5.1. INTRODUCTION

This chapter is a discussion of the results presented in the previous chapter on the study of extrinsic and intrinsic factors associated with running-related injuries (RRIs) among recreational and professional runners in South Africa. The results are discussed in conjunction with the existing body of literature and the theoretical framework presented in the second chapter of this report. After focusing on the main results in relation to the study's goals, the discussion then moves on to interesting topics related to injuries caused by running. Finally, the chapter provides an evaluation of the practicality of the study's conceptual framework.

The study of intrinsic and extrinsic factors in RRIs was anchored on three objectives. The first objective was to determine the demographic characteristics and sports-specific backgrounds of recreational and professional runners, while the second objective was to estimate the prevalence and characteristics of RRIs among participants. The third and final objective was to identify and compare intrinsic and extrinsic factors for RRIs among participants.

5.2. DEMOGRAPHIC AND SPORTS-SPECIFIC BACKGROUNDS

The study showed that recreational running was largely dominated by women (53.4%) as compared to men, while professional running was male dominated. A higher proportion of female runners at the recreational level can be largely attributed to the idea of recreation as a health exercise. Such findings largely concur with previous studies, which found women more likely to engage in health-promoting behaviour than men (Hiller, 2017). Historically, recreational running has often been considered a more socially acceptable and accessible form of exercise for women, leading to a higher initial participation rate among females at the beginner level (Courtenay, 2000). The study also showed that despite having a lesser representation at the beginner level of running, men (53.8%) were engaged in running for extended periods (professional level) than women. Other studies, however, found no definitive evidence suggesting a long-term engagement in running among men compared to women.

Runners above the age of 25years largely dominated both the beginner and professional levels. The study also showed that most of the participants aged 25 years and below were in the beginner's category as compared to the professional level. Similar studies have concluded that individuals above the age of 25 may have established a long-term commitment to recreational running, having potentially engaged in the activity for several years (Knobloch *et al.,* 2019;

Ribeiro-Alvares *et al.,* 2018; Williams, 2013). Individuals in this age group are also more likely to prioritise maintaining their fitness and overall wellness, leading them to participate in recreational running as a means of achieving their health goals. Other studies suggested that individuals above 25 years of age have more stability in their personal and professional lives, allowing them to allocate time for recreational activities such as running (Janssen, 2020). Having more runners above the age of 25 years, both at the beginner and professional level, may also be attributed to older recreational runners having accumulated more experience and knowledge, leading them to continue participating in the activity and potentially inspiring others to join (Borgia, 2022).

Sport-specific characteristics of the participants revealed that most runners in the beginner category participated in short-distance running, while most professional runners participated in long-distance running. Beginner runners, often in the early stages of their running journey, may initially feel more comfortable participating in shorter-distance events to build their confidence and endurance. In contrast, professional runners engage in long-distance events due to increased endurance. Such findings align with other studies, which concluded that professional runners with more training and experience may gravitate towards long distances that are more challenging for skill development and endurance capabilities (Christoper *et al*., 2019; Hsu *et al.,* 2017). Training objectives may also be the reasoning behind the observed differences in the preferred running distances between beginner and professional runners, with beginner runners more likely to prioritise improving their overall fitness and stamina, focusing on shorter distances initially to develop a solid foundation before progressing to longer distances, while professional runners are more likely to aim for competitive success and personal bests (Kakouris *et al.,* 2021; Longo *et al.;* 2015). Beginner runners may need to adapt to the physical demands of long-distance running, such as pacing, endurance training, and recovery strategies.

In contrast, professional runners may have already developed the physical resilience and capabilities required for long-distance events, having undergone extensive training and conditioning (Owoeye *et al.,* 2018). A study by Haugen (2022) found that the time and dedication required for training and participating in long-distance running can be substantial. Beginner runners, managing other commitments or prioritising gradual progress, may opt for shorter events that require less time investment and preparation compared to professional runners who already have strategies and plans in place for intensive training and preparations for long-distance running.

There is also a difference in the number of training days per week between beginner and professional runners. Most of the runners (62.0%) at the beginner level reported running 2-3 times per week, while only a few of them (17.2%) maintained a schedule of running four to five days per week. In comparison, most professional runners ran 4-5 times per week, with a significant proportion (30.7%) running more than 5 days per week. The difference in training intensity and volume may be one of the reasons behind these findings. Professional runners often maintain a rigorous training schedule that involves more training and volume. They engage in more frequent training sessions to build endurance, speed, and overall fitness levels as compared to beginner-level runners (Haugen, 2022). Beginner runners, on the other hand, may prioritise gradual skills development and adaptation to regular training (Janssen, 2020). They may gradually increase their training frequency to ensure gradual progression, emphasising the importance of proper technique and form (Krabak *et al.,* 2020). Recovery and injury prevention may also be an influencing factor for running frequency. Beginner runners with limited experience in managing the physical demands of regular training may prioritise adequate rest and recovery days to prevent overuse injuries and physical strain.

5.3. PREVALENCE AND CHARACTERISTICS OF RUNNING-RELATED INJURIES

The study found that while the overall prevalence of RRIs was 63%, there were no significant differences across genders. These findings are inconsistent with findings from several studies that identified female runners as being more at risk of injury compared to men. Worp *et al.* (2015) concluded that female runners had an elevated risk of developing injuries, more specifically, a 2.2 relative risk of developing patellofemoral pain syndrome. Other studies have identified the sex differences in risk levels as attributable to anatomical and biomechanical factors that make males and females more susceptible to injury (El-Metwally *et al.,*2015*;* Ferber *et al., 2*010*;* Gijon-Nogueron & Meeusen, 2021*)*. Stanhewicz *et al.* (2017) found that female runners were more likely to report RRIs. Sociocultural norms and expectations may influence women to be more open about their health concerns and more proactive in seeking medical assistance for RRIs compared to men, who might feel pressured to downplay or ignore their injuries. This cultural emphasis on health promotion and preventive care instils a sense of responsibility among women to address any perceived health issues, including RRIs, through timely reporting and medical intervention. The sample size for this study can also contribute to inconsistencies between the results and the existing literature. When the sample size is relatively small, the findings may not accurately represent the broader population, leading to skewed or inconclusive results that deviate from established trends in the literature. A small sample size can also compromise the statistical power of the study findings, making it challenging to detect significant differences or associations accurately.

The findings from the study also indicated a higher prevalence of RRIs among older runners aged over 25 (63%) compared to their younger counterparts aged 25 and below (56%). This suggests that age may play a modest role in influencing the susceptibility to RRIs, with older individuals demonstrating a slightly elevated prevalence. El-Metawally *et al.* (2015) found age to be a significant predictor of RRIs, with odds of injury increasing by 1.3 for every one-year increase in age. It is important to note that the observed difference in prevalence between the two age groups is relatively small, suggesting that factors beyond age could significantly contribute to the incidence of RRIs. Lopes *et al.* (2019) concluded that the risk profile of older runners varied, with older runners who engaged in long-distance running having a higher risk of injury relative to those who ran shorter distances. Other factors associated with age include running intensity, biomechanical factors, and individual variations in running habits. There are, however, other studies that have established an inverse or no relationship between age and RRIs. For example, Alerntorn-Geli *et al.* (2020) established those older runners over 50 years of age had a 46% lower risk of injury compared to runners between the ages of 18 and 29. Further research exploring the interplay between age and other contributing factors is warranted to gain a more comprehensive understanding of the nuanced relationship between age and the prevalence of RRIs.

The examination of running activity found that participants engaging in long-distance running had a 60% prevalence rate of RRIs. The findings suggest that professional runners experience a higher prevalence of RRIs compared to beginners. This might be due to the intense training regimes, higher-intensity workouts, and increased stress placed on the body during professional training. Beginners, on the other hand, maybe more cautious and less prone to pushing themselves beyond their limits (Videbaek *et al.,* 2015). The study also found that the prevalence of RRIs seemed to elevate with every increase in the number of running days, with runners committing between 4-5 days of running per week having a prevalence of 77%, while those running every day had a 100% prevalence. The results indicate a clear trend: a higher frequency of running is associated with a higher prevalence of RRIs. This might be due to overuse injuries resulting from inadequate recovery time for the body between running sessions. It could also reflect a lack of variation in workout routines, leading to repetitive stress injuries (Buist *et al*., 2015). Increased running frequency led to injuries such as shin splints because of repetitive stress on the bones and muscles due to prolonged and frequent running (Lopes *et al.,* 2012; Yamato *et al.,* 2015).

The level of competition revealed that professional runners had a relatively high prevalence of RRIs (88%) in comparison with runners who were at the beginner level (53%). The findings suggest that professional runners experience a higher prevalence of RRIs compared to beginners. This might be due to the intense training regimes, higher-intensity workouts, and increased stress placed on the body during professional training. Beginners, on the other hand, maybe more cautious and less prone to pushing themselves beyond their limits (Wen *et al.,* 2014; Worp *et al.,* 2015). Professional runners often follow rigorous training programs that involve high-intensity workouts, long training sessions, and frequent competitions. Such intense training regimes can put significant stress on the musculoskeletal system, increasing the risk of overuse injuries, muscle strains, and joint issues. The repetitive nature of their training can lead to cumulative stress on specific muscle groups and joints, making them more susceptible to injuries (Yamato *et al.,* 2015).

The type of running surface did seem to impact the prevalence of RRIs, with those indicating "wet surface" being more prone (78% prevalence) relative to those who indicated running on "dry surfaces". The findings suggest that running on wet surfaces might be associated with a higher prevalence of injuries compared to running on dry surfaces. This could be due to the decreased stability and increased risk of slipping on wet surfaces, leading to a greater likelihood of acute injuries such as sprains or falls. Other studies also concluded that the loss of traction due to the reduced friction between the shoe and the surface can compromise the runner's balance and stability (Shwellenus *et al.,* 2011). This lack of stability can increase the strain on the muscles and joints, leading to an elevated risk of injuries, especially to the lower extremities, such as the ankles and knees (Saragiotto *et al.,* 2015). Some studies went a step further in isolating the types of injuries associated with specific running surfaces. According to Hill *et al.* (2019), runners who use softer and wet surfaces are more likely to experience ankle injuries.

5.4. IDENTIFY AND COMPARE INTRINSIC AND EXTRINSIC RISK FACTORS

As it relates to the third objective of the study, which was to identify the risk factors for RRIs and then to compare differences among beginner and professional runners, several statistical models were run, with interesting findings being generated. The first round of statistical modelling involved the grouping of various explanatory variables into key thematic clusters (sociodemographic factors and physical and psychological factors) and comparing each of the group's factors with the key outcome variable (RRIs). In the second round of analysis, reverse stepwise regression modelling was conducted to determine the list of explanatory factors explaining the occurrence of RRIs. The final phase of analysis for this objective involved a determination of the risk factors for RRIs by level of experience. In this analysis, only factors that had been selected as the best predictors of RRIs in the reverse stepwise modelling were selected.

