

# PREVENTION OF RUNNING RELATED INJURIES

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## INTRODUCTION

Running has evolutionary roots in humans and is therefore in our genes. The 'evolution marathon' began about 2 million years ago. The area in which pre-humans lived was covered by dense forest, where chimpanzees gambolled through the branches eating sweet fruits. The climate changed to a dryer environment, the trees receded and open savannahs developed. The human race moved from a chunky, chimp-like movement pattern to our present characteristically bipedal movement strategy and human body shape with an upright position. Around the same time, we started to eat meat, mostly by scavenging meat from carcasses. This protein-rich food gave us the ability to develop more brain volume. Our body changed, leaving us with less hair and more sweat glands.

In the open savannah the human race was able to hunt large animals in hot

weather without the use of weapons. We were able to walk and run, not to sprint, but to maintain a steady, persistent endurance running speed. Humans were unique in their endurance running ability and could run long distances in hot and humid conditions. Most mammals ceased running because they could not cool their core body temperature and therefore were easy prey for the humans after a few hours of endurance running. This so-called persistence hunting is an evolutionary advantage for the human race. Without weapons, which only arrived around 200,000 to 50,000 years ago, the human race could out-compete other animals with persistence hunting, still apparently used in some cultures today. From this evolutionary perspective, running made us human. Since the invention of weapons like spears and bow and arrow there is no need to run, but in more recent history running

became important again for the human race. In 490 BC Pheidippides ran from the town of Marathon to Athens to bring news that the Greek army defeated the Persians. According to the story, he dropped dead on arrival. Centuries later, in 1896, 18 men competed in Athens in the first Olympic marathon. The winner finished in 2:58:50. In 1897 the World's oldest organised marathon was founded in Boston. The biggest marathon nowadays is the New York City marathon in which over 50,000 participants compete every year. In the early days of the marathon, only male competitive elite athletes were allowed to run. The average finishing time was around 3 hours. In 1980, 10% of the marathon runners were female compared to today where approximately 40% of the marathon runners are female. The average finishing time of running a marathon has dramatically increased. The average finishing time for female athletes

in the marathon is slightly above 5 hours and the average finishing time for male runners is 4 hours and 45 minutes. From this data it can be seen that marathon running has changed from an elite sports event to a mass recreational leisure event in which competing is more important than winning.

Running is a very popular sports activity that can be done everywhere and by almost everyone. Millions of people run regularly. It is a healthy activity with positive effects on cardiovascular risk factors, and it gives mental and social benefits. But there is another side to it. Running related injuries (RRIs) are frequent amongst the running population. From a public health perspective, it is important to look for risk factors and interventions to reduce the incidence of RRIs.

#### RRIs, RISK FACTORS AND PREVENTIVE MEASURES

In the research for prevention of injuries, the injury sequence model of van Mechelen is often used<sup>1</sup>. The first step in this model establishes the extent of the RRI problem, the second step looks for the aetiology and mechanisms of RRIs and the third step is the introduction of preventive measures.

