Factors contributing to running injuries
A narrative review

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Abstract

Design: A narrative review

Purpose: The purpose of this paper is to highlight some common extrinsic and intrinsic risk factors associated with running injuries that should be considered in the management and prevention of running injuries.

Background: Running is one the most common sports activity that is practiced throughout the world. This increase in popularity in running could gradually increase the incidence rate of injury thus contributing to overuse injuries. Research in the field of running injuries is vast and has been conducted over more than 40 years. It is however difficult to distinguish the exact cause of running injuries as the aetiologies are multifactoral and diverse.

There are various factors (extrinsic or intrinsic) that could be associated to running injuries. Extrinsic factors such as training methods, training surfaces or incorrect running shoes have been identified as some common risk factors. Some intrinsic factors such as muscle strength, flexibility and malalignment of the leg have also been identified which could further explain the aetiology of running injuries. Many researchers have identified various contributing factors to running injuries however there is a lack of conclusive evidence on the identified factors. Thus, the acquiring knowledge and scientific evidence about the risk factors related to common running injuries are important as it could assist in the treatment and prevention of long-term injuries.

Conclusion: To reduce the high incidence rates of running injuries and to promote independence in injury management, a rehabilitation programme consisting of a training programme which gradually increases mileage, frequency, resting periods, appropriate running shoes for different foot types; heel lifts to adjust malalignments of the leg; flexibility and strengthening programmes of the lower limb and the selection of appropriate training surfaces and terrain is needed.

Keywords: extrinsic factors, intrinsic factors, running injuries

Introduction

Running is an affordable and convenient sport which allows the athlete to participate in it at any time of the day. Running has considerable benefits as it improves general health and wellbeing and positively increases levels of physical activity in individuals (Paluska, 2005). Running thus addresses an important factor as physical inactivity is a contributing factor for many chronic diseases, decreased longevity, deterioration of physical function and obesity (Warburton et al., 2006). Although running has considerable health benefits, it can also contribute to lower limb injuries at both recreational and competitive levels (Paluska, 2005 & Taunton et al., 2003).

Running injuries could have a negative impact on the athlete as it can reduce activity within running programmes, lead to poor self-image and begin a sedentary lifestyle (Smith et al., 1990). For many athletes, the development of an injury is one of the main reasons for dropping out of a running program (Chorley et al., 2002). Thus, many runners sustain overuse injuries (injuries to the musculoskeletal system) especially of the lower limb and often have a relapse in training or competitions as some injuries are not managed successfully (Van Gent et al., 2007). In order for the runner to be successful in races, the awareness of possible risk factors contributing to running injuries should be known. The runner would in turn seek appropriate management for their injuries and prevent future injury thus reducing the incidence of injuries (Buist et al., 2007).

Research in the field of running injuries is vast and can be dated back to the early 1970's. It is however difficult to distinguish the exact cause of running injuries as the aetiologies are multifactoral and diverse (Buist et al., 2007). Thus a need arises to identify the possible risk factors associated to running injuries to be able to manage and prevent injuries effectively.

Most running injuries over the past 40 years have been a result of training errors, excessive speed work and inadequate rest periods (Johnston et al., 2003 & Fields et al., 1990). Extrinsic factors such as training methods, training surfaces or incorrect running shoes have also been identified as risk factors. However, some intrinsic factors such as muscle strength, flexibility and malalignment of the leg have been identified which could further explain the aetiology of running injuries (Taunton et al., 2003). Thus, acquiring knowledge about the risk factors related to common running injuries are important as it will assist in the treatment and prevention of long-term injuries.

The purpose of this paper is to highlight some common extrinsic and intrinsic risk factors associated with running injuries that should be considered in the management and prevention of running injuries. Furthermore, this paper summarizes the literature reviewed pertaining the highlighted risk factors in the tables below which provides scientific evidence to the studies mentioned.

Extrinsic factors contributing to running injuries

The most common extrinsic factors associated with lower limb injuries in runners include training methods, training surfaces and running shoes (Ryan et al., 2006; Johnston et al., 2003; Taunton et al., 2002; Yeung et al., 2001). These common factors highlighted in studies as well as other factors will be discussed to present the literature available on associations to running injuries. Factors that would be discussed under training methods include training intensity (running speed or pace), volume of training (frequency and duration) and running distance.

Training Methods

The association between risk of injury and training methods such as training intensity, frequency, duration of training and running distance will be highlighted.

