CHAPTER II

REVIEW LITERATURES

Running is one of the most popular leisure sport activity. Next to its beneficial health effect, negative side effects in terms of sports injuries should also be recognize (Van Mechelen, 1992).

Characteristic of running

Running consists of sequence of stance and swing phases (Figure 2.1) (Brody DM, 1987). During running, joint shear forces increase to approximately 50 times that of walking (Mann RA, 1981). During running, the stance phase comprises less than 50% of the total gait cycle. Another major distinction is the presence of a double-float period, which represents approximately 10% of the total gait cycle (Ounpuu S, 1990). The double-float period occurs when both feet are off the ground **(Figure 2.2)**.

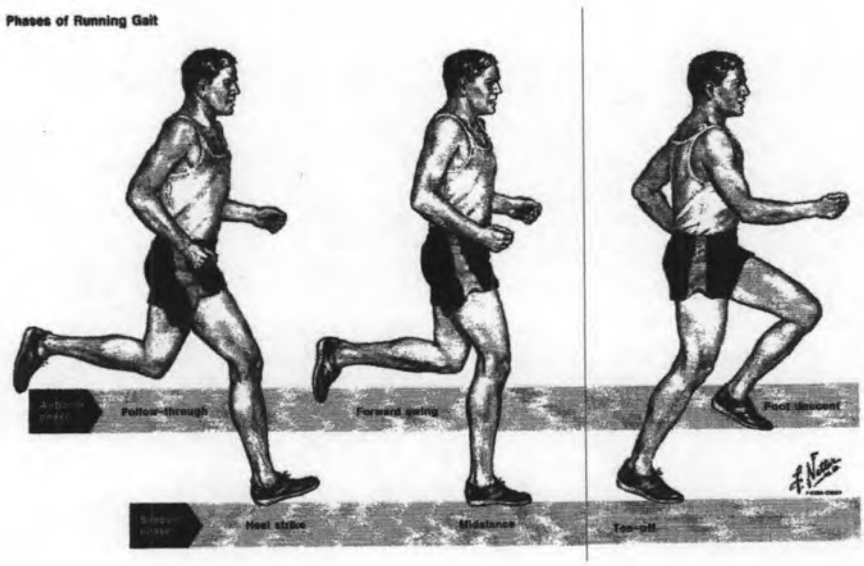

Figure 2.1: Phase of running gait. (From Brody DM. Running injuries: Prevention and Management. Clinical Symposia 1987; 39(3): 1-36.)

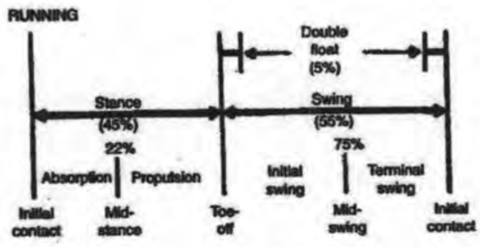

Figure 2.2: Running gait cycles. (From Ounpuu S. The biomechanics of running: a kinematic and kinetic analysis. *Instr Course Lect* 1990; 39: 305-318.)

During running, the feet "collide" with the ground 800 to 2000 times per mile (50 to 70 times per minute for each foot) at a force of two to four times body weight (depending on terrain and body weight). The impact is absorbed by the running shoe or transmitted directly to the leg and back. During running, pronation unlocks the foot for surface adaptation and shock absorption, and supination locks the foot, allowing stabilization at heel strike and propulsion at toe-off. Thus, the foot acts as both a loose adapter and a rigid lever (Brody DM, 1987). On heel strike, the rear foot is inverted, and as the foot becomes loaded, the tibia starts to rotate internally while the foot is converted from a rigid body support (supinated position) to a shock absorber (pronated position) (Mann RA, 1981). In most jogger or recreational and sports runners, impact is on the lateral heel, but foot type also plays a role in gait pattern. Heel-toe gait at this level of training offers more shock absorption than forefoot running. The high-arched cavus foot lands on the outer midfoot, pronates slightly, and then toes-off **(see Figure 2.3)**.

Figure 2.3: Gait pressure pattern of pronate (hyperflexible) foot and Cavus (rigid) supinated foot. (From Brody DM. Running injuries: Prevention and Management. Clinical Symposia 1987; 39(3): 1-36.)

In the course of the ground-contact or stance phase, the weight of the body is absorbed by the foot and then lifted as the next stride begins. Two types of landing are distinguished, namely on the heel (rearfoot strikers, 80% of all runners) and on the front part of the foot (midfoot strikers, 20% of all runners); types of landing intermediate between the two may also occur, depending on speed (Jones DC, 1993; Van Mechelen, 1994).

During the stance phase of running the major site of power generation is the ankle. The ankle performs 1.5 times the work of the knee and 3 times the work of the hip. In other words, the ankle is responsible for 60% of the running power generation, whereas the knee and hip are responsible for 40% and 20%, respectively. The knee, however, is the principal power absorber, performing approximately 2 times the work of the ankle and the hip (David N.M.C. et al, 2001).