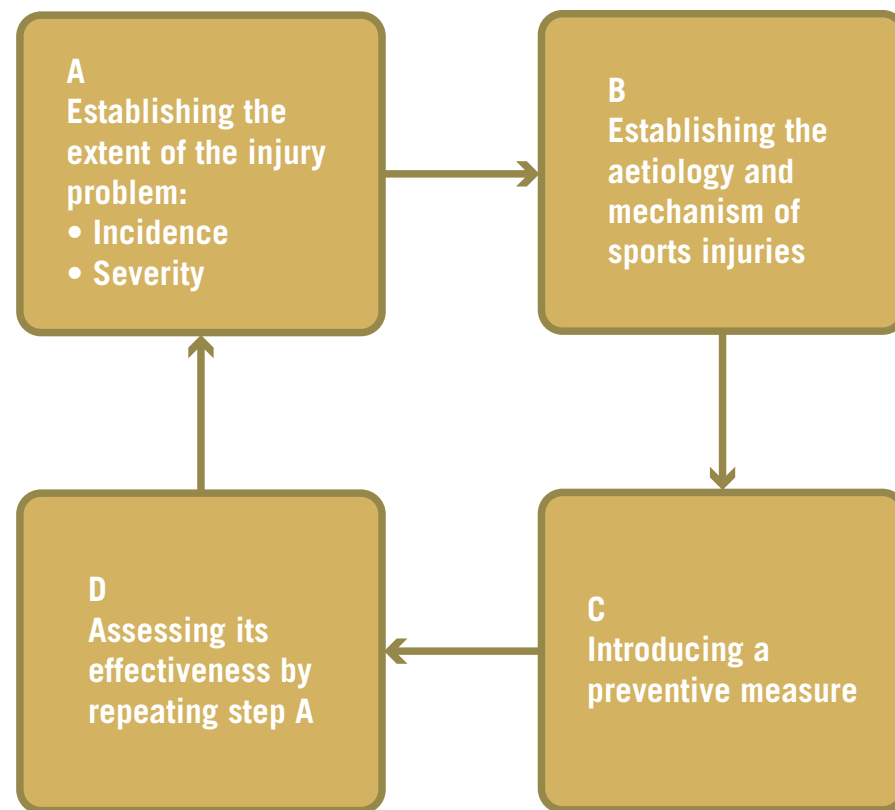
#### STEP 1: ESTABLISHING THE EXTENT OF THE PROBLEM

##### *Incidence and severity of RRIs*

When looking at step 1 it is known that the incidence of RRIs is high. Incidence rates vary from 20.3 to 84.9% and from 3 to 59 RRIs per 1000 hours of running<sup>2</sup>. Since the landmark running studies of Brody and Marti in the early 1980s, there has been no decrease in the incidence rate of RRIs. Despite all the research, shoe modifications and other knowledge, the incidence of RRIs remains high.

#### STEP 2: ESTABLISHING THE AETIOLOGY AND MECHANISM OF RRI

In running, overuse injuries of the musculoskeletal system generally occur when a structure is exposed to a large



**Figure 1:** The injury sequence model of van Mechelen<sup>1</sup>. Reprinted with permission.

number of repetitive forces, each below the acute threshold of a structure, producing a combined fatigue effect over a period of time beyond the capabilities of the specific structure<sup>3</sup>. When the time for adaptation is too short or the volume of running is too high, an overuse injury can occur. Most running injuries are repetitive overuse injuries. The major causes of most overuse running injuries are due to training errors (running too far, too fast and too often). It is thought that training volume is the key factor associated with 60 to 70% of the development of RRI, but other risk factors can play a role<sup>3</sup>.

Risk factors can be divided into extrinsic and intrinsic risk factors. Hreljac made a subdivision into three risk factor categories<sup>3</sup>:

1. Training.
2. Anatomical.
3. Biomechanical.

##### *Training as a risk factor*

As an extrinsic risk factor, training has variables such as frequency, intensity, duration, stretching, shoes, running surface, running technique, orthoses, warming up and cooling down. It is known from van

Gent's review that there is no evidence for the risk factors stretching, running surface, warming up and cooling down<sup>2</sup>.

##### *Shoes*

In the past few years there have been fierce discussions and debates about shoes, orthoses, running technique and their role in preventing or causing an RRI. The first shoes were introduced over 10,000 years ago. Their function was simply to protect the bottom surface of the foot. When the running boom started in the 1970s, running shoes were constructed of flexible material with a thin outer sole. In 1972 Nike started with a new model of shoes with a cushioning in the midsole, called Nike Cortez. The modern running shoe has a shock absorbing midsole and a heel with some elevation and stiff heel counter for optimal shock absorption and motion control. The reasons for these technologies were injury prevention and performance enhancements.

Until now there has been no evidence that the modern running shoe technology prevents RRIs or enhances running performance. Studies have looked at the effect of prescribing motion control or neutral running shoes to distance runners

and military recruits but no significant effect on injury risk has been found. Richards et al described the evidence of shoe prescription to runners<sup>4</sup>. Their conclusion was clear: there is no evidence that shoe prescription will prevent RRIs in the running population.

The discussion of running shoes changed dramatically in 2010. Lieberman published his provoking article in *Nature* with the title, 'Foot strike patterns and collision forces in habitually barefoot versus shod runners'<sup>5</sup>. In this article he concluded that forefoot and midfoot strike gaits were probably more common when humans ran barefoot or in minimal shoes, and may protect the feet and lower limbs from some of the impact-related injuries now experienced by a high percentage of runners. This conclusion gave rise to fierce discussions on running blogs and internet running communities. The biomechanical consequences of barefoot running are discussed later in this article. Since the Lieberman article was published there has been a rise in so-called barefoot running and running with minimalist shoes. Until now there has been no evidence that running barefoot or in minimalist shoes prevents RRIs.