Training intensity is associated with running speed or pace in a running program. Derrick (2000) and Mercer (2002) reported that an increase in running pace often generates larger forces and moments on the musculoskeletal structures involved in running which could increase the likelihood of injury. According to Johnston et al. (2003), the application of the 10% rule whereby the training intensity is increased by no more than 10% weekly, could decrease the risk of sustaining running injuries.

The Frequency of training is related to the number of days the runner will train per week. It was found that women who had a fixed training program that participated in a group session once a week, were at an increased risk of injury (Taunton et al., 2003). Another researcher, Van Gent (2007), conducted a systematic review of determinants of lower limb running injuries and found that running more than 2 days per week could increase the risk of injury. Thus the recommended frequency of running to decrease the risk of injury should be 2-3 days per week.

The Duration of training relates to the running time in minutes per week required by the runner (Buist et al., 2008). Yeung and Yeung (2001) found that modification to a training schedule as an intervention could prevent lower limb running injuries. The results suggested that runners who trained more than 30 minutes a day had a higher injury incidence than runners who trained for 15-30 minutes a day. Thus, it is recommended to run for 15-30 minutes a day to reduce the incidence rate of injury.

Running distance or mileage is considered as the measurement in kilometers (miles) that the runner trains daily. Researchers (Macera, 1989 & Walter, 1989) reported that an increase in injury rate for males is resultant from an increase in weekly distance beyond 64km. Furthermore, Johnston (2003) agree with this finding as runners need to follow a training programme specific to running experience and races because 60% of all running injuries are due to increasing running distance too quickly or doing “too much too soon”. The reported findings from Macera and Walter (1989), is more than 20 years old however a consistency in results with up to date researchers such as Johnston (2003) is found. Thus, an increase in weekly running distance of more than 60 km is possibly associated to running injuries and should be considered in the prevention of injuries.

Training surfaces

The different types of training surfaces can have an effect on load absorption mechanisms within the runner. Incorrect training surfaces and terrain can alter a runner's biomechanics and running performance, thus can be associated to running injuries.

Tesutti et al. (2008), found that running on asphalt (hard) surfaces provokes a bigger absorption load on the lateral rearfoot increasing the risk of injury. Whereas running on natural grass leads to smaller load absorption on the rearfoot, thus decreasing the risk of injury. A few researchers have identified in their studies that hard surfaces (road, asphalt and artificial track) can be associated to some common injuries to the knee e.g. patellofemoral pain syndrome (PFPS) and tibial stress syndrome (Tesutti et al., 2008). Running uphill, downhill and on loose surfaces like gravel roads and trail paths are commonly reported as factors contributing to patellar tendinopathy, iliotibial band syndrome (ITBS) and meniscus injuries of the knee respectively (Johnston et al., 2003)

Thus, according to literature, a variation in training surfaces (hard, soft, grass, gravel, hilly and flat) should be considered to prevent running injuries. Similarly, an optimal running surface should be smooth, resilient, flat, even and fairly soft like grass to avoid undue stress on the knee, ankle and foot (Academy of Orthopaedic Surgeons, 2003).

Runners that follow an incorrect training programme, which include improper surfaces, uneven sloped surfaces, too much mileage, frequency and duration, are more prone in sustaining injury to the lower limb than those who follow an appropriate training programme (Logan, 2006). Various training programmes are available and is specifically developed for different runners according their running experience (beginner (0-1 year), intermediate (1-3), advanced (3-10 years and older) (Runners-world, 2010).

Running shoes

Running injuries can occur during training or competing in a race wearing incorrect shoes that has insufficient height, rigid soles, twists easily or worn out (Kvist, 1994). Shoes that exceed 700km mark, loses the ability to absorb shock optimally and could be associated to injury (Fredericson, 1996). Running shoes are often selected on the runner's foot type to correct biomechanics of the runner (Moore, 2002). Schwellnus (2006), investigated whether runners who were advised on running shoes following a clinical lower limb biomechanical assessment prior to purchasing running shoes, had a reduced risk of developing a running injury when compared to runners who did not receive any advice. The results showed no difference in the incidence of common injuries between the runners that had advice on shoe purchase and the clinical lower limb biomechanical assessment and the runners that did not have an assessment and advice.

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

Stretching:

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

Van Mechelen (1995) found that a lack of stretching as part of a warm up and cool down is suggested to be a possible risk factor to injury. However, according to Pope et al. (2000), it was found that pre-exercise muscle stretching does not produce a reduction in the risk of lower-limb injury. Yeung et al. (2001) identified studies in their systematic review wherein runners had stretched before and after a training session and found that inadequate stretching for short periods of time can be associated to injury as mild stretching cause damage at a cellular level in muscles. According to Thacker (2004), stretching increases flexibility and could benefit performance or reduce the risk of injury. However it is suggested that stretching should be complementary to adequate strength training conditioning and an appropriate warm-up.