Understanding the energy transfer and power generation concepts of the running gait cycle helps improve the recognition of the underlying etiology of injury. Power generation during the swing phase is contributed primarily from the hip. Power from hip flexion during the initial swing phase, power for hip extension during the terminal swing phase, and all other motions are the result of inertia. Energy transfer at the knee and the hip occurs through concentric rectus femoris action during the terminal swing phase, with some evidence of balanced concentric activity proximally and eccentric activity distally (Ounpuu S, 1990). Many running injuries take place during the stance phase (David N.M.C. et al, 2001).

Health effective in jogging and running

Reasons for jogging are health/fitness, pleasure/relaxation and competition/personal performance (Clough et al., 1989; Ooijendijk & Van Agt, 1990). There are benefits associated with the three main risk factors in cardiovascular disease, namely obesity, hypertension and smoking (Koplan et al., 1982; Eichner, 1983): as a group runners smoke less, have a lower percentage of body fat and are less likely to have high blood pressure.

There are a number of health benefits that running or jogging provide (Kowalchik C, 1999). The effects are:

1. Running is the quickest and most efficient means of weight loss.
2. Running reduces your risk of cardiovascular disease:
   (a) Running strengthens your heart
   (b) Running reduces the risks of blood clot formation
   (c) Running lowers blood triglycerides (fat)
   (d) Running lowers total cholesterol levels
   (e) Running rises levels of high-density lipoprotein (HDL) cholesterol, also known as "good" cholesterol
   (f) Running prevents the stiffening of arteries that comes with age.
3. Running lowers your heart rate and blood pressure
4. Running reduces your risk of stroke
5. Running lowers your risk of breast cancer
6. Running enhances your Immune system

Farrell et al (1998) showed that jogging, in the absence of other risk factors (smoking, hypertension, abnormal lipid profile), had the potential to achieve a 30% reduction in cardiovascular disease risk. However, if jogger smokes, the level of exercise required to lower the risk rises dramatically, and if hypertension is present, then the gain is not significant at any level of exercise. Additionally, the World Health Organisation made the observation that jogging reduces health care costs, work absenteeism, and even increases productivity (Briazgounov IP, 1998).

Incidence, Severity, and Localization of running injuries

There is no unanimity in the literature regarding the incidence of running injuries. Different incidence figures are presented: person incidence rates (number of injured runners.100 $runners^{-1}$), injury incidence rates (number of injuries. 100 $runners^{-1}$), and incidence per exposure (number of injuries. 1000 h^{-1} of running). Differences in definitions, in runner characteristics and in research design may influence injury incidence, as well as differences in the time period of data collection. This should be kept in mind when the incidences of various studies on running injuries are compared (Van Mechelen, 1994).

According to a Review of the epidemiological literature about running injuries (Van Mechelen, 1992) reported that all limitation in mind to summarize the studies it seems that for the 'average' recreational runner, who is steadily training and who participates in a long-distance run every now and then, the overall yearly incidence rate for running injuries is about 37-56%. Depending on the specificity of the group of runners concerned (competitive athletes, boy and girls) and on different circumstances these rates may vary. If incidence is calculated according to exposure of running time the incidence reported in the literature varies from 2.5 to 12.1 injuries per 1000 hours of running. Most running injuries are lower extremity injuries, with a predominance for the knee. About 50 – 70% of all running injuries appear to be overuse injuries. Recurrence of running injuries is reported in 20 to 70% of the cases. From the epidemiological studies it can be concluded that running injuries lead to a reduction of training or training cessation in about 30 to 90% of all injuries, about 20 to 70% of all injuries lead to medical consultation or medical treatment and 0 to 5% result in absence form work.

In an 'average' jogging population strain and tendinitis was the most frequent registered injury (Marti et al., 1988). Most of the running injuries are associated with overuse (Van Mechelen, 1994).

The following arbitrary classification has been devised to correlate the level of running with the types and approximate incidence of injuries (Brody DM, 1987):

Jogger or recreational runner (level I) – 3 to 20 miles (4.8-32.18 kilometers) per week at 9 to 12 minutes per mile. Runners at this level incur 25% of injuries and usually suffer from shin splints, patellofemoral stress syndrome, muscle soreness, hamstring pain, low back pain, posterior tibial tendonitis, plantar fasciitis, and Achilles tendonitis.

Sports runner (level II) – 20 to 40 miles (32.18 – 64.36 kilometers) per week at 7.5 to 8.5 minutes per mile. The level II runner (30% of injuries) commonly suffers from Achilles tendonitis, plantar fasciitis, and stress fractures.

Long-distance runner (level III) - 40 to 70 miles (64.36 – 112.63 kilometers) per week at 6.5 to 8 minutes per mile. About 35% of injuries occur at this level of training, generally temperature-related injuries during competition, adductor muscle strains, and sciatica.

Elite marathoner (level IV) – 70 to 180 miles (112.63 – 289.62 kilometers) per week or more at 5.5 to 6.5 minutes per mile. The elite runner suffers few injuries (5%). Stress fractures, acute muscle strain, sciatica, and over-training fatigue are the most common.

Triathlete (level V) – 100 to 300 miles (160.9 – 482.7 kilometers) per week for combined swimming, biking, and running. The potential for overuse injury is highest at this level because of the multiple activities involved.

