Vancouver Sun Run In Training Clinics:
An Ordinal Severity Outcome Measure and Model of Associated Risk Factors for Running Related Pain

by

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Abstract

This study determined the feasibility of implementing a severity outcome measure for the classification of running related pain, in addition to constructing a multivariate model of associated risk factors for injury in novice runners. Throughout the Greater Vancouver Metropolitan Area, 421 participants responded in 29 separate In Training clinics. Subjects, on average, self-selected their running experience as limited with average physical fitness, average competitive motive and at least vestigial symptoms from a previous injury.

Participants in this 13-week training program were surveyed during the 6th and 12th week of the In Training clinics’ 13-week duration. Questionnaire items included a VAS scale for indication of degree of rehabilitation from prior injury, physical fitness, competitive motive, weekly distance, running frequency and running experience. The Training Function Score is designed to quantify, using an ordinal scale, function limitations that result from running injuries. Subjects also indicated whether they were “currently experiencing an injury as a result of injury”.

Overall, 36.1% of subjects experienced an injury during the training program. Univariate regression showed degree of rehabilitation, physical fitness, competitive motive and weekly distance as significantly associated with injury. Multivariate results, however, indicate only degree of rehabilitation while physical fitness accounts for 25.4% of the explained variation in the severity outcome measure. Pratt analysis further shows that 90.1% of that explained variation is accounted for by degree of rehabilitation only. Initial psychometric characteristics demonstrate outcome measured ability to discriminate injured from non-injured (uninjured = 82.91, injured = 64.56 and clinically injured = 46.29*; significant difference p<.001) and evaluate severity (significant (p<.011), regression association with severity outcome measure and increasing subjective definition of injury scale).

Moderately sedentary individuals commencing a running program for the first time should be cautious of the affect prior history of injury has toward re-injury. This study suggests that an outcome measure for generalized running injuries is possible with respect to discriminating injured from non-injured runners, as well as evaluating the severity of those injuries. While such an outcome measure for general running injuries is feasible, proper validation procedures and methodology must be established before such a scale is used formally.
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Chapter 1

1.0 Introduction

The increased popularity of running among the general population is not surprising, given the ease and economy of establishing a running program. People only require a stretch of road and a pair of running shoes to get started. After the commencement of such a program, the physiological and psychological benefits of aerobic training may be experienced in the short span of weeks.\textsuperscript{33,53}

However, with any increase in sporting activity, the incidence of injury increases concomitantly.\textsuperscript{1} The absence of injury in running depends on the congruency of certain biomechanical, anthropometric and training parameters. Injury rates in population-based studies of recreational runners may vary considerably, with most reporting incidences of at least 25%. Educating athletes in the area of injury prevention has been suggested by Van Mechelen\textsuperscript{2} to be an effective tool to reduce the injury rate among a given population. Group training programs have been used as an appropriate medium to convey such health information.

The \textit{In Training} clinics were established by the Sport Medicine Council of British Columbia to address the de-conditioned state of many of the participants of the Vancouver Sun Run 10K. These clinics proved to be immediately popular, having trained over 12,000 people since their inception five years ago. This success is thought to be, in part, a result of the program's design to train their participants to continuously run a 10 kilometre distance with minimum exposure to injury. This design is substantiated by: implementing the training protocol over a 13 week period allowing for gradual progression, experienced leadership within each clinic, detailed presentations on the aspects felt to be important for neophyte training (such as shoes, diet, safety, injury
prevention, etc), and a fun and encouraging atmosphere that sustains the participant's motivation throughout the duration of the program. However, the success of the *In Training* clinics in producing injury-free runners at the end of the 13-week period needs to be assessed. In a study conducted on 17 clinics in 2000 (unpublished data), the injury rate between clinics varied between 16 to 48%, with a mean of 29.5%. This relatively high rate of injury, along with its considerable variability, has led to some concern over whether it is possible to produce an ‘injury-free’ running program.

This concept of being ‘injury-free’, however, has its own limitations. Should health epidemiologists and sports physicians demand that participants within a running program be completely free of injury? Are group running programs able to achieve their goal of assisting participants complete a race, despite a significant injury rate? For that matter, how should one define what constitutes an injury: an ache or pain that is felt after exercise, or pain that prohibits running for over a week? While these issues have been narrowly addressed in the literature, they may significantly impact the results of epidemiological reports on running populations.

Running injury research has been primarily focused on establishing the aetiological factors and behaviors that are significantly associated with injury in selected populations. The main setbacks of past research have been the lack of consistency on the definitions, methodology and study design of these investigations. The result of such inconsistencies are factors that erode the foundation for valid scientific experimentation and proper understanding of the risks of injury in runners.