In overall, the results of the reviewed studies showed contradictory evidence in stretching and the reduction or prevention of running injuries. The data of studies relating to stretching habits were often obtained from surveys or self-reported questionnaires whereby recall bias should be taken into consideration.

Intrinsic factors contributing to running injuries

A combination of intrinsic factors (anthropometry, biomechanical variables, previous injury and running experience) are common factors found among athletes with running injuries. Anthropometry includes increased quadriceps angle, leg length inequality, age, gender, body mass index, poor flexibility, poor muscle strength, malalignment, arch type, rear-foot varus and tibia varum. Biomechanical variables comprise of kinetic or mediolateral control variables ie, magnitude of impact forces, the rate of impact loading the magnitude of active forces, increased forces of the medial side of the foot and the magnitude of knee joint forces and moments (Hreljac et al., 2006 & Johnston et al., 2003). The mediolateral control variables that are commonly associated to injury are the magnitude and rate of foot pronation.

Some common anthropometric factors such as arch height, arch type of feet, leg-length discrepancy, muscle strength, Q-angle and varus/ valgus alignment of the knee will be presented to identify the possible associations to injury.

Anthropometry:

Mckenzie et al.(1985) stated that biomechanical abnormalities are commonly overlooked as a risk factor in running injuries. Arch height and leg length differences can contribute to injury if not properly assessed and managed correctly. According to Wen (1998), it was found that arch height has no association to the risk of running injuries. Lun (2000), found no relationship between arch height and leg length inequality to injury.

The standard values for leg length is <0.5cm, >0.5-1.0cm, >1.0-1.5cm and >1.5cm. If the leg length difference is found to be less or more than 0.5-1.0cm, it has a leg length inequality or discrepancy (Taunton et al., 2002). Leg length inequality often results in muscle imbalances and contributes to injury associated to running. If the leg length inequality is not correctly managed by appropriate heel lifts on the shorter leg, it can result in pelvic tilt, scoliosis, hip and knee joint malalignment and excessive unilateral pronation (McCaw, 1992).

The different types of foot arches are the normal arch, the high arch (supinated) and the flat arch type (pronated).When these arch types are excessive (excessive pronation or supination), stress is transmitted by compensatory rotation of the tibia or lower leg which can contribute to foot, ankle, knee, hip and lower back pain (Johnston et al., 2003).

Johnston et al. (2003) found that one quarter of runners diagnosed with patellar tendinopathy had flat foot arch type which is associated to pronation. In conclusion, excessive pronation possibly due to flat foot arch type could be a risk factor to knee injuries, especially patellar tendinopathy.

Weakness of the hip abductor muscles could be associated to excessive pronation due to compensatory internal femoral and tibial rotation and sub-talar joint eversion which could possibly be associated to iliotibial band syndrome (ITBS) (Powers, 2003; Fredericson, 2000; Novacheck, 1998). Furthermore, weak hip abductor muscles may lead to increased hip adduction during the stance phase in running and possibly cause ITBS. Ferber et al. (2010), found that recreational runners with a previous history of ITBS showed a significant increase in hip adduction in stance phase during running, knee internal rotation angles and rearfoot invertor moment. Thus, ITBS is related to weak hip abductor muscles leading to abnormal running mechanics.

Runners with patellofemoral pain syndrome (PFPS) often showed weakness of the quadriceps muscle of the involved limb (Kannus et al., 1999). Mascal et al.(2003) agree with this finding and suggests that an assessment of the hip, pelvis and trunk should be considered in patients presenting with PFPS to develop a rehabilitation programme with the focus on strengthening of the involved musculature. Similarly, Souza (2009) found that females with PFPS presented with increased hip internal rotation which is accompanied by decreased hip muscle strength and increased gluteul maximus EMG activity. Thus, in conclusion, literature illustrates that weakness of muscles in the hip and knee is related to common running injuries such as ITBS and PFPS respectively.

The Q-angle provides an approximation of the angle of the quadriceps muscle on the patella in the frontal plane. The normal Q-angle values are between 11° ± 3°(men) and 15° ± 5°(women) (Horton et al., 1989). An increased Q-angle cause a larger lateral pull on the patella against the lateral femoral condyle possibly contributing to patella subluxation and patellofemoral pain disorders (Powers, 2003). According to Rauh et al.(2007), it was found that a large Q-angle (⩾20°) was related to running injuries, especially to the knee. In conclusion, research has shown that an increased Q-angle (⩾20°) is possibly associated to knee injury.