Risk factors of running and jogging injuries

Running injuries occur because of the repetitive stresses and increased forces that are placed on the musculoskeletal system.

Many believe that running injuries result from a combination of extrinsic factors (training errors, old shoes, running surface) and intrinsic factors (poor flexibility, malalignment, anthropometry, previous injury, running experience) (Taunton et al, 2002). The associated risk factors for running injuries were identified by previous studies can be summarized as follow:

Age

In civilian populations, older age has been reported as potentially protective against injuries by virtual of experience allowing a runner to "listen to the language of their body" and know how to avoid possibly compromising training habits (Van Mechelen, 1995). However, these protective effects are proxy variables that age is felt to incorporate, and not necessarily the direct result of the aging process.

In conclusion, in the majority of studies, age was not associated with running injuries or it was speculated that the association was biased by factors such as running experience, weekly running distance or running speed (Van Mechelen, 1994).

Gender

Powell et al. (1986) concluded that 'gender per se does not seem to be an important risk factor for running injuries'. This seems to be confirmed by the fact that none of the four epidemiological studies had enough female subjects to take this factor into account (Jacobs & Berson, 1986; Ijzerman & van Galen, 1987; Lysholm & Wiklander, 1987; Walter et al., 1989).

Anthropometrics

Height appears to have no association with running injury, and reports about weight are conflicting (Felson DT et al, 1988). One may speculate that larger and/or overweight individuals sustain a greater chance of running injuries as a result of greater forces on bones, joints or connective tissue. On the other hand, one may assume that at least in larger people there greater forces will be balanced by stronger muscles, larger bone surface areas, etc. (Van Mechelen, 1994).

Van Mechelen (1994) summarized that the association between body mass index (BMI), defined as w/h^2 (w, weight in kg; h, height in m^2) and running injuries was evaluated in five studies, Koplan et al. (1982) found BMI to be not independently related to running injuries. A similar finding was reported by Macera et al. (1989) and Walter et al. (1989). In contrast to these findings Blair et al. (1987) found a significant, but low, correlation of 0.1 between running, BMI and running injuries. However, Marti et al. (1988) found runners with a BMI smaller than 19.5 and runners with a BMI greater than 27 to be at greater risk of running injuries, although overweight, defined as BMI 26-28, did not prove to be a risk factor in this study. It should be noted though that overweight amongst runners is a rare finding.

Neely FG (1998) suggested that runners with a low BMI may have insufficient lean body mass to compensate for the stresses involved with running, and further points out that women with a low percentage of body fat are prone to amenorrhoea and low oestrogen levels, predisposing them to osteoporosis and reduced elasticity of collagen, thus further increasing their risk of injury.

Malalignment

Risk factors for injury in any sport may be categorically divided into extrinsic or intrinsic. Static alignment measurements of leg length discrepancy (>1 cm), femoral neck anteversion, knee genu varum, valgum and recurvatum, excessive Q angle, patella alta, tibial torsion, increased ankle dorsiflexion, and excessive subtalar and forefoot varus have been proposed as potential intrinsic risk factors for running injury (Clement DB,1981; Sperryn PN, 1983). In contrast with these observations, other studies did not find any association between running injury and measures of static lower limb alignment (Mantgomery LC, 1989; Wen DY, 1997).

In the literature (Van Mechelen, 1994), many alignment defects are mentioned as giving rise to overuse running injuries such as (1) difference in limb length (Subotnick, 1985); (2) femoral anteversion (Stanish, 1984); (3) knee anomalies, such as knock-knees or bow-legs and too large or too small patella (Gudas, 1980; Clement et al., 1981; Andrews, 1983); (4) foot anomalies, such as varus and valgus of the heel or rearfoot, flat feet and high arches (Doxey, 1985; McKenzie et al., 1985; Renstrom & Johnson, 1985).

The so-called malicious malalignment syndrome can be seen in certain runners. This syndrome is the combination of a broad pelvis, increased femoral anteversion, genu valgum with or without genu recurvatum, squinting patellae, excessive Q angle, tibial varum, and excess pronation of the foot. (Brody DM, 1987; James SL, 1978)

Leg-length discrepancy may result in iliotibial band friction syndrome, trochanteric bursitis, low-back pain, and stress fractures. A 20- to 30 mm leg-length discrepancy may be acceptable in a low-demand population. However, in the running population, the repetitive high loading forces may require that a leg-length discrepancy as small as 5 mm be compensated (Renstrom P and Johnson R, 1985; Bolz S and Davies G, 1984).