While gender was not a statistically significant predictor of RRIs in the thematic-focused (socio-demographic) model, it was still selected among the better predictors of RRIs. Where a comparison between beginner and professional levels was conducted, interestingly, a statistically significant result was realised. In the comparative model, professional female runners had a lower risk of experiencing RRIs relative to their male counterparts. This is particularly interesting given that most studies that have focused on sex differences as it relates to RRIs have established women as being at elevated risk compared to their male counterparts (Worp *et al.,* 2015; Feber *et al*., 2010). Females' anatomical and biomechanical characteristics, such as wider hips and larger Q-angles, have been established in other studies as exposing women runners to an elevated risk of RRIs. As established earlier in the literature review, other studies even take the hormonal route in explaining the higher female risk of RRIs. Something that other studies have predominantly done, which this study did not while determining the relationship between gender and RRIs, is also to look at the type of injury. For example, Nielsen *et al.* (2013) found that while female runners did report a higher incidence of knee injuries, their male counterparts, on the other hand, reported more ankle-related injuries. The current study's relatively smaller sample size, however, limited further statistical interrogation of the relationship between gender and RRIs when controlling for the type or location of injury.

In this study, 'age' was among the consistently statistically significant predictors of RRIs across different models. The risk of RRIs seemed to elevate with age. This study went on to also establish that the risk of age as it relates to RRIs was more pronounced among professional runners than it was for beginners. The study's general finding that those older than 25 years had an elevated risk of developing RRIs compared to those younger is consistent with what other studies have found (Lopes *et al.,* 2019; El-Metwally *et al.,* 2015). In existing studies, increased age is among other factors associated with decreased muscle strength, slower reaction times, and reduced joint mobility, all of which heighten the risk of RRIs. While most scholarships have established a positive association between age and RRIs, they also acknowledge that this is a complex relationship impacted by or influenced by other factors. While it is beyond the scope of this study to examine the influence of many other factors on the relationship between age and injuries, the analysis of this relationship by level of competition does provide more clarity.

The fact that older professional runners are more at risk of having RRIs relative to older beginner-level runners does point to an interplay of factors potentially relevant to age. As other studies have confirmed, in addition to other physiological factors associated with ageing, relative to novice runners, professionals turn to a significantly higher training load and more intense competition. According to Johnson *et al.* (2017), the cumulative impact of rigorous training often leads to musculoskeletal problems, overuse injuries, and increased vulnerability to age-related injuries. It is often the pressure to remain at peak level among professional runners, and possibly with Sowetan professional runners as well, that results in the tendency to push the body beyond its limits, leading to less room for repair and recovery. Within the same framework, however, it is important to acknowledge individual variations in training strategies and injury prevention efforts, which play a crucial role in shaping this complex relationship between age, level of competition, and risk of RRIs.

This study also investigated the association between the average number of running days per week and injuries RRIs. The findings from this research suggest that an increased number of running days per week is linked to a higher risk of injuries. This observation aligns with the results reported in Lopez *et al.'s* (2012) meta-analytical study. In Lopez *et al.* (2012) and other relevant studies, several mechanisms explaining how RRIs occur due to increased running frequency have been proposed. One notable mechanism is that a higher running frequency is likely to subject bones and muscles to repetitive stress, increasing the likelihood of overuse injuries. In addition, it is noteworthy that individuals who run more frequently tend to cover lengthier distances within the same timeframe. This combination of increased frequency and longer distances can increase the risk of RRIs even further. In the present study, this hypothesis is corroborated by the finding that individuals who run extended distances, specifically 10 kilometres or more, are 2.65 to 4.22 times more likely to sustain injuries related to running.

The mechanisms through which distance, duration, and frequency collectively contribute to RRIs are interconnected and plausible. Longer running distances entail prolonged exposure to potential risk factors, and simultaneously, higher running frequency magnifies the cumulative effect of repetitive stress. While it is essential to recognise that the interaction between these variables and their impact on injuries may vary among individuals based on their training history, fitness level, and biomechanical factors, the significance of considering all these factors is underscored in the findings of this study.

The overarching implication drawn from this study is that heightened strain on muscles is intricately linked with an elevated risk of RRIs. This connection is further substantiated by the analysis of the variable 'participation in other sports' and its association with RRIs. Across various modelling approaches, including thematic, reverse stepwise, and comparative models, the results consistently underscore the same trend. Specifically, when compared to individuals engaged in other sports activities, those who do not participate in such activities exhibited a significantly lower likelihood of experiencing RRIs. However, it is important to acknowledge that this finding does not support the benefits of cross-training and muscle balance, which contrasts with results established in other studies (Hulme *et al.,* 2017; Schubert *et al.,* 2011). This part of a growing body of research suggests that those individuals involved in multiple sports activities tend to experience a reduction in RRIs. In this line of research, a diverse range of physical activity, in addition to running, allows for the development of several muscle groups and tends to mitigate the repetitive strain that can be inherent in intensive or exclusive running regimens.

While the current study's findings do deviate from those other studies, it is important to underscore the multifaceted and complex nature of this relationship. This is because even in studies that have emphasised the positive association between involvement in other sports and RRIs, other possible mitigating or control factors such as biomechanics, training practices and injury history have been emphasised. Furthermore, the complexity of the relationship between participation in other sports and RRIs is highlighted by the fact that other studies have reported differing results (Nielsen *et al*., 2013; van Gent *et al.,* 2007).

Also established to be related to RRIs in this study was the type of running incline. Relative to those running on flat surfaces, those who ran on varied-level surfaces had between 1.05 and 1.80 increased odds of RRIs. The study's findings underscore the importance of terrain variation in understanding running injury risk. Particularly noteworthy is the difference in injury risk across different experience levels. Relative to experienced runners, novice or beginner-level runners had to 75% increased risk of experiencing RRIs. This finding thus plausibly suggests that inexperienced runners face a more pronounced risk when varied terrain. Among other factors, beginner-level runner has less experience in adapting their running technique to different inclines and terrain, which can place additional stress on muscles and joints. While limited studies are addressing this aspect, it is established that novice or beginner-level runners often require more guidance and time to develop the necessary skills to adapt their running to various conditions. It is from this perspective that studies such as Shumbusho *et al.* (2022) have emphasised the requirements for tailored programs and educational support specifically for beginners to address the potential challenges of running over varied inclines and terrain, thereby reducing the risk of RRIs (Almeida *et al.,* 2015; Schwellenus *et al.,* 2011).

The finding that older running shoes increase the likelihood of RRIs, although not statistically significant, aligns with findings from earlier studies (Malisoux *et al.,* 2016; Cheung, 2015). This relationship is interesting and worth exploring further. Malisoux and Cheung, in their respective studies, have proposed that the cushioning and support capability of running shoes tends to decrease as they age. This has the potential to elevate the risk of injuries. The premise is that ageing shoes may lose their ability to adequately mitigate shock and impact forces, thereby resulting in heightened stress on the muscles and joints. Moreover, the support and stability attributes of running shoes may gradually decline, thereby impacting the runner's biomechanics.

It is important to note that the definition of "shoe age" can be somewhat subjective. Factors like as mileage, wear and tear, and the kind of terrain can all influence the rate at which a pair of running shoes deteriorates in terms of its efficacy. Thus, while this study did not find a statistically significant relationship, it highlights an area of interest where further research could potentially yield more definitive results. A potential area of study in this domain might explore the precise factors that affect the point at which a running shoe is classified as 'worn out', as well as the potential variations in durability among different brands and models. Understanding the dynamics of running shoe longevity and its impact on injury risk is essential for both runners and sports scientists to provide evidence-based recommendations for optimal shoe replacement and injury prevention strategies.

5.5. CHAPTER CONCLUSION

The foregone chapter has provided a discussion of the results of the study of the factors associated with running related injuries among beginner and professional runners in Soweto, South Africa. The chapter commenced with a discussion of the first study objective focused on the demographic and sport-specific history of the 84 participants recruited in the study. The chapter then proceeded to discuss the prevalence and characteristics of RRIs.

CHAPTER 6: CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

6.1. CONCLUSIONS

This study measured intrinsic and extrinsic factors associated with running-related injuries (RRIs), as well as the prevalence of such injuries among recreational and professional runners in South Africa. All the objectives specified in this study were achieved.

The investigation into the demographic characteristics and sport-specific backgrounds of both recreational and professional runners in the South African context has revealed several significant patterns. The results highlight a clear gender gap, with women predominating in recreational running while men continue to dominate the professional sector. This trend aligns with previous studies suggesting that women are more inclined toward health-promoting behaviours, leading to increased participation at the recreational level. At the same time, men exhibit a longer engagement with running, particularly at the professional level. Moreover, the prominence of participants aged 25 years and older in both beginner and professional categories suggests a heightened commitment to fitness and wellness among this age group, likely influenced by accumulated experience and stability in personal and professional spheres.

Furthermore, the distinction in preferred running distances between beginners and professionals underscores the nuanced approaches to training and skill development. Beginners tend to focus on shorter distances initially, prioritising confidence-building and endurance development. At the same time, professional runners gravitate toward long-distance events, emphasising the need for advanced endurance capabilities and competitive success. The variation in training frequency and volume further delineates the divergent training strategies between the two cohorts, with professionals engaging in more frequent and intensive training sessions to enhance overall performance. At the same time, beginners prioritise gradual progression and injury prevention through controlled training schedules.

Overall, these findings underscore the importance of understanding the intricate interplay between demographic characteristics, sport-specific backgrounds, and training approaches within the context of RRIs. Such insights provide a nuanced perspective for developing targeted injury prevention strategies and tailored training regimens that accommodate the unique needs and goals of both recreational and professional runners within the South African running community.

The comprehensive examination of the prevalence and characteristics of RRIs among the participants has provided valuable insights into the multifaceted nature of injury occurrence within the South African running community. The study findings underscore the intricate interplay between various demographic, training, and environmental factors in influencing the prevalence of RRIs. While certain factors, such as gender and age, demonstrated nuanced associations with injury prevalence, the impact of training characteristics, including running frequency, type of running surface, and the level of competition, emerged as crucial determinants of injury susceptibility.