### 1.1 Purpose of the Investigation

The first objective was to provide an adequate database of descriptive variables, including height, weight, age and seven previously identified risk factors in runners. Four of these were intrinsic risk factors (previous injury, running experience, running to
compete and level of physical fitness) and two were extrinsic risk factors (weekly
distance, compliance to program/running frequency) of injury. These data were gathered
from 29 In Training running clinics within the greater Vancouver area (i.e. North
Vancouver, West Vancouver, Burnaby/New Westminster, Richmond/Delta, Tri-Cities,
Surrey/White Rock and Fraser Valley).

Secondly, the overall and inter-clinic training function score (T.F.S.) was
assessed. The T.F.S. is a generalized severity outcome measure for running related pain.

The third purpose was determining the associative nature of the T.F.S. with the
mean clinic injury rate and subjective definitions of injury.

Lastly, the mean T.F.S. for the injured, non-injured and clinically injured runners
was compared.

This study was designed to use a severity outcome measure to determine the
number of injuries experienced by participants in the In Training clinics. In addition, the
associative nature of the severity outcome scores was determined through multivariate
analysis. A brief psychometric examination of the TFS was performed through a
comparison with the subjective definition of injury, inter-clinic mean injury rate and the
mean T.F.S. for non-injured, injured and clinically injured runners.

1.2 Significance of the Study

Group training programs have been used as an effective avenue for training a
large group of individuals in the past, as they adequately deliver education on proper
training techniques and injury prevention. The running program employed by the Sun
Run In Training clinics has been developed and modified by sports medicine physicians
at the Allan McGavin Sports Medicine Centre (AMSMC), with a focus on injury
prevention. However, until this study, there has been a paucity of research concerning
the injury rate within a strictly novice running program, as well as information on injury risk factors for this specific population.

This study determined the relative contribution for each of the six outlined risk factors to the injuries that occur. This was accomplished by the introduction of a generalized outcome measure for the severity of running related injuries. The influence of individual and collective groupings of risk factors on the inter-clinic injury rate discrepancy was assessed. Furthermore, the T.F.S. introduced the prospect of a standardized running injury definition (i.e. the definition “pain prohibiting all running” ~80 on the T.F.S., while the definition “pain or stiffness only after running” ~50 on the T.F.S.).

1.3 Statement of the Problem

It is unknown how many runners registered in the In Training program will experience an injury during their training for a 10 kilometre run. In particular, there has been little attention paid to a group of neophyte runners as they progress through a training program designed primarily for completion of a set distance, rather than improved performance. The Sun Run In Training clinics were involved in a pilot investigation in 2000 that formed the basis for the present study.¹ The results from the 2000 In Training study suggest: being over 50 years old was associated with increased risk of injury in women, being less than 31 years old was associated with a reduced risk of injury also in women, one-half of the subjects in this study reporting an injury also had a prior history of injury, and, of those injured with a prior history, 42% reported they were not completely rehabilitated upon commencement of the 13-week program. Certain limitations of the 2000 study prompted the authors to reexamine the questionnaire format and overall methodology of this survey based investigation. Of specific concern were the following details: data was obtained from only 17 of the 46 clinics, subjects with less
severe injuries were considered injured possibly overestimating the injury rate; and prominent risk factors such as exposure time to running, competitive motive and running experience were not addressed. In addition, due to the limited number of regions involved in the study in 2000, it is unclear whether certain groups of individuals within a particular geographical area experience a greater number of injuries, or injuries of greater severity. Considering the principal objective of the *In Training* clinics is motivating primarily sedentary individuals to become more active, a significant number of injuries could limit the clinics’ success in this respect.

There is currently no standardized definition for what constitutes a ‘running injury’. Consequently, comparison of the extensive research done in this area is compromised by our inability to answer the question, “to what running population do these results apply?” Given the tremendous increase in recreational jogging among all age groups over the past 20 years, this issue is mounting in significance.

### 1.4 Delimitations

1. Sample selection; assuming average of 40 participants per clinic over 46 clinics allows for an N ~ 1840 healthy, mostly sedentary male and female subjects between 16 to 60 years of age.

2. The use of the same respective program for all novice and intermediate subjects for the 13-week duration provides controls for weekly running time, type of training and running frequency.

3. The prescribed running program will be lead by individuals with experience in leadership and running related fitness.

4. Use of a severity outcome measure, incorporating a visual analogue scale (VAS), will allow statistical modeling of associated risk factors for running injuries.
1.5 Limitations

(1) The use of a questionnaire format may result in recall bias.

(2) The trial design is at risk of being confounded by a 'healthy runner effect'; whereby subjects who were injured either prior to the commencement of the training program, or during the first weeks of its operation, will not be included in this study.

(3) While the running injury severity outcome measure is based on the VISA score for patellar tendinopathy and Achilles tendinopathy, the proposed severity scale has yet to be formally tested for validity and reliability.

(4) This study may not necessarily apply to runners within a marathon, half-marathon, triathlon or other running based training programs.

(5) This study may not necessarily apply to runners of advanced, experienced or elite calibre.