Several studies have identified large quadriceps (Q) angle (Messiser SP, 1991; Schwellnus MP, 1993) as risk factors for running injury. The quadriceps angle formed by the intersection of a line, from the anterior superior iliac supine (ASIS) to the midpoint of the patella, with a line from the midpoint of the patella to the midpoint of the tibial tubercle. Theoretically, a large Q-angle (>15-20°) increases the lateral pull on the patella against the lateral femeral condyle, thus contributing to patellar subluxation and other patellofemoral pain disorders (Livingston LA, 1998). Normally, the Q angle is 13 to 18 degree. The normal angle for male is 13 degrees, and for females it is 18 degrees. Less than 13 degrees suggests patellofemoral dysfunction or patella alta. And greater than 18 degrees suggests patellofemoral dysfunction, subluxating patella, increased femoral anterversion, genu valgum, or increased lateral tibial torsion. (Evans RC, 2001)

There are three common foot arch types: "normal" arch, pes cavus (high-arched or supinated feet), and pes planus (flat-footed or pronated feet). Pronation and supination are normal phenomena. When they are excessive, compensatory rotation occurs in the tibia, and stress is transmitted proximally through the leg. This stress contributes to foot, ankle, knee, hip, or lower back pain in pronated or supinated runners (Mckenzie DC. et al, 1985). Pronation or supination that demonstrates excessive displacement or velocity during stance phase may contribute to running injuries (David N.M.C. et al, 2001).

Many running injuries take place during stance phase. It is during this phase that maximal eccentric muscle activation and power absorption within the musculoskeletal system occurs. If abnormal pronation occurs during midstance, musculoskeletal stresses may become evident on the medial aspect of the extremity. In contrast, if abnormal supination occurs during midstance (as seen with a cavus foot), musculoskeletal stresses may become evident on the lateral side of the foot and knee (Renstrom P and Johnson R,1985).

From the contradictory results of many studies the important of malalignment as a cause of running injures is still not made clear (Van Mechelen, 1994). However, as stated by Powell et al. (1986) 'the hypothesis that structural abnormalities are a risk factor for running injuries is too reasonable to deny ... [and] ... careful, abnormality-specific studies should be a top priority for future research'.

Muscular imbalance and inflexibility

Structural variations around the foot and ankle that create impingements, traction effects, or decreased mobility can subsequently the runner to injury (David N.M.C. et al, 2001).

Running strengthens the muscles at the back of the thigh and leg (the hamstrings and calf muscles) relatively more than those at the front (Mirkin, 1975; Clement et al., 1984; Subotnick, 1985), and the resulting imbalance supposedly facilitates the occurrence of various type of overuse injuries.

Muscle inflexibility and weakness of the quadriceps and the gastrocnemius and soleus group have been associated with injury (Clement DB et al, 1981). Johansson C (1992) hypothesizes that muscle fatigue lead to an inability to resist impact that can result in injury.

Training errors

Training errors may include too much volume, too much intensity, or inadequate recovery. Clement et al. (1981) described four categories of training error: (a) persistent high-intensity training without lower intensity (easy days); (b) sudden increases in mileage and intensity without adequate rest; (c) single, severe training or competitive session; and (d) repetitive uphill-downhill training. Running experience or speed of training has not been shown to alter the propensity for running injury. The need for an individualized balance between training volume, intensity, and recovery must be recognized and maintained.

Almost all of the cited authors state weekly running distance as the most important risk factor for running injuries (van Mechelen, 1994). Jacop and Berson (1986) found weekly distance to be significantly associated with running injury. The same was confirmed in epidemiological studies of Blair et al. (1987), Ijzerman and van Galen (1987), Marti et al. (1988), Macera et al. (1989), Walter et al. (1989) and Bovens et al. (1989). In some studies a significant relationship between running frequency (Jacobs & Berson, 1986; Macera et al., 1989; Walter et al., 1989; van Mechelen, 1992) and running injuries was found, although this relation was not confirmed by Marti et al. (1988). Marti et al. (1988) examined in their study a subgroup running the same weekly distance in two, three or four weekly sessions. No significant differences appeared in the incidence of running-related injuries. In the study of Jacobs and Berson (1986) duration of running was not associated with increased running injury incidence.

Training speed was not associated with increased risk of running injuries in the studies of Koplan et al. (1982), Ijzerman and van Galen (1987), Walter et al. (1989) and van Mechelen (1992). In the study of Jacobs and Berson (1986), however, training speed was significantly associated with an increased risk of running injuries, as in a subpopulation of younger runners in the study of Ijzerman and van Galen (1987).

In conclusion it can be stated that weekly running distance is a strong determinant of running injuries. The role of running frequency, weekly running time and running speed remains unclear.

Running surfaces

Running on too hard a surface causes mechanical shocks and may overload joints, tendons, etc. (Clement & Taunton, 1981), while too soft a surface quickly tires the muscles and it is thought that it may thereby give rise to injury (Gudas, 1980). Surface irregularities – pot-holes, the root of trees, pavement edges and so on – may cause acute injury to the ankle and knee. In the case of running on public roads, problems may arise not only through the hardness of the surface but also through its camber which places a different loading on the legs and can thus give rise to overuse injuries of various type, e.g. short leg syndrome (Gudas, 1980).

The importance of the running surface in the etiology of injuries should not be overlooked. In certain sporting activities, the frequency of injury may as much as quadruple depending on the running surface (Nigg BM,1978). Frequent running on asphalt or concrete surfaces increases mechanical loading. This increase in loading can act on joints, muscle, and tendons, thereby promoting greater injury rates (Cook S. et al, 1990). In contrast, running on too soft a surface may cause hypermobility within the joints, tendons, and muscles, leading to overuse injuries (Renstrom P and Johnson R, 1985). Running on uneven surfaces, slippery roads, or banked tracks may cause a functional leg-length discrepancy. This discrepancy may cause excessive loading on the long leg and result in an iliotibial band syndrome or trochanteric bursitis.