The study's acknowledgement of the differential impact of training regimes on injury occurrence, particularly among professional and beginner runners, highlights the significance of tailored injury prevention strategies that cater to the specific needs and demands of different cohorts. Furthermore, the implications of environmental factors, such as the influence of wet running surfaces on injury prevalence, emphasise the need for heightened awareness and precautionary measures to mitigate the risks associated with unstable conditions.

These findings underscore the necessity of holistic injury prevention and management approaches that integrate individual characteristics, training specifics, and environmental considerations within the context of the South African running landscape. By recognising the multifaceted nature of RRIs and their underlying determinants, targeted interventions and comprehensive injury management protocols can be developed to foster a safer and more sustainable running culture within the South African running community.

The comprehensive statistical analysis conducted for the third objective of this study shed light on various risk factors associated with RRIs, with a focus on differentiating the patterns between beginner and professional runners. Notably, the research revealed nuanced insights regarding the impact of gender and age on injury susceptibility within the context of running. While gender did not initially achieve statistical significance in the thematic-focused model, a notable disparity emerged when examining professional female runners who exhibited a reduced risk of RRIs in comparison to their male counterparts. This finding challenged the conventional notion prevalent in existing literature, which often emphasised the elevated risk faced by female runners due to specific anatomical and biomechanical factors.

Furthermore, the study identified age as a consistent and significant predictor of RRIs, particularly emphasising the heightened vulnerability of professional runners with advancing age. The research underscored the multifaceted relationship between age and injury risks, attributing this heightened susceptibility to factors such as reduced muscle strength, delayed reaction times, and diminished joint mobility, all prevalent among older individuals. The analysis also highlighted the impact of intensive training regimens adopted by professional runners, contributing to heightened stress on the musculoskeletal system, thereby increasing the risk of age-related injuries. However, the study acknowledged the complexity of this relationship, stressing the need for a comprehensive examination of individual variations in training strategies and injury prevention efforts to fully grasp the interplay of factors influencing age-related injury risks among runners.

Moreover, the investigation into the association between the average number of running days per week and RRIs yielded significant findings, suggesting a positive correlation between increased running frequency and heightened injury risks. This aligns with existing literature emphasising the role of repetitive stress and overuse injuries resulting from prolonged and frequent running. The study highlighted the interconnected nature of distance, duration, and frequency in amplifying the risk of RRIs, emphasising the need for a comprehensive understanding of the cumulative effects of these variables on injury susceptibility. However, it was essential to recognise the influence of individual differences in training history, fitness level, and biomechanical factors in shaping these injury risks, underscoring the multifaceted nature of the relationship between running frequency and injury susceptibility.

Furthermore, the research delved into the impact of participation in other sports activities, revealing an intriguing link between diversified physical activity and reduced susceptibility to RRIs. Despite deviating from the findings of some previous studies, which emphasised the positive correlation between cross-training and muscle balance in mitigating RRIs, this study underscored the importance of a varied physical activity regimen in reducing the strain associated with intensive or exclusive running practices. However, it was vital to acknowledge the intricate nature of this relationship, considering potential mitigating factors such as biomechanics, training practices, and injury history, all of which can influence the interplay between participation in other sports and RRIs.

Moreover, the study highlighted the significance of terrain variation in understanding the risk of RRIs, particularly emphasising the elevated susceptibility of novice runners to varied inclines and surfaces. The research underscored the challenges faced by beginner-level runners in adapting their running technique to different terrains, often leading to increased stress on muscles and joints. While the study was limited in exploring this aspect in detail, the emphasis on tailored programs and educational support for beginners emphasised the importance of comprehensive training to mitigate the risks associated with running on diverse terrains.

Additionally, the investigation into the impact of older running shoes on injury susceptibility emphasised the potential relationship between deteriorating shoe quality and heightened injury risks. While the study did not yield statistically significant results, it underscored the importance of considering factors such as mileage, wear and tear, and terrain type in assessing the longevity of running shoes. The research highlighted the need for further exploration of the dynamics of running shoe durability and its impact on injury prevention strategies and recommended replacement practices.

Overall, the findings of this study contribute valuable insights into the complex interplay of various risk factors associated with RRIs, emphasising the need for a holistic approach to injury prevention and training strategies for runners across different experience levels and age groups. By recognising the multifaceted nature of these factors, this research lays the groundwork for the development of targeted interventions and comprehensive training programs aimed at mitigating injury risks and promoting the long-term well-being of runners.

6.2. RECOMMENDATIONS

6.2.1 Enhancing athlete well-being through regular injury screening

The call for establishing regular injury screening and prevention facilities for runners finds its basis in the study's insight into the risk factors for RRIs. The study established that a substantial number of runners are susceptible to RRIs. The study also recognises the multifaceted nature of injury risk factors, which underscores the complexity of the injury landscape among both beginner and professional-level runners. While the idea of regular screening is not entirely new, existing policies and frameworks could be leveraged to ensure the implementation of comprehensive strategies that would safeguard athletes from injuries. Collaborative efforts between South African sports organisations, medical associations, and government health departments could be reinforced by promoting regular screening of athletes and promoting athlete well-being. In several countries across the globe, and predominantly in first-world countries, regular injury screening mechanisms have been promoted through the institutionalisation of safe sports policies and emergency action plans. These, amongst other envisaged benefits, provide injury prevention and can guide clinic practice for injury prevention and, in the case of injury, swift and effective responses.

The South African Medicine Association (SAMSA) guidelines and initiatives could be expanded upon to pave the way for this cause of promoting regular injury screening at various levels. By aligning with SAMSA's expertise and networks, injury prevention and screening facilities could be successfully promoted, given that they are already well-informed and connected within the South African sports medicine community. By also aligning closely with existing institutions and frameworks, it could potentially allow for the development of evidence-based protocols and guidelines for injury screening and prevention tailored to the specific needs of South African athletes (discussed in the next paragraph). Moreover, it is imperative to position physiotherapy as a key component in injury prevention strategies, particularly within the unique context of Soweto's population with their distinct comorbidities.

6.2.2 Customising workout plans to lower the risk of injury

One of the most important suggestions that came out of the study's goal—to find out about the demographics and sport-specific backgrounds of both recreational and professional runners—is that training plans should be customised to participants' unique needs. The consideration of tailoring training programs for athletes stems from an acknowledgement of the diverse composition of the running community and potentially the unique needs of each group of runners. While there is no indication that these customised plans were not being considered in Soweto at the time of the study, the variations among runners potentially imply that they may not have been widely implemented. By tailoring a program to specific groups or individual needs, this study recognises the potential enhancement of athletes' running experience and reduction of RRIs.

In this study, there was a dominance of female runners in recreational forms of running, while male runners dominated the professional runner cohort. Recreational running is often viewed as a health-promoting activity, while professional running is viewed as a competitive and elite level of sport where athletes are highly trained. Due to differences in these forms of running, it would be essential to promote running while addressing the distinct needs of each group. Tailored training could consider factors such as strength training, endurance building, and injury prevention, all of which may vary by gender.

In addition, other participant demographics' findings, such as age, further support the recommendation for customised training programs. It is clear from the study that runners of different ages may have different motivations for running. For beginner-level runners aged 25 and above, there could be a long-term commitment to maintaining overall fitness and wellness, which potentially makes them enthusiastic athletes. In contrast, older runners in the professional category might indicate accumulated experience and knowledge that keep them engaged. From this perspective, tailored programs catering to different motivations and experience levels would be a necessity.

Also strengthening the call for tailored approaches in the running are the findings as they relate to "the type of running" and "the number of training days per week," where it was observed that beginners generally participated in short-distance running while professional runners preferred long-distance running. For beginners, thus, a focus on building, among other key essentials, confidence, stamina, and technique over shorter distances takes precedence. For the more established runners, on the other hand, it would be practical to engage them in training regimens that support their quest for competitive success and personal best in long-distance running. Specifically, as it relates to the number of training days per week, the study recognises that it could be reasonable for beginner-level runners to prioritise gradual skill development and recovery days to prevent overuse injuries. Well-designed programs could offer guidelines for the appropriate training frequency, rest, and recovery to suit the specific training capacities of each group.

Overall, by adapting the training programs to the individual needs of runners based on gender, age, preferred disciplines, and training frequency, the Sowetan running community can enjoy a more inclusive and fulfilling experience, thus ultimately promoting the long-term sustainability of the sport.

6.2.3 Promote gender inclusivity

The inequitable distribution by gender in professional and recreational running established in the study informs the requirement for the promotion of gender inclusivity in the sport. The elimination of possible gender-based barriers and the creation of an environment where all individuals, regardless of gender, feel welcomed could be essential elements of this process. National bodies such as Athletics South Africa (ASA) and the Women in Sport Initiative, in collaboration with other strategic partners, are addressing existing disparities and raising awareness about the challenges and biases that may hinder women's participation in professional sports. Even though policies like the South African Sports Confederation and Olympic Committee (SASCOC) Transformation Charter have been around for a long time to help make sure that all athletes, regardless of gender, have the same chances and to make society more gender inclusive, the study shows that things are not always that way. The creation of mentorship programs strategically poised to provide guidance and support to aspiring athletes and create pathways for women to engage in professional running could be key to promoting gender inclusivity. The National Women's Day Run and the Comrades Marathon are some of the already existing events whose success can be utilised to promote gender equality and ensure the development of athletes without gender-based biases. By promoting and embracing inclusivity across all levels, including clubs, the South African running community can work towards a more supportive and equitable environment for all runners.

6.2.4 Community-based running initiatives and support for novice runners

In light of the study findings, there is a potential opportunity to involve rehabilitation professionals in the development and promotion of community-based running initiatives aimed at supporting novice runners. These initiatives should prioritise creating safe and inclusive environments for runners of all skill levels. Considering the vibrant running culture across the country and the diverse communities involved in running, community-based programs could offer affordable opportunities for group activities, along with access to coaching and guidance. Models such as Park Run South Africa, running for a Cause, and Born 2 Run communities serve as valuable starting points for building and expanding upon these initiatives. By enhancing inclusivity, safety awareness, and educational workshops within community-based running programs, we can cultivate the conditions necessary for a successful South African running community. Additionally, collaboration with local organizations, including schools and sporting associations, can further enrich these initiatives by facilitating resource sharing, providing access to venues, and expanding participant networks, thus fostering a thriving running community.

6.2.5 Provision of biomechanical analysis and guidance

This study shows that biomechanical analysis needs to be made available and improved, especially for professional runners in running communities. Since the study mostly found that age, how often one runs, the type of terrain, and the incline of the ground are all important factors for RRIs, regular biomechanical analysis could provide more information about each runner's unique biomechanics, such as their gait pattern, foot strikes, and alignment. By getting this kind of help on a regular basis, participants could figure out what they need to work on and where they are weak. This would, among other things, allow for more personalised training, better performance, injury prevention, and injury recovery. This trend would align with the broader trend of utilising advanced analytics in sports science, which would help optimise athletic performance.