#### *Technique*

Another important risk factor as a training variable could be running technique. Usually endurance runners are

heel strike runners. In a study of Larson et al looking at foot strike patterns in recreational marathon runners, 89% ran with a heel strike, 3% with a midfoot strike and 2% with a forefoot strike<sup>6</sup>.

In their retrospective study, Daoud et al compared foot strike pattern during running to injury rate in 52 competitive cross-country runners on a college team<sup>7</sup>. Surprisingly, heel strike runners were 2.5 times more likely to have RRIs compared to midfoot strike runners. Future prospective studies should shed more light on the value and interpretation of these results. According to Lieberman, "How you run is more important than what is on your feet" and "What is on your feet can affect how you run".

#### *Anatomical risk factors*

These factors are intrinsic risk factors. Examples of this category are foot type, arch height, range of motion of the ankle, Q angle, leg length discrepancies, gender, body mass index and age.

#### *Foot type*

The most studied risk factor in the development of RRIs is foot type. Nielsen recently looked at foot pronation, using the foot posture index and the incidence of RRIs<sup>8</sup>. Over 900 novice runners were followed for 1 year. All participants ran with

neutral running shoes. Foot structure was divided into:

- highly supinated,
- supinated,
- neutral,
- pronated and
- highly pronated.

There was no association between different foot type and RRIs in this large group. When looking at these data there seems to be robust evidence that foot type is not associated with RRIs. However, future work on this risk factor has to be done.

Another anatomical risk factor could be asymmetry of the lower extremity. Asymmetry could expose one of the lower limbs to more stress than the other, resulting in a lower threshold for the development of a RRI. In a recent prospective study by our institute it was shown that running had a high variability in asymmetry between kinetic but also in spatio-temporal variables. This high variability was seen between runners but also within the runner and the level of asymmetry did not have an effect on the incidence of RRIs. So, perhaps a biological variability, as described in Darwin's *Origin of Species*, is an advantage for a runner.

#### *Biomechanical risk factors*

Examples of this third category are kinematic (magnitude and rate of foot pronation, knee, ankle, hip moments) and kinetic (ground reaction forces, impact force, active force and loading rate).

Barefoot or minimalistic running alters the biomechanics of the lower extremity<sup>5</sup>. In normal shod running a runner has a typical vertical ground reaction force with a so-called impact peak. When someone runs barefoot or with minimalistic shoes there is a change in landing strategy. There is no impact peak, and the landing strategy is more directed to a midfoot strike<sup>5</sup>. The impact peak itself does not change significantly. The stride frequency is higher and other kinematic changes occur. A recent study by Kulmala showed that forefoot striking produced lower patellofemoral stress and a lower frontal plane knee moment, but a higher ankle plantarflexor moment and higher Achilles tendon loading compared to heel strike running<sup>9</sup>.

When looking at these data it seems that barefoot or minimalistic running is not the

***How you run is more important than what is on your feet***



Holy Grail in the prevention of RRIs. When running barefoot, the stride frequency goes up, so that per mile, the total load is higher compared to heel strike running. The data from the Kulmala study may have value in the clinical setting<sup>9</sup>. When a runner has a patellofemoral injury he or she can adjust their running technique to a midfoot pattern, or when someone has an Achilles tendon disorder he or she can adjust to a more heel strike running pattern.

Another clinical application of this new information can be seen in a recent study by Diebal et al<sup>10</sup>. They showed that forefoot running improved symptoms and disabilities in patients with chronic compartment syndrome of the lower leg. The positive effect of the modification in running style was still effective after 1 year. In a study from our institute no significant differences were found in kinetic or spatio-temporal variables between injured and non-injured runners.

One often overlooked factor is the proximal contribution of structures in the function of the lower extremity. In recent years much attention has been paid to the distal coupling or contributions in the development of RRIs of the lower extremity. Excessive or prolonged pronation, tibia rotation, foot alignment and greater Q angles could lead to pathomechanical changes and injuries of the lower extremity<sup>11</sup>.

More recently, research has looked at the role of the proximal structures in the function of the lower extremity and the role of these structures in the development of sporting injuries. The function of these proximal structures, the lumbo-pelvic hip complex (core muscles), are essential in their role of controlling movements seen more distally<sup>11</sup>.