(6) Not all risk factors for injuries in runners have been selected in order to enhance the clarity of the relationships involved in the analysis.

1.6 Hypotheses

It is hypothesized that:

(1) There will be a significant T.F.S. discrepancy between the clinics studied.

(2) The risk factors investigated in this study will significantly account for the proposed T.F.S. discrepancy in clinics investigated.

(3) Previous history of injury, as indicated in the “running profile” section of the questionnaire, will significantly correlate (positively) with the T.F.S.
(4) Running experience, as indicated in the "running profile" section of the questionnaire, will significantly correlate (positively) with the T.F.S.

(5) Running frequency, as indicated in the "running profile" section of the questionnaire, will significantly correlate (positively) with the T.F.S.

(6) Physical fitness, as indicated in the "running profile" section of the questionnaire, will significantly correlate (positively) with the T.F.S.

(7) Competitive motive, as indicated in the "running profile" section of the questionnaire, will significantly correlate (positively) with the T.F.S.

(8) Weekly distance, as indicated in the "running profile" section of the questionnaire, will significantly correlate (positively) with the T.F.S.
Chapter 2

2.0 Review of the Literature

The benefits and risks associated with running have been thoroughly discussed in the literature. There are many positive incentives for the commencement of a running program, particularly from the standpoint of influencing degenerative health conditions, such as cardiovascular disease and obesity. In fact, as these benefits have been realized in recent decades, various sports organizations have encouraged increased participation in sport, demonstrated by the ‘Participaction’ campaign here in Canada, as well as the ‘Sport for All’ and ‘Trim U Fit’ campaigns in Britain and the Netherlands respectively.1 Running has become a popular medium with which to translate the health message of increased activity to people, due to its relative convenience and low-cost. However, apart from the health-giving aspects of running, there is a significant probability of injury, especially for those individuals commencing a running program for the first time. The incidence of running injuries varies from 24 to 77% and running distance is the only consistent factor strongly associated with an increased risk of injury in population-based studies of recreational runners.3,4 Unfortunately, there is still no clear consensus amongst authors as to a uniform definition of a running injury. Furthermore, the lack of standardization with respect to runner characteristics, sport participation, research design and length of study further confound comparison of the incidence rates.
2.1 Severity and Costs Associated with Running Injuries

The severity of running injuries may be classified into six categories: nature of the injury, duration and nature of treatment, sports time lost, working time lost, permanent damage and actual costs to the individual and society.\(^2\)

2.1.1. Nature of Running Injuries

A large percentage of running injuries are associated with overuse.\(^5,6,7,8,9,10,11,12\)

These injuries are the result of repeated high levels of stress to the bone and soft tissue of the structures responsible for the mechanics of running. In fact, the often high rate of injuries seen in population based studies is not surprising when one considers that the lower-extremity is loaded with 1.2-2.1 times body weight at heel strike, 2.5 times body weight at toe-off and that a runner strikes the ground an average of 1000 times per mile.\(^8\)

When these forces are extended over a lower extremity with poor biomechanical alignment, such as an individual who has a leg length inequality, high Q-angle (figure 1),

![Figure 1. The Q-angle is used to indicate the presence of a structural abnormality, which causes the patella to drift inwards during the stance phase of running. The Q-angle affects the running stride. 1) Contact, 2) Pronates, 3) Lower Leg Twists Inwards, 4) Measurement of Q-angle. From: Noakes T, Granger S. Running Injuries: How to prevent and overcome them. 1996; Oxford, UK. Oxford University Press. Pp. 21.](image-url)
clinically high or low arches or is bow-legged (genu varum), the risk of experiencing an injury sharply increases.\textsuperscript{13,14}

In the majority of epidemiological studies, the knee is the most frequently injured location.\textsuperscript{3} In a retrospective analysis of 2002 overuse injuries seen over a two year period, Taunton et al.\textsuperscript{55} reported 42.1\% occurred at the knee. Similar retrospective analyses have yielded comparable results: Clement et al.\textsuperscript{10} reported that 41.7\% of their injuries were at or about the knee, and Macintyre et al.\textsuperscript{11} reported an even higher rate of 43.05\% overall injuries at the knee. Most other running injury studies cite knee injuries to account for approximately 25\% of reported injuries.\textsuperscript{3} The range for other anatomical locations commonly injured include: feet between 2 and 22\% of injuries, ankle between 9 and 20\%, lower leg between 2 and 30\%, shins between 6 and 31\%, upper leg 3 and 18\%, back between 3 and 11\% and hip/pelvis and groin between 2 and 11\%.\textsuperscript{4,5,6,7,15,16,17} Injuries to the upper-extremity contribute only to a minor extent.\textsuperscript{3}