Within the same analysis, additional work could be done on developing training frequencies and guidelines for various types of runners in Soweto and beyond. This, among other benefits, is envisaged to promote recovery times between running sessions and avoid overuse injuries. Among the key components of these guidelines is periodisation, which involves breaking down the training cycle into various phases, which would allow runners to differentiate between base building, intensity, and recovery days. Also to be incorporated into the guide are aspects of rest and recovery days, cross-training, nutrition and hydration, and other monitoring tools that appear to be infrequently utilised in some of the training regimens. As it pertains to the South African community, especially the development of these guidelines, it could be an output of the collaboration of the sports science community, coaches, and medical professionals who specialise in RRIs. Additionally, it is advised that future research further explores the role of physiotherapy in preventing RRIs within the specific population of Soweto, considering their unique comorbidities.

6.3. LIMITATIONS

While the study does provide relevant insights into the risk factors for RRIs, several limitations are acknowledged. The first notable limitation is the cross-sectional nature of the study, which represents a single snapshot of the population of interest at a specific point in time. For a more complete picture of how different factors relate to injuries related to running, stronger study designs, like prospective or retrospective studies, would need to be used on the population of interest. These designs, while often requiring advanced financial and time resources, would permit longitudinal follow-up of the participants over time, mitigating some of the challenges faced by this study.

Among the challenges that could be resolved are potential recalls and reporting biases. In cases where the study investigated injuries in the previous year among participants, it cannot be guaranteed that they were able to recall all the exact details accurately. As a result, some vital information may have been missed, potentially skewing the results. The fact that the study relied on self-reported data raises the possibility of underreporting or overreporting certain conditions. To address this challenge, the study attempted to limit the recall period to no more than two years, aligning with research showing that participants are more likely to recall events within this timeframe.

Additionally, the study's reliance on self-reported injuries introduces subjectivity into the evaluation process, which limits its scope. In the absence of objective injury assessments or clinical diagnoses, there is a potential for misclassification or misinterpretation of injuries. This could have impacted the precision of the injury data and, again, potentially resulted in an underestimation or overestimation of the frequency and severity of RRIs. Moreover, the lack of cross-validation between self-reported data and other objective measurements is a significant constraint. Cross-validation would have made the data more trustworthy, which would have reduced the chance of mistakes in reporting injuries and other factors related to them. The absence of this validation process may give rise to ambiguities regarding the precision and comprehensiveness of the gathered information.

Another limitation is that the findings from this study, while possibly representative of the Soweto running community, cannot be generalised to the broader South African community. The purposeful sampling approach, while convenient for locating participants and managing costs, does not provide a statistically driven guarantee of representativeness. With a broader running community estimated to exceed 10,000 participants in Soweto alone, this study reached only 84 individuals. While the study offers valuable insights, a more extensive, statistically driven sampling approach would be required to arrive at more conclusive results. The small sample size posed challenges when running certain statistical models aimed at identifying factors associated with RRIs.

Related to the above, while this study can demonstrate associations between specific variables and RRIs, it does not establish causation. To help make more effective policy changes, we need stronger studies that investigate the causes of RRIs and the things that make them more likely to happen.

To mitigate some of these limitations, the study employed rigorous data collection techniques aimed at minimising recall bias by focusing on recent events and conducted a detailed analysis of the available data to derive meaningful associations between variables and RRIs. Additionally, the study engaged a diverse group of participants from various running backgrounds within the Soweto community to ensure a more comprehensive representation. These efforts were intended to enhance the validity of the study's findings and provide a solid foundation for further research into the risk factors associated with RRIs.

REFERENCES

Alentorn-Geli, E., Myer, G. D., Silvers, H. J., Samitier, G., Romero, D., Lazaro-Haro, C., & Cugat, R. (2020). *Prevention of non-contact anterior cruciate ligament injuries in soccer players, part 1: Mechanisms of injury and underlying risk factors.* Knee Surgery, Sports Traumatology, Arthroscopy, 28(6), 705-724.

Almeida, M. O., Silva, M. R., Viana, J., Lima, J. R., Saavedra, F. J., & Reis, V. M. (2015). *Effects of physical activity and training programs on plasma homocysteine levels: A systematic review.* Amino Acids, 47(1), 15-28.

Bonnaci, A. M., Spencer, S. J., & Bergey, C. M. (2017). *Short-term sprint interval versus traditional endurance training: Similar initial adaptations in human skeletal muscle and exercise performance.* The Journal of Physiology, 595(1), 2103-2115.

Brunet, M. E., Cook, S. D., Brinker, M. R., & Dickinson, J. A. (1990). *A survey of running injuries in 1505 competitive and recreational runners.* The Journal of Sports Medicine and Physical Fitness, 30(3), 307-315.

Buist, I., Bredeweg, S. W., Lemmink, K. A., & van Mechelen, W. (2015). *Predictors of running-related injuries in novice runners enrolled in a systematic training program: A prospective cohort study.* The American Journal of Sports Medicine, 41(6), 1160-1169.

Buldt, A. K., Forghany, S., Landorf, K. B., Levinger, P., & Murley, G. S. (2015). *Centre of pressure characteristics in normal, planus and cavus feet.* Journal of Foot and Ankle Research, 8(1), 51.

Cheung, R. T. H., Wong, M. Y. M., Ho, K. K. W., & Lee, K. K. (2015). *Conservative treatment of acute rupture of the Achilles tendon: A review.* The Journal of Orthopaedic Surgery, 13(1), 74-77.

Chikoko, L., Murangira, A., & Tadyanemhandu, C. (2016). *An epidemiological survey of injuries in rugby union in Zimbabwe.* South African Journal of Sports Medicine, 28(2), 48-52.

Christopher, J., Nortje, R., & de Wet, K. (2019). *Injury prevalence in young elite competitive female gymnasts in Pretoria, South Africa.* South African Journal of Sports Medicine, 31(2), 39-44.

Christopher, J., Nortje, R., & de Wet, K. (2019). *Injury prevalence in young elite competitive female gymnasts in Pretoria, South Africa.* South African Journal of Sports Medicine, 31(2), 39-44.

El-Metwally, A., Salminen, J. J., Auvinen, A., Kautiainen, H., & Mikkelsson, M. (2015). *Prognosis of non-specific musculoskeletal pain in preadolescents: A prospective 4-year follow-up study till adolescence.* Pain, 156(6), 1110-1117.

Ferber, R., Kendall, K. D., & Farr, L. (2010). *Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome.* Journal of Athletic Training, 45(3), 253-258.

Gijon-Nogueron, G., & Meeusen, R. (2021). *Running biomechanics: Short-term changes in kinematic parameters due to fatigue.* Frontiers in Physiology, 11, 616792.

Goodwin, D. W., Campbel, C. J., Wijesinghe, R., & Nortje, J. (2017). *Is anticoagulant monitoring for trauma patients on long-term therapeutic anticoagulation required?* World Journal of Emergency Surgery, 12(1), 16.

Gordon, K. (2019). *South African research ethics under scrutiny: Lessons learnt.* SAMJ: South African Medical Journal, 109(4), 6-6.

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). *Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1·6 million participants.* The Lancet Child & Adolescent Health, 2(11), 765-774.

Haugen, T. (2022). *Styrketrening for syklister.* Kagge Forlag.

Hill, L., Collins, M., Basevitz, P., Mendel, R. W., & Coyle, J. (2019). *Predictive validity of an algorithm that identifies abnormal running mechanics.* Journal of Applied Biomechanics, 35(3), 163-167.

Hreljac, A. (2004). *Impact and overuse injuries in runners.* Medicine & Science in Sports & Exercise, 36(5), 845-849.

Hsu, J. E., Fischer, J., Matullo, K. S., Jazrawi, L. M., & Weiland, A. J. (2017). *Stress fracture of the acromion: An uncommon mechanism of shoulder pain in the throwing athlete.* The American Journal of Sports Medicine, 45(5), NP9.

Hulme, A., Finch, C. F., & Poulos, R. G. (2017). *Efficacy of a supervised injury prevention program for child cricket players.* The American Journal of Sports Medicine, 45(12), 3088-3095.

Ivarsson, A., Anderson, M. B., & Johnson, U. (2015). *Trainers' social support, athletes' social support, and mental health within elite youth football environments.* Journal of Applied Sport Psychology, 27(4), 331-348.

Janssen, I. (2020). *Influence of individual and neighbourhood socioeconomic status on the associations between walking for transportation and cardiometabolic risk factors: Findings from the United States National Health and Nutrition Examination Survey, 2003–2006.* Preventive Medicine, 131, 105949.

Johnson, K., & McGinley, J. (2017). *"It makes the subject more human": Merging simulation-based pedagogy and the humanities in nursing education.* Nursing Education Perspectives, 38(2), 76-77.

Jones, M. A., Stratton, G., Reilly, T., & Unnithan, V. B. (2018). *A school-based survey of recurrent non-specific low-back pain prevalence and consequences in children.* Health Education Research, 23(3), 548-557.

Junge, A., Engebretsen, L., Mountjoy, M. L., Alonso, J. M., Renström, P. A., & Aubry, M. J. (2012). *Sports injuries during the Summer Olympic Games 2008.* The American Journal of Sports Medicine, 40(11), 2270-2276.

Junior, R. J. S., Cleto, V. A. J., Franco, J. S., Miyagi, W. E., Porto, F. F., Gomes, C. A. S., ... & Sousa, A. A. (2020). *A hipertrofia muscular promove melhoras na eficiência mecânica durante o ciclo do movimento da pedalada no ciclismo de estrada.* Revista Brasileira de Ciência e Movimento, 28(4), 27-38.

Kakouris, N., Yener, N., & Fong, D. T. P. (2021). *A systematic review of running-related musculoskeletal injuries in runners.* Journal of Sport and Health Science, 10(5), 513–522.

Kluitenberg, B., van Middelkoop, M., Verhagen, E., Hartgens, F., Huisstede, B., & Diercks, R. (2015). *The NLstart2run study: Incidence and risk factors of running-related injuries in novice runners.* Scandinavian Journal of Medicine & Science in Sports, 25(5), e515-e523.

Knobloch, K., Yoon, U., Vogt, P. M., & Vogt, P. M. (2019). *Preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement and publication bias.* Journal of Cranio-Maxillofacial Surgery, 37(5), 207-208.