Running experience

Running experience is thought to be a factor associated with running injuries, the inexperienced runner being susceptible to running injuries (Powell et al., 1986). This factor did not prove to be significantly associated with running injuries in the studies of Koplan et al. (1982), Blair et al. (1987), Ijzerman and van Galen (1987) and Walter et al. (1989).

Marti et al. (1988) found in an age-specific analysis among men of similar age a positive association between years of jogging and decreased incidence of running injuries. In the study by Macera et al. (1988) after univariate analysis it was found for men that running regularly for less than 3 years was significantly associated with running injuries of the lower extremity. This association remained after multivariate logistical regression: runners with less than 3 years of running experience had an odds ratio of 2.2 (95% CL, 1.5 - 3.3).

These findings suggest that at least for men, running experience, resulting in a better adaptation to running on the biomechanical and/or tissue level, may lead to less injuries, although bias as a result of a 'health runner effect' should be taken into consideration (Marti et al., 1988)

Konradsen et al. (1990), in examining subjects with 30 to 40 years of distance running experience, failed to discover an increased incidence of osteoarthrosis of the hip. Similar findings have been noted at the knee and ankle (Lane NE et al, 1986; Lane NE et al, 1987).

Shoes

Running shoes can affect the type and frequency of injury (Luethi SM et al, 1986). If running shoes become wet or the midsole is worn for greater than 400 km, the shock absorption capability decreases by approximately 30% to 50% (Cook et al, 1990). In addition, the proficiency in which running shoes provide effective heel pad containment is important (Jorgensson U and Ekstrand J, 1988). Proper heel pad containment in the normal foot can increase shock absorption by 29.5%, and in the traumatized heel pad, it can increase shock absorption capability by as much as 48.5%.

Walter et al. (1989) found owning two pairs of shoes to be significantly related with a 50% increase in injury risk. However, in this study shoe characteristics (presence of varus wedge, waffle sole, wear pattern and personal shoe repair) were not related with injury risk. The effect of owning more shoes was said to reflect greater levels of training of such runners.

Verdejo R. and Mills N.J. (2003) found that the peak plantar pressure increased on average by 100% after 500 km run. Scanning electron microscopy shows that structural damage (wrinkling of faces and some holes) occurred in the foam after 750 km run. Fatigue of the foam reduces heel strike cushioning, and is a possible cause of running injuries.

Orthotic devices

These supports are placed in running shoes to compensate for biomechanical problems, preventing abnormal movements in the foot and lower limb during running. Most running shoes are made with removable insoles (Brody DM, 1987).

The use of orthotic devices is capable of correcting minimal alignment abnormalities, in this way creating normal running conditions. Marti et al. (1988) found the use of in-shoe orthotics to be significantly related with both a positive history of previous injury and with running-related injuries during the period of study.

Warm-up, stretching exercise and cool-down

Lack or improper use of warm-up, stretching exercises and cool-down is thought to be a risk factor with regard to running injuries (van Mechelen et al., 1987)

Walter et al. (1989) found runners who 'sometimes' stretch to be significantly at risk of injury in contrast to runners who 'always , usually or never stretch' leaving this finding unexplained. Blair et al. (1987) found frequency of stretching to be unassociated with running injury. Macera et al. (1989) found stretching before running to be not associated with running injury.

With regard to warming up, Walter et al. (1989) found runners who say they never warm up to run a significantly smaller risk of running injury in comparison to runners who say they 'always, usually or sometimes' use warm-up. In the same study, regular use of cool-down was not related to running injuries at all. It is also know that the majority of recreational runners (80-90%) perform a warm-up or stretching exercise one way or the other (Ooijendijk & Van Agt, 1990).

Finally, van Mechelen (1992) was not able to detect any preventive effect in terms of a reduction of running injury incidence from a standardized programme of warm-up, stretching exercises and cool-down in a randomized trial, in which runners were matched for age, weekly distance and knowledge on the prevention of running injuries.

Previous injury

According to Powell et al. (1986) persons with a previous injury may be more likely to become injured again because (i) the original cause may remain; (ii) the repaired tissue may function less well or be less protective than the original tissue; or (iii) the injury may not have healed completely.

Marti et al. (1988) found in univariate analysis, after adjustment for differences in weekly running distance a 65% increased risk of injury for runners with a history of previous injury. This remained after multivariate analysis. Macera et al. (1989) found for men a history of previous injury to contribute significantly to injury after univariate age-adjusted logistical regression (odds ratio of 2.7; 95% CL, 1.9-3.9). After multivariate analysis, the odds ratio remained the same. Walter et al. (1989) found after univariate age-adjusted logistical regression for men a significant odds ratio for previous injury of 1.7 (95% CL, 1.2 - 3.5) and for women of 2.4 (95% CL, 1.3-4.1). After multiple logistical regression in which age and gender were featured, previous injury proved to be one of two strongest predictors for running injury with an odds ratio of 1.5.