Lysholm and Wiklander reported that tendinopathy was the most frequently registered injury among competitive athletes, periostitis/stress fracture in boys and girls
by Watson and DiMartino and Marti et al. noted strains and tendinopathy to frequent a normal jogging population. In terms of clinical diagnosis, patellofemoral pain syndrome is the most frequently occurring injury in runners, followed by iliotibial band friction syndrome, plantar fasciitis, Achilles tendinopathy and tibial stress syndrome.\(^{10,11,55}\)

While a significant majority of running injuries are chronic in nature, runners may still experience acute problems during the course of a run or race. In Caselli and Longobardi’s review of injuries in the 1994 New York City Marathon, they found that acute shear and stress injuries were the most common (corns, calluses and blisters 41.1%), as were acute muscle fatigue injuries (muscle cramps 20.8%), knee injuries 6.0%, ankle injuries 5.3%, plantar fasciitis 4.9% and metatarsalgia 3.7%.\(^{18}\) In a review of the 1998 Nestle Around the Bays Fun Run 10K report, a similar breakdown of acute injuries (blisters 23% ankle injuries 10%, muscle strains 8%, abrasions 7%, lacerations 6%, and abrasions 7%) was shown with the only exception for mild hypothermia occurring in 18% of the subjects.\(^{19}\)

### 2.1.2. Duration and Nature of Treatment

As a majority of running related injuries are chronic in nature and the result of a culmination of many associated factors, it is necessary to correct any underlying training or biomechanical abnormalities in order to completely eliminate the existing injury, as well as the likelihood of reoccurrence.\(^{20,21}\) Noakes suggests that only a fraction of running injuries are not completely curable by simple techniques and that surgery is required in very exceptional cases.\(^{21}\) However, certain exceptions may delay or even prevent the treatments prescribed, such as runners with severe biomechanical abnormalities for which conventional measures are unable to adequately correct, injuries that result in severe degeneration of the internal structure of important tissues (i.e. Achilles tendon), injuries that occur in those who start running on abnormal joints of the
hip, knee or ankle, and injuries in those with such weak bones that they are forever
afflicted by bone injuries (i.e. tibial stress syndrome or stress fractures).

In a study investigating the nature and response to 196 injuries seen over a 6
month period at the University of Cape Town SAB Sports Injury Clinic, approximately
50% of the injured runners were completely cured within 8 weeks, and between 62 and
77% had a “75% cure” (no more pain, and running nearly the same pre-injury distance).20
Where appropriate, treatment consisted of advice on the following subjects: age or
control/rigidity of running shoes, incorporation of in-shoe support or orthoses, corrections
for leg-length inequalities, adjustments to training methods, ice application and referral to
physiotherapy. Only 13% of runners did not show any improvements on this treatment
regimen.

The exact time frame for return to baseline distance and speed proceeding a
running injury is often difficult to determine, and will depend on the type of injury and its
location. Certain injuries may only require a reduction in training, while others (i.e.
stress fractures) will force the cessation of running for periods of weeks to months.22
Ballas et al, Noakes and Granger and Pinshaw et al. all agree that the cornerstone of
treatment is absolute or relative rest, and most injuries will respond to R.I.C.E. (rest, ice,
compression and elevation).20,21,22

2.1.3. Sports Time Lost

From a psychosocial and physical perspective, the immediate cessation of running
caused by an injury may produce significant negative side effects on an individual’s well
being. As a result, it is important for runners to safely resume activity as soon as
possible. The length of sporting time lost provides a precise indication of the
consequence of an injury to the individual.3
2.1.4. Working Time Lost

In addition to the medical costs associated with the treatment of injuries, the length of working time lost gives an indication of the financial consequences to society. Fortunately, a majority of running injuries are not severe enough to impede an individual from their employment. Marti et al. reported 5% of their study population were absent from work, and Hplmich et al. report absenteeism as only 1%.9,23

2.1.5. Permanent Damage

Due to the significant cure rate seen for running injuries, it is anticipated that only very few of these will result in permanent disability (i.e. femoral neck stress fractures complicated with avascular necrosis resulting in osteoarthritis of the hip or acute compartment syndrome with muscle and nerve necrosis and foot drop). However, the cessation of running altogether, due to the insidious nature of poorly managed injuries, is more likely. In this sense, it is difficult to speculate the number of actual functional disabilities caused by a running related injury due to the incidence of otherwise curable conditions that contribute to disability through insufficient or inappropriate treatment.

2.1.6. Costs of Running Injuries

The economic costs associated with running injuries may be divided into either direct or indirect.2 Direct costs refer to the actual cost of medical treatment, primarily diagnostic expenses such as doctors fees, x-ray, MRI, ultrasound, CT scan, prescriptions, admission costs, etc. Expenditures incurred as a result of the loss of productivity due to the increased morbidity levels are thought of as indirect costs, and are often the result of a loss of working time and expertise. The direct and indirect costs of medically treated sporting injuries in the Netherlands in 1992 was estimated to be as high as US$225 million.2
Social costs may also be included in the assessment of the severity of running injuries on society. These include quantifiable parameters such as insurance and legal expenses; and the unquantifiable psychosocial effects of running injuries owning to economic dependence, loss of social status or position, or social isolation.