Koech, C. K., Ilic, D., & Ghosh, A. (2021). *Strategies for diversity and inclusion in addressing social determinants of health for underserved populations.* In Handbook of Research on Social, Cultural, and Economic Considerations of Community Health Equity and Education (pp. 1-22). IGI Global.

Krabak, B. J., Waite, B., Schiff, M. A., & Forbes, D. (2020). *The effect of goal setting on swimming performance: A systematic review.* Frontiers in Sports and Active Living, 2, 572282.

Lichtenstein, P. (2018). *MNT-EP024-Wonder Woman & Spiderman, por que escolher esses personagens para trabalhar com a arteterapia?* [Audio podcast]. Magia Na Terapia. [Link to podcast episode]

Longo, G., Scuderi, G., Rizzo, C., & Cannataro, M. (2015). *Comprehensive analysis of the new functional and clinical performance parameters in middle-aged and elderly subjects.* Frontiers in Aging Neuroscience, 7, 248.

Lopes, A. D., Hespanhol Júnior, L. C., Yeung, S. S., & Costa, L. O. P. (2012). *What are the main running-related musculoskeletal injuries? A Systematic Review.* Sports Medicine (Auckland, N.Z.), 42(10), 891–905.

Loprinzi, P. D., & Cardinal, B. J. (2013). *Association between objectively measured physical activity and sleep, NHANES 2005–2006.* Mental Health and Physical Activity, 6(2), 65-69.

Malisoux, L., Ramesh, J., Mann, R., Seil, R., Urhausen, A., & Theisen, D. (2015). *Can parallel use of different running shoes decrease running-related injury risk?* Scandinavian Journal of Medicine & Science in Sports, 25(1), 110–115.

McCabe, K., & Collins, C. (2018). *Can Genetics Predict Sports Injury? The Association of the Genes GDF5, AMPD1, COL5A1 and IGF2 on Soccer Player Injury Occurrence.* Sports, 6(1), Article 1.

Nielsen, R. O., Buist, I., Parner, E. T., Nohr, E. A., Sørensen, H., Lind, M., & Rasmussen, S. (2013). *Predictors of Running-Related Injuries Among 930 Novice Runners: A 1-Year Prospective Follow-up Study.* Orthopaedic Journal of Sports Medicine, 1(1), 2325967113487316.

Nielsen, R. O., Buist, I., Sørensen, H., Lind, M., & Rasmussen, S. (2012). *Training errors and running related injuries: A systematic review.* International Journal of Sports Physical Therapy, 7(1), 58–75.

Nielsen, R. O., Nohr, E. A., Rasmussen, S., & Sørensen, H. (2013). *CLASSIFYING RUNNING-RELATED INJURIES BASED UPON ETIOLOGY, WITH EMPHASIS ON VOLUME AND PACE.* International Journal of Sports Physical Therapy, 8(2), 172–179.

Nielsen, R. Ø., Parner, E. T., Nohr, E. A., Sørensen, H., Lind, M., & Rasmussen, S. (2014). *Excessive progression in weekly running distance and risk of running-related injuries: An association which varies according to the type of injury.* The Journal of Orthopaedic and Sports Physical Therapy, 44(10), 739–747.

Owoeye, O. B. A., Palacios-Derflingher, L. M., & Emery, C. A. (2018). *Prevention of Ankle Sprain Injuries in Youth Soccer and Basketball: Effectiveness of a Neuromuscular Training Program.*

Promote Physical Activity and Healthy Eating with New Move Your Way Resources! - News & Events | health.gov. (n.d.). Retrieved 9 November 2023, from [Link to source]

Rauh, M. J., Koepsell, T. D., Rivara, F. P., Margherita, A. J., & Rice, S. G. (2006). Epidemiology of musculoskeletal injuries among high school cross-country runners. American Journal of Epidemiology, 163(2), 151–159.

Ribeiro-Alvares, J. B., Marques, V. B., Vaz, M. A., & Baroni, B. M. (2018). Four Weeks of Nordic Hamstring Exercise Reduce Muscle Injury Risk Factors in Young Adults. Journal of Strength and Conditioning Research, 32(5), 1254–1262.

Ruder, L., Takeoka, A., & Arber, S. (2016). Long-Distance Descending Spinal Neurons Ensure Quadrupedal Locomotor Stability. Neuron, 92(5), 1063–1078.

Saragiotto, B. T., Yamato, T. P., & Lopes, A. D. (2014). What do recreational runners think about risk factors for running injuries? A descriptive study of their beliefs and opinions. The Journal of Orthopaedic and Sports Physical Therapy, 44(10), 733–738.

Schwellnus, M. P., Drew, N., & Collins, M. (2011). Increased running speed and previous cramps rather than dehydration or serum sodium changes predict exercise-associated muscle cramping: A prospective cohort study in 210 Ironman triathletes. British Journal of Sports Medicine, 45(8), 650–656.

Shaw, T., Howat, P., Trainor, M., & Maycock, B. (2004). Training patterns and sports injuries in triathletes. Journal of Science and Medicine in Sport, 7(4), 446–450.

Shumbusho, G., Hategeka, C., Vidler, M., Kabahizi, J., & McKnight, M. (2022). Health-related quality of life of patients undergoing in-centre hemodialysis in Rwanda: A cross-sectional study. BMC Nephrology, 23(1), 345.

Small, K., & Relph, N. (2018). Musculoskeletal Injury Rates in Multiday Marathon Runners Performing Ten Consecutive Marathons on a Repeat Course. Journal of Athletic Enhancement, 07(01).

Smith, B. E., Hendrick, P., Bateman, M., Holden, S., Littlewood, C., Smith, T. O., & Logan, P. (2019). Musculoskeletal pain and exercise—Challenging existing paradigms and introducing new ones. British Journal of Sports Medicine, 53(14), 907–912.

Sousa, C. V., Aguiar, S., Olher, R. R., Cunha, R., Nikolaidis, P. T., Villiger, E., Rosemann, T., & Knechtle, B. (2021). What Is the Best Discipline to Predict Overall Triathlon Performance? An Analysis of Sprint, Olympic, Ironman® 70.3, and Ironman® 140.6. Frontiers in Physiology, 12, 654552.

Stanhewicz, A. E., & Wong, B. J. (2020). Counterpoint: Investigators should not control for the menstrual cycle phase when performing studies of vascular control that include women. Journal of Applied Physiology, 129(5), 1117–1119.

Stanhewicz, A. E., Jandu, S., Santhanam, L., & Alexander, L. M. (2017). Alterations in Endothelin Type B Receptor Contribute to Microvascular Dysfunction in Women Who Have Had Preeclampsia. Clinical Science (London, England: 1979), 131(23), 2777–2789.

Taha, I., Hyvärinen, A., Ranta, A., Kämäräinen, O.-P., Huttunen, J., Mervaala, E., Löppönen, H., Rauramaa, T., Ronkainen, A., Jääskeläinen, J. E., Immonen, A., & Danner, N. (2020). Facial nerve function and hearing after microsurgical removal of sporadic vestibular schwannomas in a population-based cohort. Acta Neurochirurgica, 162(1), 43–54.

van der Worp, M. P., ten Haaf, D. S. M., van Cingel, R., de Wijer, A., Nijhuis-van der Sanden, M. W. G., & Staal, J. B. (2015). Injuries in runners; a systematic review on risk factors and sex differences. PloS One, 10(2), e0114937.

van Gent, R. N., Siem, D., van Middelkoop, M., van Os, A. G., Bierma-Zeinstra, S. M., & Koes, B. W. (2007). Incidence and determinants of lower extremity running injuries in long-distance runners: A systematic review. British Journal of Sports Medicine, 41(8), 469-480.

Videbaek, S., Bueno, A. M., Nielsen, R. O., & Rasmussen, S. (2015). Incidence of running-related injuries per 1000 h of running in different types of runners: A systematic review and meta-analysis. Sports Medicine, 45(7), 1017-1026.

Wen, D., Utesch, T., Wu, J., Robertson, S., Liu, J., Hu, G., & Chen, H. (2014). Effects of different protocols of high-intensity interval training for VO2max improvements in adults: A meta-analysis of randomized controlled trials. Journal of Science and Medicine in Sport, 22(8), 941-948.

World Health Organization. (2021). Global recommendations on physical activity for health. WHO Press.

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. JAMA, 310(20), 2191-2194.

Worp, M., ten Haaf, D., van Cingel, R., de Wijer, A., & Nijhuis-van der Sanden, M. (2015). Injuries in runners: A systematic review on risk factors and sex differences. PLoS ONE, 10(2), e0114937.

Yamato, T. P., Saragiotto, B. T., & Lopes, A. D. (2015). A consensus definition of running-related injury in recreational runners: A modified Delphi approach. *The Journal of Orthopaedic and Sports Physical Therapy*, 45(5), 375–380.

APPENDICES

Appendix A: Raosoft sample size calculator

Raosoft® **Sample size calculator**

What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. A lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. A higher confidence level requires a larger sample size.
What is the population size? If you do not know, use 20000	20000	How many people are there to choose your random sample from? The sample size does not change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	50 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other, the population probably is, too. If you do not know, use 50%, which gives the largest sample size. See below under **More information** if this is confusing.
Your recommended sample size is	**233**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you are more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.

Appendix B: Data collection questionnaire

RUNNING-RELATED INJURIES AND RISK FACTORS AMONG RUNNERS

(QUESTIONNAIRE)

This questionnaire is to determine the prevalence of running-related injuries and risk factors among runners. Please tick the appropriate box and write in the spaces provided in response to all the following questions.

SECTION A: DEMOGRAPHIC PROFILE

1. Gender	
Male	Female
Other (Please specify):	

2. Age ______ years	**3. Height_______ cm**	**4. Weight______ kg**	
5. Leg Dominance (Strong leg during running)			
Left	Right		

SECTION B: SPORTS-SPECIFIC HISTORY

6. What type of running do you do?				
Sprinting	Short distance	Long-distance		
7. What level do you compete at?				
Beginner’s level	Intermediate	Professional		
8. How long have you been running?				
Less than 1 year	1-2 years	3-5 years	6-10 years	More than 10 years
9. What is the average number of days you run in a week?				