From the findings of these three studies it can be concluded that previous injury as defined above is an important independent risk factor for running injuries, although the mechanisms still needs clarification.

Based on the available data form Clinical Practice of Sports Injury Prevention and Care: Injuries in Running by Van Mechelen (1994), it seems clear that previous injury, lack of running experience, running to compete, excessive weekly running distance and performing warm-up and stretching exercises are associated with running injuries. The association between running injuries and factors such as body height, malalignment, muscular imbalance, restricted range of motion, running frequency, level of performance, stability of running pattern, shoes and in-shoe orthoses and running on one side of the road remains unclear or is backed by contradictory of scarce research findings. Factors such as age, gender, BMI, running hills, running on hard surfaces, participation in other sports, time of the year and time of the day seem not to be associated with running injuries.

Preventive measures of running injuries

The ideal management of running injuries is prevention, and the best time to prevent injuries is when the person first begins to run (Brody DM, 1987).

According to a systematic review of interventions to prevent lower limb soft tissue running injuries by Yeung and Yeung (2001), summarized the available randomized and quasirandomized trials on preventing running injuries. Twelve studies met the criteria for inclusion in this review. The ages of the participants ranged from adolescence to middle age (17 to 36 years old). The intervention period varied between studies, from 8 to 20 weeks. There are three main preventive strategies in this review: modification of training schedule; stretching exercises; use of external support or footwear modification. The results of this review can be summarized as follows:

Effect of modification of the training schedule:

This review of trails found that injuries from running are reduced by modifying training schedules by duration, frequency or running distance. One study illustrated that novice runners who were prison inmates (male; 20 – 35 years old) reduced their injury rate by running 1 to 3 days weekly (RR 0.19, 95%CI 0.06 – 0.66) and 15 to 30 minutes daily (RR 0.41, 95%CI 0.21 – 0.79) rather than 5 days weekly and 45 minutes daily (Pollock et al., 1977). In addition, studies of military recruits (male; 17 – 31 years old) showed a reduction of running distance from 280 to 82 km in basic training over 12 weeks decreased the number of injuries (RR 0.70, 95%CI 0.54 – 0.91), especially of the knee (0.45, 95%CI 0.26 – 0.80) (Rudzki, 1997). However, no guideline were available from trials about the best training schedule to adopt to avoid injury.

Effect of stretching exercises:

This review identified five eligible trails that examined the effect of a stretching regimen on lower limb injuries. Suggested stretching routines varied between one and five stretches and holding for 20 - 30 seconds for major lower limb muscle groups. Reduced risk of injury was identified in only one of these studies when five stretches and holding for 30 seconds for hamstrings muscle groups in military recruits (male; mean age 20 years) for 13 weeks. The number of lower limb overuse injuries was significantly smaller in the stretching intervention group (RR 0.57; 95%CI 0.37 – 0.89) (Hartig and Henderson, 1999). However, there was insufficient evidence to suggest whether stretching exercises are effective in preventing lower limb injuries.

Effect of the use of external support or footwear modification:

The application of shock absorbing insoles is not effective in reducing soft tissue injuries but the role of corrective insoles for malalignment is not clear (Fauno et al, 1993; Schwellnus MP et al, 1990; Smith W et al, 1985). The use of knee braces and the modification of footwear (from infantry boots to modified basketball shoes) appear to be effective in reducing knee (anterior knee pain) and foot injuries respectively (BenGal et al., 1997; Milgrom C. et al, 1992). However, in view of the limited number of studies, more data are required to confirm this effect.

Based on evidence from this review found that the subjects included were mainly young and active male. Controlled investigations of running-related injuries are difficult due to the variation in the definition of injury, study population and outcome measures used.

In addition, prevention assesses each etiologic factor and tries to mitigate it. Still, it is difficult to predict injury because the combination of intrinsic and extrinsic factors that cause injury in one runner do not necessarily injure another. Despite all these findings it still makes sense to promote warm-up and stretching exercises as preventive measures. Moreover, although the role of running shoes in running injury prevention remains unclear, the importance of shock absorbance by running shoes does not seem to be denied by the cited epidemiological studies. (Van Mechelen, 1994)

Aging and running injury

In the process of aging, several degenerative musculoskeletal changes occur that may significantly affect the mechanics of running. For example, loss of lower-extremity joint flexibility may reduce the joint ranges of motion (ROM) during running (Such CH et al, 1975; Vandervoort AA et al, 1992). In addition, progressive weakness in muscle and bone (Larsson L et al, 1979; Riggs BL and Melton LJ, 1986; Vandervoort AA and Mccomas AJ, 1986), to gether with atrophy and loss of elasticity of elasticity of plantar fat tissue (Hsu TC et al, 1998; Jahss MH, 1986), reduce the shock-absorbing capacity of the body and may lead to higher impact forces. Finally, loss of strength and contraction velocity of major lower-extremity muscle groups may reduce the ground reaction forces (GRF) during the propulsive phase of running (Larsson L et al, 1979; Vandervoort AA and Mccomas AJ, 1986).