### 2.2 Prevention of Running Injuries: Sequence of Prevention & Definitional Issues

Given their unwanted adverse psychosocial and physical effects, it has been recognized that a preventive approach towards the reduction of running injuries should have high priority. However, as outlined by van Mechelen, measures to prevent sports injuries do not stand by themselves, but rather form part of what has been called a 'sequence of prevention' (figure 3).

![Sequence of Prevention Diagram](image)

According to this model, the problem must first be identified and described in terms of incidence and severity of sports injuries. Secondly, the factors and mechanisms that play a part in the occurrence of sports injuries have to be recognized. The third step in the sequence is to introduce measures that are likely to reduce the future risk of sustaining an injury and/or to reduce their severity. These measures should be based on
the aetiological factors and mechanisms that were outlined in the second step. Finally, the effect of the intervention needs to be evaluated, thus bringing this sequence full circle.

In order for the efficacy of this preventive sequence to be realized, it is imperative that consistency be reached as to the definition of the criteria that a sports injury surveillance system should meet. This issue, as pointed out by Wade, is a major problem in sports epidemiology. In particular, this means finding answers to questions such as 'how many, how often, how long and how serious?' By addressing these questions, a sports injury surveillance system should determine the sports injury incidence rate (i.e. the number of new sports injuries per population at risk over time, preferably taking exposure into account), sports injury prevalence (i.e. the proportion of persons with a sports injury in the population at risk at any one time) and the duration and seriousness of the sports injury (e.g. in terms of a reduction of sports participation, time lost from study or work, medical diagnosis, affected part of the body, level of treatment, etc.).

The sensitivity of a sports injury surveillance system in answering specific questions largely depends on the definitions applied. Standardized definitions are needed to answer questions such as: How should a population at risk of injury be defined? What is a meaningful measure of exposure to injury risk? What is a sports injury? How should sports injury severity be measured? How severe must an injury be before it should be considered to be a sports injury for surveillance purposes? One of the problems with current epidemiological research in the field of sport injury surveillance, Finch asserts, is the lack of internationally agreed definitions or answers to the above mentioned questions.

This is true with respect to running injuries. Injury definitions are varied and range from any insult to the body that results in a: reduction in training (Bovens et al.,
Marti et al.), reduction in training for greater than 7 days (Lysholm and Wiklander, Blair et al.), stoppage of training for more than 7 days (Pollock et al.), a reduction or stoppage in training (Jacobs and Berson), a stoppage in training lasting longer than 2 sessions or a reduction in training or a missed meet (Watson and DiMartino), a reduction in training, or requires a visit to a health professional, or requires medication (Macera et al., Walter et al.) and a subjective self-defined injury definition (Clough et al.). In addition to the variety of definitions that exist for running injuries, the subject populations and study design have also varied considerably. For instance, Watson and DiMartino conducted a prospective cohort design on members of a high school track team that average 10 hours of training per week; while Marti et al., in their prospective design, investigated entrants to a popular 16km road race who averaged 22.5km per week. There is a 28% difference in the incidence rate of injury between these two studies (17.5% and 45.8% for Watson and DiMartino, and Marti et al. respectively). From this analysis of the literature, it is apparent that the differences in the incidence rates may be confounded by differences in the methodology, injury definition and/or study population.

2.3 Aetiological or Explanatory Factors of Running Related Injuries

The second step in the sequence of prevention outlined in figure 3 focuses on identifying the aetiology and mechanism of sports injuries. Aetiological factors can be defined as items that will lead to a change in the incidence, prevalence, duration and/or seriousness of the sports injury problem if manipulated under controlled circumstances. These factors have been divided into two primary categories: intrinsic or person-related risk factors and extrinsic or circumstantial/environmental risk factors. However, in many cases it is difficult to determine whether a particular variable is, in fact, aetiological
or simply correlated with an increased risk of injury. For instance, it is thought by some that running in the early morning may place an individual at a higher risk of injury.\textsuperscript{21} Yet, it is difficult to scientifically validate such a claim. Individuals who perform their runs in the early morning may be more competitive than those who choose to run at the end of the day. Perhaps people who run in the mornings must do so in order to juggle a stressful work schedule, and the resulting stress could, in turn, result in higher muscle tension. Competitive motive and high muscle tension or poor flexibility are more likely to relate directly as risk factors for injury. Essentially, while time of day may be associated with an increased injury risk, it may not be this factor per se that needs manipulation in order to reduce the incidence, prevalence, duration and/or seriousness of an injury. It is, therefore, important to differentiate which factors are truly aetiological in nature, from simple associations.