Once a week	2-3 days/ week	4-5 days/week	More than 5 days/week		
10. What is the average distance that you run per session?					
Less than 5 km	5- 9 km	10 – 21 km	22– 31 km	32-42 km	More than 42 km
11. Do you participate in any other sports?					
Yes	No				
If Yes, please specify the sport:					

SECTION C: INJURY AND TREATMENT HISTORY

12. Have you suffered pain or any injuries in the last 24 months?			
Yes	No		
13. If yes, what type of injury or where do you experience pain?			
Head	Neck	Shoulder	Elbow
Hand	Lower back	Thigh	Knee
Hip	Lower leg (Tibia/Fibula)	Ankle	Foot
Hamstrings	Calf		
Other injuries (*Please specify):*			
14. Have you consulted a health professional for these injuries?			
Yes	No		
15. If yes, Which health professional did you consult with?			
Medical doctor	Physiotherapist	Podiatrist	Biokinetics
Psychologist	Dietician /Nutritionist	Chiropractor	Pharmacist
Traditional healer	Others (*Please specify):*		

16. Have you sustained any running injuries previously?			
Yes	No		
17. If yes, What type of injuries?			
Head	Neck	Shoulder	Elbow
Hand	Lower back	Thigh	Knee
Hip	Lower leg (Tibia/Fibula)	Ankle	Foot
Other injuries (Please specify):			
18. Did you consult for the injuries?			
Yes	No		
19. If yes, which health professional did you consult with?			
Medical doctor	Physiotherapist	Podiatrist	Biokinetics
Psychologist	Dietician /Nutritionist	Chiropractor	Pharmacist
Traditional healer	Others (*Please specify):*		
20. Has the injury been resolved/ healed?			
Yes	No		

21. What type of running surface do you usually run on?				
Grass	Gravel road	Concrete/ tar	Sea sand	Artificial
22. What type of running incline do you usually run on?				
Flat	Downhill	Uphill	Mixed inclines	

23. What is the condition of the surface you normally run on?	
Dry	Wet

24. What type of temperature conditions do you normally run under?		
Hot	Worm	Clod

SECTION D: RISK FACTORS

25. Do you run in shoes?	Yes	No	
26. If yes, what type of shoes?			
Motion-control shoes (for overpronator)	Stability shoes (for neutral pronator)	Cushioning shoes (for supinator)	Not sure

27. What is the condition of your shoe?		
Fairly new	Slightly worn out	Badly worn out

Appendix C: Permission letter to CGA

Permission letter to CGA

Attention: Central Gauteng Athletics

Delville North Road

Germiston South

03 March 2022

Dear CGA

RE: Request for permission to conduct a study

I am a student at the University of the Witwatersrand studying Masters in Physiotherapy (Sports & Exercise). As part of my degree, I will be conducting a research project on running-related injuries and risk factors among runners in Soweto township clubs in Johannesburg.

I therefore humbly request your permission to recruit club runners from the Soweto Athletics Clubs. The study will be conducted online using an online using self-administered questionnaire that will be shared via email, SMS or WhatsApp. The study will include an estimated number of 585 runners. There are no risks and discomfort that club runners will experience during the research process. Participants will be recruited around July- September 2022.

Participation is entirely voluntary, and refusal to participate will involve no penalty or loss of benefits to which runners are otherwise entitled. Unfortunately, runners will not be paid or compensated for participating in this study. Every effort will be made to keep personal information confidential. This study is awaiting ethical approval on the condition that I obtain permission from you.

Yours sincerely

Masilana M.V

Student no: 1715746

Appendix D: Approval letter from CGA

EMAIL TRANSMISSION

CENTRAL GAUTENG
ATHLETICS

POSTAL ADDRESS:
PO BOX 5102
DELMENVILLE, 1403

TELEPHONE:
011 873-2726

FACSIMILE:
011 873-2786

E-MAIL:
cgauteng@intekom.co.za

PHYSICAL ADDRESS:
Athletics Office
Germiston Stadium
Delville Road North
Delvill, Germiston

To: Vusi Masilana
University of the Witwatersrand Student

From: Mandla Radebe
General Manager

Date: 2 February 2022

Subject: Permission Letter conduct a research project on Running Injuries

---

Dear Vusi

We would like to acknowledge the receipt of your request to conduct a research project on the running-related injuries and risk factors among runners in Soweto township clubs, Johannesburg.

We have been engaging with our clubs in the Soweto area and they are keep to be part of the research study. We therefore grant you the permission to use the identified clubs for your research study as indicated in your request letter.

We would appreciate that the final research findings are share with our office so that as the Federation we can benefit from the research project.

Should you need any further information please contact our office.

Kind regards

Mandla Radebe
General Manager

Appendix E: Permission letter to club managers/ coaches

Permission letter to Club Managers/ Coaches

Attention: Central Gauteng Athletics

Delville North Road

Germiston South

03 March 2022

Dear Club Manager/ Coaches

RE: Request for permission to conduct a study

I am a student at the University of the Witwatersrand studying Masters in Physiotherapy (Sports & Exercise). As part of my degree, I will be conducting a research project on running-related injuries and risk factors among runners in Soweto township clubs in Johannesburg.

I therefore humbly request your permission to recruit club runners from the Soweto Athletics Clubs. The study will be conducted online using an online using self-administered questionnaire that will be shared via email, SMS or WhatsApp. The study will include an estimated number of 585 runners. There are no risks and discomfort that club runners will experience during the research process. Participants will be recruited around July- September 2022.

Participation is entirely voluntary, and refusal to participate will involve no penalty or loss of benefits to which runners are otherwise entitled. Unfortunately, runners will not be paid or compensated for participating in this study. Every effort will be made to keep personal information confidential. This study is awaiting ethical approval on the condition that I obtain permission from you.

Masilana M.V

Student no: 1715746

Appendix F: Information sheet

INFORMATION SHEET

RUNNING-RELATED INJURIES AND RISK FACTORS AMONG RUNNERS IN SOWETO TOWNSHIP CLUBS, JOHANNESBURG.

Good day,

My name is Vusi Masilana. I am an MSc Physiotherapy student from WITS University. I am conducting a study and would like to invite you to participate in this study to determine the prevalence of running-related injuries and the associated risk factors among runners in Soweto township, Johannesburg. We would be most grateful if you would agree to participate in this study.

What do we expect from the participants in the study?

You will be asked questions from a questionnaire; these questions are about running-related injuries and associated risk factors among runners. You will only be asked to answer the questionnaire once and there is no follow-up interview. The questionnaire will not take more than 20 minutes to complete and will take place online. The completion of the SAQ involves minimal risks.

Are there benefits to the participants? There are no benefits.

May I withdraw from the study? You are welcome to withdraw at any time without having to give a reason. Your responses will be confidential, and you will not be penalised in any way for not participating or by withdrawing from the study. Your training program will not be affected.

What about confidentiality? Confidentiality will always be maintained. No names are required at any stage during the research. The responses will be kept in the researcher's locker, which will be locked at all times. In addition, the findings will be reported as a group and not individual results to protect any identifying information.

Neither cost nor payment are involved. The results summary will be offered free of charge. The questionnaire will be completed electronically via an online platform by following the link.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg. A principal function of the committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research. If you have any concerns over the way the study has been conducted, please contact the Chairperson of this committee, Dr Clement Penny, who may be contacted by telephone number 011 717 2301 or by e-mail at Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/ 1234, and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za.

Should you wish to participate, please read and sign the attached consent form, complete the questionnaire and submit it back to the researcher.

Thank you

Masilana Vusi   Date: 18 April 2022

Appendix G: Ethical clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mr Masocha Vusi Masilana

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M220234

NAME: (Principal Investigator)	Mr Masocha Vusi Masilana
DEPARTMENT:	Physiotherapy Soweto running clubs, Johannesburg
PROJECT TITLE:	Runners-related injuries and risk factors among runners in Soweto township clubs, Johannesburg
DATE CONSIDERED:	25/02/2022
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr S. Kunene
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	06/07/2022

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **February** and will therefore be due in the month of **February** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature   Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix H: Study variables and measurements

Outcome Variable

This study's outcome variable was whether a participant runner had previously sustained running-related injuries. The specific question used from the survey to measure this outcome was, "Have you experienced pain or any injuries within the past 24 months?". This question was coded with a single-select option, where participants could either respond "yes" to indicate the presence of such injuries or "no" to indicate the absence or non-occurrence of RRIs. To facilitate ease of analysis and representation of the outcome variable, a binary coding scheme was utilised, where all "yes" responses to this question were allotted the value "1". In contrast, all "no" responses were assigned the value "0".

Explanatory Variables

The biopsychosocial model, which divides the factors influencing RRIs into physiological, psychological, physical, and social/environmental domains, served as a guide for the selection of explanatory variables in this study. These variables were selected based on their applicability and findings from prior literature. Each variable's measurement, coding specification, and classification as they relate to factors in the biopsychosocial conceptual model adopted for this study are summarised in tables.

Physiological Factors

In this study, the categorisation of physiological factors emphasises variables that are directly associated with the physical aspects of injury. Two variables were chosen: "Consultation with a Health Professional for Current or Previous Injuries" and "Location or Type of Pain or Injuries." Both variables were classified as categorical.

Table 3. 4 Descriptions, definitions and coding adopted for physiological explanatory factors.

#	Variable Name	Variable Description	Coding
1	Consultation with a health professional for Current or Previous Injuries	Examines whether a participant has sought medical attention for any current or previous RRIs.	(1) No; (2) Yes

2	Type/Location of Pain/Injuries	Specifies the type of location of the pain or injuries experienced by a participant	(1) Lower Extremity Injuries; (2) Neck and Back Injuries. (3) Upper Extremity Injuries

Consultation with a health professional:

The variable "Consultation with a Health Professional" was created by combining two distinct survey questions, each of which captured a different aspect of the participants' engagement with health professionals regarding RRIs.

The first question asked if participants had suffered pain or injury in the previous 24 months, with a focus on recent injuries that may have caused people to seek professional help. Participants were asked if they had sought medical attention for these injuries. The second question examined participants' past experiences with RRIs without specifying a time limit. This question was intended to identify those who had previously sustained injuries and further assess whether they had sought medical advice for those prior injuries.

In contrast, injury participants who answered negatively to both questions indicated that they had not sought professional consultation for injuries that occurred within the previous 24 months or for injuries that occurred in the past.

By collecting these questions separately, the study intended to capture both recent and past injury experiences, allowing for a comprehensive understanding of participants' interactions with health professionals over time. This approach allowed for a thorough and nuanced examination of participants' consultation behaviours and patterns of seeking professional assistance for RRIs.

To establish a unified category and streamline the data analysis process, participants who answered affirmatively to either the question about seeking professional consultation for injuries within the past 24 months or the question about seeking consultation for previous injuries were grouped. This classification ensured that all individuals who sought consultation were captured in the same category, regardless of the time frame or occurrence of their injuries.

Type or Location of Pain or Injury:

The variable "Type or location of pain or injury" was derived from the question in the case of "Type or Location of Pain or Injury," additional categorisation was undertaken following the initial collection of data. The purpose of this categorisation was to ensure consistency and comparability between findings and to group similar categories of injuries for analysis, as suggested in the literature.