The conclusion of the review by Chuter et al is that there is a lack of evidence supporting a cause-effect relationship between distal contributions to lower

extremity injury, including RRIs<sup>11</sup>. On the other hand, reduced core stability, as a function of proximal structures, is a possible risk factor in the development of overuse injuries in the lower extremity, affecting foot and ankle injuries, patellofemoral pain syndrome, iliotibial band syndrome and also anterior cruciate ligament injury. It is not only a risk factor, it should also be the base of rehabilitation programmes after sustaining an injury. Another example of the involvement of the proximal structures is shown in the study by Noehren et al who showed that female runners who developed patellofemoral pain had different proximal biomechanics compared to healthy female runners<sup>12</sup>.

### STEP 3: INTRODUCING A PREVENTIVE MEASURE

The last step in van Mechelen's injury sequence model is introducing a preventive measure. A Cochrane review was recently published on the prevention of RRIs. In this review interventions for preventing lower limb, soft-tissue running injuries were studied<sup>13</sup>. The review included 25 trials. Participants were military recruits (19 trials), runners from the general population (3 trials), soccer referees (1 trial) and prisoners (2 trials). The interventions tested fell into four main preventive strategies:

1. Exercises.
2. Modification of training schedules.
3. Use of orthoses.
4. Footwear and socks.

The overall conclusion of the authors was that the evidence base for the effectiveness of interventions to reduce soft-tissue injury after intensive running is very weak. More well-designed and reported randomised controlled trials which test interventions in recreational and competitive runners are needed.

After publication, two more randomised trials in the prevention of overuse RRIs were published. The aim of our clinical trial (randomised controlled trial) GRONORUN 2 was to determine the effect of a pre-conditioning programme on the incidence of RRIs among novice runners. The outcome was that a 4-week pre-conditioning programme with walking and hopping exercises had no influence on the incidence of RRIs in novice runners.

Another study looked at the preventive effect of custom-made orthoses to prospectively reduce the risk of lower limb injury in military recruits<sup>14</sup>. This study demonstrated a significantly reduced rate of exercise-related lower limb injury across the training period for those wearing the custom-made orthoses. These results look promising but further research in a real running population is necessary.

As mentioned earlier, in preventive medicine it is important to develop interventions based on the understanding of the aetiology and mechanisms of injury and the preventive intervention has to be acceptable, practical and adopted by athletes and sport bodies so that the implementation of the intervention can be successful. When looking for an intervention it has to be practical, easy to do and therefore have a good chance for success in terms of compliance, efficacy and effectiveness for the target population.

#### CLINICAL AND PRACTICAL APPLICATIONS

Good advice is start low and go slow. When someone is not used to exercise or sport they have to start with a 4-week period of walking sessions.

Begin with 2× training, walking or running sessions a week. A runner can move to the next training session when he has no or little complaints such as pain or stiffness either during the running session or the following morning. Runners can use a visual analogue scale. The intensity of running should be a comfortable pace at which a runner could converse without breathlessness. A runner has to learn to listen to their body and not just look at the training programme. When the body gives signals of pain or stiffness the runner must decrease running mileage to prevent an RRI.

As described in this discussion it is not important what kind of shoes a runner wears. Lieberman stated that “how someone runs is more important than what is on their feet”. This means that a runner can choose a running shoe that is comfortable. When a runner runs more frequently it is advisable to buy another, but different, pair of running shoes.

The runner can try different running surfaces, running with different shoes, different durations and intensities of training sessions, various running techniques and they can play other sporting activities with less axial loading. In this way

the body receives different stimuli over time and is probably better able to react on these varying loads with a positive adaptation of the musculoskeletal system and thereby decreasing the chance of a RRI.

#### CONCLUSIONS

The aetiology of running related injuries still remains unclear. The primary cause of an RRI is the imbalance between load and time for recovery or positive adaptation of the musculoskeletal system. Most overuse running injuries are due to training errors; This means running too far, too fast and too often. Since the early 1980s until now the incidence of injuries is still high. Studies looking at risk factors show that training volume and previous injury is a risk for the development of an injury. Other risk factors showed no significant association with the occurrence of RRIs. There have been 27 randomised controlled studies conducted on the prevention of RRIs. Only four studies were conducted in the running population to prevent RRIs. Even though it may be comparable to the quest for the Holy Grail, further studies on modifiable risk factors and prevention of running related injuries need to be performed to better advise the running population in the future.

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