Van Mechelen\textsuperscript{3}, in his review of the literature, reported that previous injury, lack of running experience, running to compete and excessive weekly running distances were the only aetiological factors related to injury. Brill and Macera\textsuperscript{4}, in a later review, concluded that running distance or ‘volume’ was the only consistent factor in population-based studies of recreational runners that is strongly associated with an increased risk of injury. Although the role that malalignment of the lower extremity plays in injury incidence is controversial; it is too reasonable to deny the hypothesis that structural abnormalities are a risk factor for running injuries.\textsuperscript{31} Other factors that have either an unclear association to injury or are backed by contradicting or scarce research findings include: warm-up and stretching exercises, age, gender, body height, body weight, body mass index, muscular imbalance, restricted range of motion, running frequency, early morning runs, level of performance, stability of running pattern, shoes and inshoe orthoses, running surface and running one side of the road.
2.3.1. Intrinsic Risk Factors

2.3.1.1. Age

Age proved to be not significantly related with running injuries in studies with comparable study populations.\(^4,5,6,26\) While one study did demonstrate through age-stratification a decrease of running injuries with an increase in age, it was speculated that the 'healthy runner effect', by which only those runners remaining free of injuries continue to run, may have accounted for this reduced injury incidence in older populations.\(^9\) In a retrospective case-control analysis of 2002 running injuries, Taunton et al. reported being less than 34 years old a risk factor across gender for patellofemoral pain syndrome, and in males for iliotibial band friction syndrome.\(^55\) Among military populations, age greater than 24 years does appear to result in a higher risk of injury, due to the relatively uniform nature of training and the fact that individuals have no choice as to which activities they undertake and how often.\(^33\) This contrasts the notion that older athletes may experience less injuries by listening to their bodies and knowing when to avoid potentially injurious situations.

2.3.1.2. Gender

Jacobs and Berson\(^5\), Lysholm and Wiklander\(^15\) and Walter et al.\(^5\) confirmed the conclusion made by Powell et al.\(^31\) that gender per se, does not seem to be an important risk factor for running injuries. Studies done on military populations suggest that females are at a greater risk of injury than males.\(^32,33\) However, it is of interest that after injury rates are corrected for 1 mile run times, the gender differential with respect to injury rate ceases to exist. This suggests that the difference in injury rates for males and females entering the army can be, at least partially, explained by their different levels of fitness. This assumes that the average female has the physiological capacity to achieve the similar levels of endurance as the average male. For women to achieve the same or better
run times than men, they will have to train harder, due to physiological differences between gender. These differences include: 1) for similar body types, cardiac output is about 10% less in women due to smaller heart volume; 2) for the same bodyweight, women have a 20% lower blood volume; 3) for the same volume of blood, women have about 10% less haemoglobin; 4) the wider pelvis of women decreases mechanical efficiency by increasing the angle of the femur necessary to bring the knees close together; 5) for the same bodyweight, the average female possesses about 10% more fat than the average male; 6) the vital capacity of a woman is about 10% lower than that of a man; 7) the Achilles tendon, important in the elastic recoil of running, is shorter in women; and 8) the menstrual cycle imposes physiological and psychological stresses on a woman’s body and mind which may decrease athletic performance.

While it is debatable the effects that gender has on overall injury incidence, it has been suggested that a certain gender may have a higher propensity for a particular overuse injury. Taunton et al. (in print), report that women were more likely to experience gluteus medius injuries, sacroiliac injuries and stress fractures (ratio of at least 7:3) than men. Conversely, men were more apt to suffer adductor and tibialis posterior injuries at the same ratio.

2.3.1.3. Anthropometrics

It has been speculated that taller individuals sustain a greater likelihood of running injuries as a result of a higher centre of gravity, longer limbs, greater mechanical loading or even due to the relative clumsiness associated with height. However, the association between height and injury has yet to be confirmed.

Leg length inequality has been associated as a risk factor in the development of a variety of overuse injuries because of the resulting alteration in the mechanical stress within the body. There are three separate classifications of leg length inequalities:
A functional short leg occurs secondary to pelvic tilt, which itself is usually a result of weak hip abductors. Structural short leg exists as a result of an actual bilateral difference in the length of one or more of the bony components of the lower limb. Cambered roads, drainage crowns built into roadway and certain banked athletic tracks may result in an environmental short leg. A bilateral leg length difference, regardless of the underlying mechanism, greater than 6 cm is classified as being severe. Leg length inequalities are believed to be associated with the onset of iliotibial band friction syndrome secondary to excessive tension on the lateral aspect of the long leg. In addition, running with a leg length inequality over many years may predispose an individual to develop osteoarthritis in the hip.