The normal BMI is between 24kg/m - 26kg/m, anything less is underweight and anything more is considered overweight and extremely high values are obese. (Rauh et al., 2005). Taunton et al.(2003), found that an increased BMI (greater than 26 kg/m) was a protective factor against injury in men and could be due to the fact that these individuals train seldomly. There is however inconclusive evidence that an increased BMI is associated to running injuries.

Biomechanical Variables

A significant association was found between a group of injured runners and larger vertical impact forces and loading rates (Hreljac et al., 2000). Ferber et al.(2002), found that female runners with a history of stress fractures were associated to greater vertical impact ground forces, loading rates and peak tibial acceleration. Willems et al. (2006), found a strong association between runners with overuse injuries and an increased amount of pressure under the medial side of the foot during midstance. At the same time, it was reported that these injured runners revealed a great amount of pronation and possibly could be related to one of the mediolateral control factors. According to Hreljac et al. (2006), many researchers have studied the correlation of kinetic variables to overuse injuries but have not reported on the impact forces.

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

History of previous injury:

A history of previous injuries related to running is found to be an associated risk factor as runners tend to continue training whilst experiencing pain and this delays healing of the injured structures. This involves competitiveness as the runner will run excessive mileage, possibly sustain an injury but will ignore the signs and symptoms and continue to run through pain (Wexler, 1995). Similarly, Wen et al. (1998) agrees with the statement that a history of previous injury is significantly associated to running injuries.

Thus, once the athlete returns to running after the presumed recovery of injuries, the athlete tends to be more competitive and predisposes the already compromised injured structure to an increase in training and possibly causing re-injury (Ryan et al., 2006).

Running experience

According to Satterthwaite (1999), a significant association was found between hamstring and knee injuries and a first time participation in a marathon. This could possibly have been the result from a lack of running experience as it has been identified as a contributing factor to overuse injuries by Taunton (2002). It was found that inadequate running experience was likely to be associated to injury as both men and women that had a below average history of running (less than 8.5 years) was relatively at risk for tibial stress syndrome.

Summary

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

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

The following tables present the characteristics such as the author and year of publication, the study design, sample group, outcome of study, identified risk factors and limitations of the various studies

Table 1. Study Characteristics

Author, year of publication	Study design and duration of study	Sample group	Outcome of study or Incidence of injury	Risk factors to injury	Limitations
Ferber et al., 2010	Cross sectional experimental laboratory design	35 female participants	The runners who had previous ITBS showed significant greater stance phase peak hip adduction and peak knee internal rotation angles compared to the control group.	* The study provides evidence linking atypical lower extremity kinematics and ITBS due to possible muscle weakness of hip abductor and external rotator muscles	*No measurement of hip abductor strength
Souza et al., 2009	Controlled laboratory study using a cross sectional design	21 females (intervention) with patellofemoral pain and 20 females (control) who were pain free.	Results show that females who complained of PFP had increased hip internal rotation and was accompanied by weak hip muscles. Thus the findings of this study supports the link between abnormal hip function and PFP.	Possible weakness of hip muscles, especially the external rotator muscles, could lead to increase hip internal rotation, which leads to injury.	*No cause-and-effect relationships. *Hip function was assessed and not patellofemoral joint instability.
Buist et al., 2008	Randomized controlled trial	532 novice runners. Control group (236) did a standard 8 week training programme. The intervention group (250) did a graded 13 week training programme based on 10% rule.	The outcome was the absolute number of running related injuries expressed per 100 runners. The incidence of running injuries of the standard 8 week programme was 20.3%. The incidence of the graded 13 week training programme was 20.8%.	It was hypothesized that an incorrect training programme could result in increased incidence of injury, however this study found no effect of a graded 13 week training programme applying the 10% rule compared to the standard 8 week programme.	*No assessment for modifiable risk factors *Factors such as intensity, frequency and duration of training and injury risk needed to be assessed. *Short study period of 13 weeks.
Tesutti et al., 2008	Prospective study: To investigate the plantar pressure distribution during running on natural grass and asphalt surfaces.	44 adult recreational runners	Natural grass is a safe and more compliant surface which will diminish the risk of injuries commonly caused by rigid surfaces like asphalt.	*Incorrect running surfaces, like asphalt surfaces	*A small sample size *A different design of study, perhaps a RCT to determine incidence of injury.
Rauh et al., 2007	Prospective cohort study	393 high school cross country runners	148 of the 393 runners were injured with cumulative incidence of 37.7%.The shin and knee was the most common site of injury.	*Increased Q-angle (>20°) for females and (15°-20°) for males, predictor for knee injuries	*The use of a self reported injury data sheet by participants and coaches.
Van Gent et al., 2007	Systematic Review	Selected 17 articles (13 prospective and 4 retrospective studies)	Incidence varied from 19.4%- 92.3%	*Increased running distance per week *History of previous injury	*Inadequate discussion on factors such as downhill running, biomechanical factors such as coupling forces and the degree of rehabilitation from previous injury.
Schwellnus et al., 2006	Retrospective cohort	94 participants for Experimental group and 83 participants in the control group	EXP= 6.04 per 1000 running sessions.(93 injuries) CON= 6.71 per 1000 running sessions.(115 injuries)	*Past history of running injuries is a strong predictor, however showed no significance between the past injury group and the no past injury group	*The small number of participants in the subgroups. *Recall bias as the runners completed the questionnaire. *The runners self reported their injuries.