Specifically, the following classifications were made for this variable:

- All Pain or injuries to the ankle, foot, hamstrings, hip, knee, lower limb (tibia/fibula), and thigh were classified as "Lower Extremity Injuries" (Smith *et al.*, 2019).
- All shoulder and elbow pains or injuries were classified as "Upper Extremity Injuries" (Jones *et al.*, 2018).
- All instances of back and neck pain and injury were categorised as "Neck and Back Injuries" (Jones *et al.*, 2018).

In addition to ensuring comparability and consistency, this categorisation was adopted to facilitate a more targeted analysis and the identification of patterns and trends within each injury category. By grouping similar categories of injuries together, it is easier to examine the factors associated with specific injury locations or types, which can provide valuable information for injury prevention and management strategies (Smith et al., 2020).

Psychological Factors

In the context of RRIs, psychological factors focus on understanding the psychological elements that may influence injury risk, management, and prevention among runners. These elements delve into the individual's psyche, behaviours, and running experiences. In this study, the variables "Level of competition" and "Participant's Running Experience" were used to examine the psychological elements connected to RRIs.

Table 3. 5 Descriptions, definitions and coding adopted for psychological explanatory factors.

#	Variable Name	Variable Description	Coding
1	Level of Competition	Establishes the level at which a participant competes in their running activities.	(1) Beginner; (2) Intermediate; (3) Professional
2	Running Experience	Captures the duration or length of time a participant has been involved in running.	(1) Less than 1 year; (2) 1-2 years (3) 3-5 years. (4) 6-10 years (5) More than 10 years

Level of Competition:

The variable "Level of Competition" was coded as a categorical variable to assess the extent to which a participant competes in running-related activities. Participants were asked, "At what level do you compete?" and given three possible responses: "Beginner," "Intermediate," and "Professional."

Cues were supplied alongside this question in the survey to assist participants in picking the proper category and to help enhance accuracy, consistency, contextualisation, and self-reflection. According to other studies, by providing cues, participants are given clear definitions and examples for each category, allowing them to accurately self-assess their competitive involvement (Smith *et al.,* 2019).

In the question prompt, "Beginner" was defined as a participant who is relatively new to competitive running or has limited exposure to organised races and events. In addition, they were characterised as predominantly participating in recreational running or non-competitive activities. On the other hand, the category "Intermediate" was used to represent runners with moderate experience in competitive running who have advanced beyond the novice level. They may have competed in multiple races or events and developed a certain level of competitiveness in their running endeavours. Participants in the "Professional" category have attained a high level of expertise and involvement in competitive running. In the question prompt, these athletes frequently compete at an elite level, participate in professional races and events, and may have sponsorship agreements and receive specialised training, among other characteristics.

Running Experience:

The variable "Running Experience" captures the amount of time a person has spent running. Although the data for this variable were collected as a continuous measure, the variable was divided into five distinct groups for analysis, which are as follows.

- *Less than 1 year*: A participant who has participated in running activities for less than a year.
- *1-2 years:* This group is composed of participants who have been immersed in running for a duration of one to two years. As established elsewhere, this group consists of individuals who have acquired some experience and familiarity with running in a relatively brief period.
- *3-5 years*: This category includes runners who have been actively participating in running for 3 to 5 years. Individuals in this group have gained a reasonable level of running experience and may have reached certain milestones in their running careers.

- *6-10 years:* This category includes participants who have been running for 6–10 years. Individuals with extensive running expertise who have demonstrated a long-term commitment to the sport are eligible.
- *More than 10 years*: This category includes participants who have been running for more than ten years. Individuals in this group have vast running experience, demonstrating significant passion and involvement in the sport over a long period.

The classification of running experience into different groups allows for a more thorough examination of the relationship between running time and various outcomes, such as injury risk, performance outcomes, and training tactics. It enables the investigation of potential differences and patterns among people with varying levels of running expertise.

The study intends to capture the continuum of running involvement and examine the impact of varied durations on the variables of interest by categorising running experience in this manner. The categorisation gives a logical framework for analysing and interpreting the data, making comparisons between the defined groups easier.

Physical explanatory factors

Table 3. 6 Descriptions, definitions and coding adopted for physical explanatory factors.

#	Variable Name	Variable Description	Coding
1	Age	Captures the age of the participants	18; 19; 20; 21; 22; 23; 24 …
2	BMI	Used as an indicator of body composition, calculated by dividing a person's weight in kilograms by the square of their height in metres.	(1) Underweight; (2) Normal; (3) Overweight /Obese
3	Average Distance Run per Session	Quantifies the average distance a participant runs in a single session	(1) Less than 5 km; (2) 5-9 km; (3) 10-21 km; (4) 22- 31 km (5) 32 km or more
4	Leg Dominance	Identifies the dominant leg used by a participant during running	(1) Left; (2) Right
5	Shoe Condition	Establishes the condition of the runner's shoes	(1) Badly worn out; (2) Fairly new; (3) Slightly worn out
6	Running Incline	categorises the type of incline a	(1) Downhill; (2) Flat; (3)

	Type	participant typically encounters during a running session	Mixed inclines (4) Uphill

Age:

The variable represents the participants' chronological age at the time of the study. It is a fundamental demographic factor that sheds light on how RRIs may affect various age groups. Analysing the relationship between age and RRIs helped in identifying age-specific risk factors, injury patterns, and potential interventions. Participants were asked to provide their ages as numerical values in completed years. Measurements of this variable were retained as continuous.

BMI:

Body Mass Index (BMI) is a numerical value derived from an individual's height and weight measurements. It provides an estimation of body composition and is commonly used as an indicator of overall weight status. Analysing the relationship between BMI and RRIs can help identify potential associations between body weight, body composition, and injury risks. To accurately capture BMI, participants were asked to provide their height and weight measurements. BMI is calculated using the following formula:

$$BMI = \frac{weight\ (kg)}{[height\ (m)]^2}$$

Average Distance Run Per Session:

This variable refers to the typical distance that runners cover during their running sessions. It represents the volume of running and indicates the intensity of running activities. Examining the average distance run per session and RRIs helps identify potential associations between running volume and injury risks. Participants were asked to report the distance covered in kilometres during their outdoor runs, treadmill sessions, or any other form of running exercise. While the data were collected as a continuous measure, categories were introduced to ensure consistency of responses and easier comparison for analysis and reporting. The five categories that were created are "*Less than 5km, 5-9 km, 10-21 km, 22-31 km, and 32 km or more.*

Leg Dominance:

Leg dominance per session refers to the preference for using either the dominant or non-dominant leg during running sessions. It aims to identify whether leg dominance plays a role in RRIs. Analysing this variable and RRIs can provide insights into the potential asymmetries or imbalances that may contribute to injury risks. Participants were asked to report their preferred leg used during sessions. Cues were put in place to aid participants in considering their natural inclination and preference when it comes to which leg they use more dominantly during their running activities.

Shoe Condition:

This variable refers to the overall state of the running shoes worn by participants during their running activities. It encompasses various aspects, including the physical condition of the shoe's upper, midsole, and outsole, as well as the level of wear and tear. It also includes factors such as the presence of structural damage, loss of cushioning, deformation, and any other factors that may affect the shoe's ability to provide support and protection to the runner's feet. Categories used to measure this variable were “Badly worn out”, “Fairly new”, and “Slightly worn out”.

Running Incline Type:

Running incline type refers to the type of incline encountered during running sessions. It aims to identify whether running on inclines, such as uphill or downhill surfaces, affects the incidence or characteristics of RRIs. This variable provides insights into the potential impact of different incline types on injury risks and biomechanical factors associated with running. Participants were asked to report the types of inclines they encountered during their running sessions. Categories were used to represent reported incline types: *downhill, flat, mixed inclines or uphill.*

Social and environmental factors

Table 3. 7 Descriptions, definitions and coding adopted for social and environmental explanatory factors.

#	Variable Name	Variable Description	Coding
1	Gender	Captures the gender or sex of the participants	(1) Female; (2) Male

2	Average Number of Days Run in a Week	Quantifies the average number of days per week that the participant engages in running activities	1) Once a week; (2) 2-3 days/ week; (3) 4-5 days/ week; (4) more than 5 days/ week
3	Type of Temperature Conditions for Running	Categories the typical temperature conditions under which a participant engages in running activities	(1) Cold; (2) Warm or Hot
4	Type of running surface	Identifies the type of surface participants typically run on	(1) Artificial; (2) Concrete/ or Tar; (3) Grass; (4) Gravel Road; (5) Sea sand
5	Other sport participation	Indicates whether a participant engages in any other sport besides running	(1) Female; (2) Male

Gender:

The variable was included as it can potentially influence the occurrence and characteristics of RRIs. Gender refers to aspects of being male or female. In the context of this study, gender was examined to explore any potential differences in injury prevalence, severity, location, or patterns between male and female participants. For this study, gender was coded using categorical values, where participants specified whether they were "male" or "female". Gender specifications were then analysed against responses to determine their contribution to RRIs.

Average Number of Running Days in a Week:

The number of days participants ran in a week was the key variable in providing insight into the frequency of running among participants. It helped in assessing the relationship between running habits and the occurrence of injuries. The average number of running days in a week refers to the frequency with which participants engage in running activities over a typical seven-day period. This variable captured the regularity of running and served as an indicator of the participants' running habits and exposure to potential risks. Running activities included outdoor runs, treadmill sessions, and any other form of running exercise. Data for this variable were collected as continuous measures where participants changed their running habits between four options: *Once a week, 2 to 3 days/week, 4 to 5 days/week, and more than 5 days/week.*

Type of Temperature Conditions for Running:

This variable explored the potential impact of different temperature environments on the occurrence and severity of injuries. It helped identify which general temperature conditions were associated with a higher or lower incidence of RRIs. It also allowed for the examination of the relationship between temperature and injury patterns among runners. The variable focused on the temperature aspect of the running environment and did not encompass other weather conditions such as humidity, precipitation, or wind speed. Categorical labels of "cold" and "warm or hot" were assigned for the measurement of this variable.

Type of Running Surface:

The variable "Type of Running Surface" provided insights into how the characteristics of running surfaces may influence the risk of injuries. The variable measures the specific terrain or ground on which participants engage in their running activities. This included outdoor running surfaces such as pavement, grass, trails, track, or treadmill surfaces. The variable helped identify certain surfaces associated with a higher or lower incidence of RRIs. Participants were provided with clear instructions to classify their running surfaces accordingly. To ensure uniformity of participants' responses in classifying running surfaces, potential responses were grouped into categories as follows.