Increased body weight or body mass index (BMI) is thought to contribute to injury due to the increased force applied on bones, joints and connective tissue. Individuals with a very low BMI or body weight measurements may not have enough lean body mass to support their weight during the stresses of vigorous physical activity. Furthermore, females with a low percentage of body fat are prone to amenorrhea and low estrogen levels, predisposing to osteoarthritis and reduced elasticity of collagen, thus increasing the risk of injury. In addition, amenorrheaic females are at an increased risk of stress fractures and osteoporosis as a result of reduced bone mineral density. One study, Marti et al. found runners with a BMI smaller than 19.5 and greater than 27 to be a greater risk of running injuries, and Blair et al. found a significant, but low correlation (p<.05, r=0.10) between BMI and running injuries. However, it has been shown in studies by Walter et al. and Macera et al. that there is no relationship between BMI or weight and an increased incidence of injuries. These latter investigations support the belief that stronger muscles and larger bone surface areas will balance the greater forces associated with extra weight.
2.3.1.4. Physical Fitness

The majority of studies that have assessed the impact of physical fitness on the risk of injury have been undertaken on military basic trainees. These populations are subjected to a relatively uniform training regimen over a specific period of time, and are already controlled for factors such as exercise undertaken, shoes worn, type of training surface, time and duration of exercise, and running speed. When endurance fitness is measured by 1 or 2 mile run times, there is a virtual consensus that individuals with faster run times are less likely to suffer an injury during basic training.\textsuperscript{32} In fact, low cardiorespiratory fitness, measured by running performance, is the most documented risk factor for injuries in US army populations.\textsuperscript{33} It is felt by Jones and Knapik that individuals with a low aerobic capacity will experience greater physiological stress relative to their maximum capacity at any given absolute level of performance.\textsuperscript{32} Jones et al. found that for both men and women, comparing the risk of injury for the 2 slowest quartiles and the 2 fastest quartiles, the injury incidence values were 34 and 12\% respectively.\textsuperscript{34} Positive correlations between run times and injury during training were found in further studies by Jones et al., Cowen et al., Jones et al., and Jones et al.\textsuperscript{33,36,37,38}

2.3.1.5. Previous Injury

There is strong support in the literature indicating that a prior history of injury, defined as a positive history of a running injury in the 12 months prior to the start of an investigation, is an important independent risk factor for running injuries. Persons with a previous injury may be more likely to be injured again because the original cause may remain (i.e. similar training errors or uncorrected biomechanical factors), the repaired tissue may function less well or be less protective than the original tissue or the injury may not have healed completely.\textsuperscript{31} Furthermore, upon return to running after an injury, athletes may be more competitive and aggressive with a mindset to immediately return to
pre-injury training status which, on top of an already compromised musculoskeletal framework, may result in re-injury. Marti et al.\textsuperscript{9} found, after adjusting for differences in weekly distance, a 65% increased risk of injury for runners with a history of previous injury. After a univariate and multivariate age adjusted logistic regression, Macera et al.\textsuperscript{7} found that habitual runners with a past history of injury were at 3 times the risk of suffering a lower limb injury than runners without a previous injury. Walter et al.\textsuperscript{5}, after multiple logistic regression in which age and sex were forced into the model, previous injury proved to be 1 of the 2 strongest predictors of running injury with an odds ratio of 1.5. The higher incidence of meniscal injuries witnessed in Taunton et al.'s retrospective analysis of runners in 2000, compared with a similar retrospective design at the same clinic in 1991 and 1981, may be attributed to degenerative changes inside the knee of middle aged athletes secondary to repetitive knee micro-trauma.\textsuperscript{55}

2.3.1.6. Running Experience

Runners who are experienced are thought to be less at risk of sustaining an injury because of a possible musculoskeletal adaptation process that would actually result in a decrease in the injury rate as the years of training increase, even if the weekly distance is high.\textsuperscript{39} This idea is supported by findings that non-elite marathon runners have lower injury rates than would be expected given their training distance.\textsuperscript{23} A lower rate among more seasoned runners may be also be due to the self-selection by injury-prone individuals for other types of physical activities. Both Macera et al.\textsuperscript{7} and Marti et al.\textsuperscript{9} found that inexperienced runners were at an increased risk of injury during a 1-year follow-up. Running experience was not found to be significantly associated with running injuries in the studies of Blair et al.\textsuperscript{27} and Walter et al.\textsuperscript{5}.
2.3.1.7. *Running Caliber*

The relationship between running caliber and the incidence of specific running injuries has not been well investigated. In their retrospective analysis, Macintyre et al.\(^{11}\) investigated injury rates between three groups of runners: elite middle-distance, marathon, and recreational. It was found that recreational runners had the highest frequency of knee injuries (i.e. PFPS); lower-leg and foot injuries (i.e. tibial stress fractures) were more prevalent with the elite middle-distance class; and marathon runners had the highest rate of ITBFS. Running caliber in Taunton et al. was not significantly associated with injury and was designated depending on whether patients ran recreationally and locally or whether they competed in either provincial, national or international competition.\(^{55}\)

It is not unreasonable to assume that runners of higher caliber typically run at a higher intensity over a greater weekly distance, and have a prior history of injury – thereby predisposing them to further injury.\(^{7,9,15,38}\) However, Macera et al.\(^7\) concluded that high caliber runners likely have more running experience, and a greater ability to “listen to the language of their body”, both of which are thought to negatively contribute to the incidence of running related injuries. Due to the conflicting opinions of how running caliber influences injury patterns, further investigation into the possible relationship between running caliber and injury is encouraged.