J Hum Ergol (1997) clarified the characteristics of physical health conditions in middle-aged and elderly joggers who run regularly, they were compared with middle-aged and elderly people who did not exercise routinely. The physical health conditions were investigated by a questionnaire survey sent by mail. While the results of this study reconfirm that continuous jogging in middle-aged and elderly people may effectively improve their physical condition, based on the finding that the morbidity was low, it appears that many joggers have knee joint pain, a typical disorder due to running.

There have been clear demonstration of increasing injury risk in runners with increasing volume of running (Samet JM. et al, 1982; Macera CA. et al, 1989; Walter SD. et al, 1989). Also, studies in the elderly have found that the incidence of walking injuries is much lower (4.8 – 13.1%) than the incidence of jogging/running injuries (31.5–57%) (Matheson GO et al, 1989; Pollock ML et al, 1991).

Bus SA. (2003) studied to determine whether the stance phase kinematics and ground reaction forces in running are different between younger-aged (20-35 years old) and older-aged (55-65 years old) men. Because of the biomechanics of distance running has not been studied before in older-aged runners but may be different than in younger-aged runners because of musculoskeletal degeneration at older age. This study found that the biomechanics of running is different between older- and younger-aged runners on several relevant parameters. Impact peak force (1.91 vs. 1.70 BW) and maximal initial loading rate (107.5 vs. 85.5 $BW.S^{-1}$) were significantly higher in the older runners at the controlled speed of 3.3 $m.s^{-1}$. The larger impact peak force and initial loading rate indicate a loss of shock-absorbing capacity in the older runners. This may increase their susceptibility to lower-extremity overuse injuries.

There are numerous studies have been reported the running injuries. Most data come from an analysis of prospective and retrospective survey studies and cohort studies.

Taunton et al (2002) studied retrospectively 2002 running injuries. A total of 2002 patients with running related injuries were investigated at the Allan McGavin Sports Medicine Centre (AMSMC) at the University of British Columbia. The patient charts were extracted from the period 1998-2000. The most common site of injury was the knee (42.1% of the total injuries), with 46% of these injuries being due to patellofemoral pain syndrome (PFPS). Other common site were the foot/ankle (16.9%), lower leg (12.8%), hip/pelvis (10.9%), Achilles/calf (6.4%), upper leg (5.2%), and lower back (3.4%). The most common overuse injury was PFPS seen in 331 patients, followed by iliotibial band friction syndrome (ITBFS) (168 cases), plantar fasciitis (158), meniscal injuries (100) and patellar tendinopathy (96). In addition, the factors related running injuries in this study can be summarized as follows.

Age: being less than 34 years old was a risk factor for patellofemoral pain in both sexes and in men with ITBFS, patellar tendinopathy, and tibial stress syndrome. An age below the mean (36.2 years old) was calculated as a protective factor across the sexes for meniscal injuries and in men with plantar fasciitis and Achilles tendinopathy.

Activity history: patients with a below average activity history (< 8.5 years) were found to be at least 2.5 times more likely to experience tibial stress syndrome in both sexes.

Duration of activity: being involved with activity for less than five hours a week was found to be a protective factor for women with patellofemoral pain. Again, as we cannot distinguish how many of those hours were spent running (actual time at risk), interpretation of this analysis is difficult.

Height: men who were shorter than this study average (157 cm) were at a higher relative risk of experiencing plantar fasciitis. Commonly cited anatomical factors associated with the incidence of plantar fasciitis include leg length inequality, valgus alignment of the subtalar joint, and pes cavus foot type (Krivickas L, 1997; Warren B and Joes J, 1987). In addition, excessive pronation increases the tension placed on the plantar fascia during the stance phase of running (Krivickas L, 1997).

Weight: women with a body weight of less than 60 kg were at reduced risk of experiencing plantar fasciitis in this study. This is probably explained by the reduced stress/force applied to the foot musculature during running with a lower body weight. However, Walter et al. (1989) did not find a significant association between body weight and running injuries.

Body mass index (BMI): women with a BMI less than 21 kg/m^2 were at higher relative risk of experiencing tibial stress fractures and spinal injuries according to our final regression model.

History of injury: having a prior history of injury has been associated with an increased risk of injury in previous studies (Powell KE et al, 1986). However, a past history of injury and increasing caliber of runner were not significantly associated with any injury in this investigation.

Taunton et al (2003) were investigated to determine the number of injuries that occur in a running programme designed to minimize the injury rate for athletes training for a 10 km race. The 84 subjects were registered in 17 of the In Training clinics administered by The Sport Medicine Council of British Columbia. These were primarily recreational runners interested in either completing the 10 km race distance or improving their existing race time. The 13 week training protocol was designed by sport medicine doctors practicing at the AMSMC, and includes two sections to accommodate novice and intermediate runners. Both training programmes require the participants to run three times a week. It is recommended that participants allow one day of rest (or cross training) between any two running sessions. Training sessions vary in length from 35 to 65 minutes, depending on their progression in the programme. The same questionnaire was administered on three separate trails (4^{th}, 8^{th}, and 12^{th} week) over In Training clinics 13 week duration. The two page questionnaire consists of 19 questions divided into four separate sections: personal profile, activity profile, injury history, and injury profile.