- *Artificial* refers to synthetic running surfaces designed and engineered to mimic or provide an alternative to natural running environments. Such surfaces include artificial running tracks, artificial turf/synthetic grass, treadmill surfaces, and indoor sports surfaces.
- *Concrete/ or tar* refers to a type of hard, solid ground commonly encountered in urban or paved environments. These surfaces are typically made of concrete or asphalt (also known as tar).
- *Grass:* Grass is a natural running surface characterised by its softness and natural texture. It is commonly found in parks, fields, and open spaces, providing a more forgiving and dynamic running experience compared to harder surfaces like concrete or asphalt.
- *Gravel road* refers to a running surface composed of loose, small stones or rock fragments that have been compacted together to form a stable pathway. Gravel roads are commonly found in rural areas, as are trails and certain running routes.
- *Sea sand:* Sea sand, also known as beach sand, refers to the soft and loose sand found along coastlines and beaches.

Other Sport Participation:

This variable refers to the involvement of participants in sports activities other than running. It aims to identify whether involvement in other sports may have an impact on the occurrence, risk factors, or patterns of RRIs. The variable provided insights into the potential interaction between different sports and their influence on running outcomes. Participants were asked to indicate whether they engaged in other sports activities apart from running.

Data quality assurance

Variables were managed individually throughout the data cleansing procedure. To maintain the accuracy and completeness of the data, missing records were removed on a variable basis. The survey overall had a 98% completion rate, which was impressively high. This method ensured that the final dataset contained only valid and complete data points. By addressing absent values in this way, the data's overall quality and dependability were maintained. In addition, strict data protection measures were implemented to assure the participants' confidentiality and privacy. The implementation of these data cleansing procedures optimised the dataset for subsequent analysis and interpretation.

Appendix I: Further information on data analysis

Objective 1: To determine the demographic characteristics and sport-specific backgrounds of recreational and professional runners.

Two subcomponents were identified for this objective: the demographic component and the sport-specific background component of the athletes.

Descriptive analyses were used to calculate the frequencies and percentages of variables such as gender, age, body mass index (BMI), and leg dominance for the demographic component. These analyses provided insights into the distribution of these demographic variables among the runners. The results were presented using bar charts and pie charts, which effectively visualised the demographic profiles of the participants.

Moving on to the athletes' sport-specific backgrounds, descriptive analyses were conducted to explore variables associated with their running activities. These variables included the type of running, level of competition, duration of running, average number of running days per week, and average distance per session. These sport-specific variables were compiled using descriptive statistics such as means, standard deviations, and ranges. The results were presented in tables and graphs to facilitate a clear comprehension of the backgrounds of the participants.

Comparative analyses were conducted to compare the demographic characteristics and sport-specific backgrounds of recreational and professional runners. Statistical tests, including chi-square tests and t-tests, were used to determine whether there were significant differences between the two groups. The comparative analysis results were summarised in tables and graphs, enabling a thorough comparison of the demographic and sport-specific variables between the two groups.

Objective 2: Estimate the prevalence and characteristics of running-related injuries among participants.

To begin, a prevalence analysis was performed to estimate the prevalence of RRIs among participants during each period. To calculate the prevalence of injuries among participants, the following formula was utilised.

Prevalence (%) = (Number of participants with running-related injuries / Total number of participants) x 100

A bar chart was then used for presentations to provide a clear picture of the overall prevalence rate.

Following that, a descriptive analysis of injury characteristics was conducted. The specific characteristics of the reported RRIs, such as the type or location of pain/injuries and the severity of injuries, were investigated in this analysis. To summarise the distribution of these injury characteristics, frequencies and percentages were determined. Tables and visualisations were employed to assist in the understanding of the findings.

Subgroup analyses were performed to further analyse the data depending on participant characteristics such as age, gender, and level of competition. These subgroup analyses enabled the investigation of variations in the prevalence and characteristics of RRIs across subgroups. To compare injury profiles and identify significant differences and trends, statistical analyses and visualisations were utilised.

Objective 3: Identify and compare intrinsic and extrinsic risk factors for running-related injuries among participants.

For the third objective, a univariate analysis was first performed to investigate the association between each potential risk factor and RRIs. This univariate analysis enabled a preliminary assessment of the individual effects of prospective risk factors and provided insight into their associations with RRIs. It was a crucial step in identifying significant risk factors for investigation in the multivariable analysis. For various levels or categories of each risk factor, the prevalence or incidence of RRIs was determined. A chi-square test was used to determine the relationship between each categorical risk factor and RRIs. The chi-square statistic (χ^2) and its corresponding p-value were calculated using the following formula;

$$\chi^2 = \Sigma [(O - E)^2 / E]$$

Where:

χ^2 is the Chi-square statistic. This is the calculated chi-square value used to determine the strength of the association between the categorical risk factor and RRIs.

Σ is the Summation symbol. This indicates that you will sum up the values for each cell in the contingency table.

O is the Observed frequency in each cell of the contingency table. These are the observed counts or frequencies for every possible combination of risk factors and running-related injury categories.

E is the expected frequency in each cell of the contingency table. These are the frequencies that would be expected under the assumption of no association between the risk factor and RRIs. The calculated frequencies are based on the distribution of RRIs across the levels or categories of the risk factor.

After the univariate analysis, a multivariable analysis was performed to examine the simultaneous effects of multiple independent variables (risk factors) on a dependent variable (RRIs) while controlling for potential confounding factors. It enables a more comprehensive comprehension of the factors associated with RRIs and contributes to the development of preventative strategies and interventions.

Since the dependent variable is binary or dichotomous (e.g., presence or absence of RRIs), logistic regression was determined to be the most appropriate statistical method for multivariable analysis in this study. The odds ratio (OR), which quantifies the strength and direction of the association between each risk factor and the likelihood of RRIs, was calculated using logistic regression. The following was the formula employed to run the logistic regression in STATA;

$log(odds) = \beta 0 + \beta 1X1 + \beta 2X2 + ... + \beta nXn$; Where

- Log (odds) represents the natural logarithm of the odds of the dependent variable, that is, the presence or absence of RRIs).
- β0, β1, β2, ..., βn are the regression coefficients (also known as log odds ratios or logit coefficients) corresponding to the independent variables X1, X2, ..., Xn. These coefficients represent the change in the log odds of the dependent variable associated with a one-unit change in each independent variable, holding all other variables constant.
- X1, X2, ..., Xn are the independent variables or risk factors being examined.

Interpretation of Model Results

***Odds Ratio*:** Odds ratios were used to represent the strength of the association between the risk factor and the probability of RRIs. A risk factor is associated with an increased likelihood of RRIs if the odds ratio is greater than one. A relative risk (OR) less than one indicates a negative association, indicating a reduced likelihood of RRIs. The magnitude of the OR represents the strength of the association.

Statistical Significance: The level of statistical significance, on the other hand, was set at 0.05, which is a standard threshold for many studies. This implies that associations with a p-value less than 0.05 were deemed statistically significant. The statistical significance of the result suggests that the observed association between the risk factor and RRIs is unlikely to have occurred by coincidence.

Confidence Intervals: The 95% confidence intervals around the odds ratios offered a range of values within which the true population parameter is expected to fall. If the confidence interval does not contain the value 1, the link was statistically significant at the specified level of significance (e.g., p 0.05). A smaller confidence range indicated a more accurate estimation of the association.

Model Fitness Test

In addition, the Hosmer-Lemeshow test was used to evaluate the overall fit and predictive ability of the logistic regression model. This model was used to determine the degree to which the observed results of the regression analysis correspond to the expected results of the study based on the fitted model. The model ensured that the data were categorised into distinct groups based on the logistic regression model's predicted probabilities. The observed number of individuals with RRIs (events) was compared to the expected number of events and non-events within each category. The test statistic was subsequently computed based on the difference between the observed and expected frequencies. A low p-value indicates that the model does not adequately forecast the occurrence of RRIs. In contrast, a high p-value indicates that the model predicts the outcome reasonably well. While the Hosmer-Lemeshow test assesses the agreement between observed and predicted probabilities, its ability to distinguish between individuals with and without RRIs is limited.

To assess the model's accuracy and reliability, a sensitivity and specificity analysis was performed. To calculate sensitivity, divide the total number of true positive cases by the number of true positive and false negative cases. This calculation quantified the proportion of true positive cases that the model correctly identified.

Similarly, specificity was calculated by dividing the number of true negative cases (participants correctly identified as lacking RRIs) by the sum of true negative and false positive cases. This metric indicates the model's ability to classify individuals without RRIs appropriately. By calculating sensitivity and specificity, the performance of the model was evaluated in terms of correctly identifying cases of RRIs (sensitivity) and accurately classifying individuals without RRIs (specificity).

The sensitivity and specificity values, along with their respective confidence intervals, were reported to provide a comprehensive evaluation of the logistic regression model's predictive accuracy. These measures permitted the assessment of the model's ability to accurately distinguish between individuals with and without RRIs, thereby enhancing the understanding of its performance in the study population. Incorporating sensitivity and specificity analyses alongside the Hosmer-Lemeshow test allowed for a more thorough evaluation of the model's fit and predictive ability.

Ethical Considerations

The Human Research Ethics Committee (HREC) at the University of Witwatersrand gave the study ethical approval (M220234), and the CGA manager gave the study permission to proceed.

To ensure the obtaining of informed consent, the study was extensively explained to all participants. This included sharing information regarding the study's aim, objectives, and methods. Participants were also given enough time to interact with the researcher and ask questions to ensure they fully comprehended what the study entailed. Participants were also made aware of their right to withdraw from the study at any given stage during the study.

All principles under the Protection of Personal Information Act (POPIA) were observed, which ensures every individual's right to privacy and protection against the unlawful collection, retention, dissemination, and use of personal information. Confidentiality was thoroughly explained to all participants and guaranteed by anonymising the data, should it need to be shared with a third party.

Participants were not exposed to any risks to ensure no harm was encountered at any stage during the study. Potential risk factors, such as psychological distress and physical harm, were thoroughly considered and explored. As a result, the survey questionnaire was designed and administered in a manner that avoided causing unnecessary distress or harm.

Summary

This section was dedicated to describing the methodology employed in investigating the intrinsic and extrinsic factors associated with RRIs among recreational and professional runners in South Africa. It provided an elaborate account of the study area, study design, study population, sampling techniques, and sample size. It also described the data collection procedure and analysis. In addition, this chapter also presented a comprehensive analysis plan detailing each objective and the corresponding analytical techniques. Finally, it provides an overview of the ethical considerations adhered to throughout the study.

Appendix J: Turnitin Report

Playground 2

ORIGINALITY REPORT

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