Rauh et al., 2005	Prospective cohort study (5-8 weeks during 1996 summer preseason	421 runners	The shin was the most common location of injury. The incidence was 17.0 per 1000 athletic exposures. The females had higher injury rate than males and were at greater risk of running injury and disability. .	*Increase in number of days/ week of training *Large Q-angle (>20°) especially in females *History of previous injury.	*The coaches recorded the injuries of the runners and not a physiotherapist. *Recall bias as the participants self reported their height and weight.
Johnston et al., 2003	Peer Review, focus on the prevention of injuries related to running	Results retrieved from systematic review, comparison trials and expert opinions.	None mentioned	*Malalignment of the leg *Incorrect training surfaces *Incorrect running shoes *Muscle weakness and inflexibility of lower limb	None mentioned
Mascal et al., 2003	Case Report (14 week period)	2 cases complaining of patellofemoral pain	Both patients had reported a decrease in patellofemoral pain after completing a 3 month treatment program. The program consisted of non-weight bearing strengthening of the hip muscles, then in weight bearing positions using functional activities.	*Weakness of muscles of hip, pelvis and trunk that could lead to patellofemoral pain.	None mentioned
Taunton et al., 2003	Prospective Cohort (13 week period)	844 recreational runners	29.4% (249 injuries for 844 runners)	*Increased age in females (>50 yrs) *Running frequency (1 day a week-females only) *Previous injury that has not been completely rehabilitated.	*Clinic attendance was inconsistent, resulting in possible inaccurate recordings of 3 survey trials. *Running distance could not be included in analysis as exposure time was not recorded.
American Academy of Orthopaedic Surgeons, 2003	Online survey	853 runners responded to the survey	76% of 853 runners were injured.	*Inadequate resting periods after injury *Incorrect running surfaces *Improper running shoes *Inadequate warming up, stretching and cool down *Rapid increase in running distance	None mentioned
Taunton et al., 2002	Retrospective case-control study	2002 patients were included from period of 1998-2000	The knee was the most common location for injury, (PFPS- 331 patients; ITBS- 168; plantar fasciitis- 158; meniscal injuries- 100; patellar tendinopathy- 96)	*Younger age (<34 years) *Below average activity history (8.5 years) *Lower than average BMI (<21kg/m²)	* Factors such as malalignment and weekly running volume not included in analysis. *Could not report shorter height as a risk factor as its correlated to the factors above
Yeung et al., 2001	Systematic Review to examine evidence for prevention of running injuries	Selected 12 studies (from 1974-1998) that studied 8806 participants collectively	None mentioned	*Running frequency: (>5 days per week) *Duration of training (>30 minutes per week) *Running distance (>32 km per week) *Inadequate stretching for short periods	*Insufficient evidence from studies to show significance for stretching and reduction in running injuries.
Wen et al., 1998	Prospective study (32 week period)	255 participants	32.9% (84 injuries from 255) The lower leg and the knee was the most prevalent location for injury (32.1% and 31% respectively)	*Increased age *Increased weight *Leg length malalignment *Past history of injury *Increase in training hours per week.	None mentioned

mentioned in the narrative.

Conclusion

The various factors discussed in this review highlighted that there are numerous factors to consider before treating any running injury as the symptoms are possibly the result of training errors in conjunction with biomechanical imbalances. It is imperative to identify all the possible factors, extrinsic and intrinsic, associated to running related injuries to be able to assess and treat runners effectively and holistically. Treating the runner more effectively and efficiently will aid in the athlete's performance when returning to training and competitions.

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