The results reported that most runners (69.1%) chose to run primarily on roads. Close to 60% of the participants surveyed complied with the recommended running frequency of three times a week. The 29.5% of overall injury (included both new injuries and injuries that result from previous injury) was reported in this study. Half of those reporting and injury had previously sustained an injury to the same anatomical area, and a large percentage of these (42%) declared themselves not 100% rehabilitated on starting the In Training programme. The knee was the most commonly injured anatomical site for both sexes. Tibial stress syndrome was the most documented diagnosed injury in this investigation. Unfortunately, this provides little indication of the most common injury during the 13 week programme, as diagnoses were obtained from only 43.7% of the injured population. Most injuries (35.5%) were grade 2 (pain during a run, but not restricting distance or speed grade).

In addition, the results from the logistic regression show that women over 50 years old, who wear running shoes four to six months old, and who run only one day a week have a higher odds ratio of experiencing an injury. Conversely, wearing running shoes four to six months old was associated with a reduced likelihood of injury in men, as was having a BMI of greater than 26 kg/m^2. Being less than 31 years old and wearing new running shoes (one to three months old) were associated with less injuries for female respondents.

Lun, Meeunisse, stergiou, et al. (2004) studied to examine the relation between static measurements of lower limb alignment and the incidence of lower limb running injury in a prospective cohort study of 87 recreational runners. The subjects were age greater than 18, running more than 20 km/week, and no current injury. The study found that sixty nine runners (35 men and 34 women) sustained at least on injury, giving and incidence of 79%. A total of 81 injuries were sustained, with 11 runners experiencing two injuries and one experiencing three. Seventeen subjects had injuries that caused them to stop running completely. Only 35 of the 81 injuries were evaluated by a sport medicine doctor. The remainders were self reported. When data for the two sexes were combined, S3 injuries (caused stoppage of running more than seven days) were the most common (24%) severity of injury. The location of the injury was only identified in 52% of the injured runners. The most common were foot (15%) followed by thigh (9%) and lower leg (9%). Measurements of static lower limb biomechanical alignment were not found to be related to lower limb injury in recreational athletes. The findings of this study are in agreement with a number of retrospective and prospective cohort studies (Mantgomery LC et al, 1989; Walter SD et al, 1989; Wen DY et al, 1998; Gross MT et al, 1995). However, the effect of static lower limb alignment may be injury specific.

Furthermore, biomechanical assessment of runners should at minimum consist of measuring leg length and determining arch type.

Rauh et al. (2006) studied to determine the incidence of lower-extremity injury among high school cross-country runners and to identify risk factors for injury, the authors prospectively monitored a cohort of 421 runners. During the 11 week season, 162 runners (38.5%) incurred 316 running-related injuries. The total injury rate was 17/1000 AEs (Athletic exposures) reported in this study. Overall, higher rates of initial injuries and total injuries were reported during practices than during meets. The shin was the most common body part initially injured (3.6/1000 AEs), followed by the knee (2.5/1000 AEs) and ankle (1.2/1000 AEs). Among injured runners, the overall rate of reinjury of the same body part was highest for the shin (73.6/1000 AEs), hip (53.8/1000 AEs), and knee (41.8/1000 AEs). Moreover, runners with a Q-angle of $\geq 20^{\circ}$ were almost twice as likely to be injured than runners whose Q-angle was $< 20^{\circ}$. No significantly increased injury risks were found in relation to overall mileage, mileage by running pace, surface, or terrain for the overall sample or within gender.

This study concluded that runners with large Q-angle and a previous running injury had a greater risk of lower-extremity running injuries. Furthermore, the generalizability of our findings is unknown. The characteristics and training practices of our high school cross-country teams may differ from those for high school cross-country teams in other geographic regions. Thus, additional epidemiologic studies in other settings and focusing on other risk factors may be worthwhile.

Recently, Van Gent RN et al (2007) present a systematic overview of published reports on the incidence and associated potential risk factors of lower extremity running injuries in long distance runners (recreation or competitive runners, but not belonged to the elite group). This systematic review concluded that the incidence of lower extremity running injuries ranged from 19.4% to 79.3%. The predominant site of these injuries was the knee. There was strong evidence that a long training distance per week in male runners and a history of previous injuries were risk factors for injuries, and that an increase in training distance per week was a protective factor for knee injuries.

As evidenced from the review above, the causes of running injuries are so multi-factorial and diverse, and apparently vary greatly form individual to individual. Bus SA (2003) suggested that in older-aged runners should give further insight into the assumptions made on the magnitude and causes of lower extremity injuries as well as the need for modification of the prescription of exercise for older-aged runners. Moreover, Prospective data on injury incidence would be necessary to make definitive recommendations on exercise prescription for older-aged runners. In Thailand, the data is very limited, especially in middle age and elderly joggers. Thus, this study was undertaken to identify risk factors for injury and to determine the incidence of lower limb injury among middle age and elderly Thai joggers. This is to benefit for middle age and elderly joggers and to provide the preliminary data for further research.