2.3.1.8. *Malalignment*

There have been many alignment defects identified as being associated with running injuries in the literature. These include: leg length inequality, pelvic obliquity, femoral anteversion, excessive pronation or supination, genu varum or valgum, high tubercle-sulcus angle, squinting patella, high Q-angle, varus or valgus of the forefoot or rearfoot, flat feet and high arches, among others.\(^3\) Lysholm and Wiklander\(^{15}\), in an
attempt to determine the cause of injuries occurring in two high level track and field athletic clubs, found that in 40% of the cases malalignment (foot insufficiency, lower extremity muscle stiffness, genu varum and high Q-angle) was at least one of the factors causing the injury. Malalignment (overpronation, genu varum, genu valgum, patellar squinting, leg length discrepancy and pelvic asymmetry) was also found to significantly influence the injury rate reported by Taunton et al. By contrast, none of the measured variables by Walter et al. (femoral anteversion, pelvic obliquity, knee and patella alignment and rear foot valgus) were significantly associated with running injuries. Similarly, Wen et al. and Wen et al. both conclude that minor variations in lower extremity alignment (i.e. high or low arch index, or excessive heel valgus, knee tubercle-sulcus angle, knee varus and leg length inequality) do not appear to be conclusive risk factors for overuse injuries in runners.

While previous research on malalignment has resulted in inconclusive findings, it may be more appropriate to investigate the specific alignment defects on an injury-by-injury basis. Krivickas has conducted an extensive review of 16 biomechanical defects, and their association with various lower extremity musculoskeletal injuries (figure 4). Clement et al., Winter and Bishop, Wen et al. and Wen et al. have also performed large injury reviews that have investigated the influence of one or more biomechanical factors on risk of injury. From these analyses there are few conclusive findings. Patellofemoral pain syndrome is, at least in part, caused by malalignment of the lower extremity, as confirmed by Kettelkamp and Thomee et al. The plausible relationship
<table>
<thead>
<tr>
<th>Factor</th>
<th>PFSS</th>
<th>JK</th>
<th>MTSS</th>
<th>ITB</th>
<th>Plantar Fasciitis</th>
<th>Stress Fracture</th>
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<tr>
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<tr>
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<tr>
<td>Genu Valgus</td>
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<td>Subtalar Valgus</td>
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**Abbreviations:** ITB = iliotibial band syndrome; JK = jumper's knee; MTSS = medial tibial stress syndrome; PFSS = patellofemoral stress syndrome


between genu varum, leg length inequality, pronation and a high Q-angle with an increased risk of injury has not been unequivocally substantiated.

### 2.3.1.9. Muscular Imbalance

Running is known to strengthen the muscles at the back of the thigh and leg more than those at the front. The resulting imbalance between the hamstrings and calf muscles against the quadriceps group and anterior compartment has been thought to facilitate the occurrence of overuse injuries. It is also speculated by Van Mechelen that running injuries may result from an asymmetric contraction, or a strength imbalance, between the right and left hamstrings. In a case controlled study conducted by Van Mechelen et al., there was no significance found with regard to the strength ratio between the hamstring and quadriceps muscles, or overall weakness in these two muscle groups. Certain anatomical malalignments such as pelvic asymmetry secondary to a leg length inequality, may result in excessive stretch and fatigue in one muscle group relative to its contralateral counterpart. This unbalanced muscle fatigue often leads to soft tissue...
breakdown and the occurrence of injury (i.e. iliotibial band friction syndrome) with hip abduction weakness. Further prospective research is needed to follow-up and confirm the importance of this risk factor.

2.3.1.10. *Range of Motion and Stretching*

Although regular stretching is often recommended as a preventative measure against running injuries, this has yet to be conclusively proven in controlled experimental studies. Either a lack of, or improper execution of warm up, stretching and cool-down activities have been suggested as a risk factor for injury. \(^4\) Jacobs and Berson reported a higher rate of injury among runners who stretched on a regular basis compared to those who did not. \(^6\) However, by not controlling for previous injury or weekly distance, these results are difficult to interpret. In addition, it was put forward in this study that runners who are injured stretch because of their injuries. Conversely, Walter et al. found that the risk of injury was higher among runners who stretched irregularly, compared with those who always or never stretch. \(^5\) Again this analysis was conducted without controlling for previous injury or weekly distance. Jones and Knapik reported on the relationship between flexibility and the cumulative incidence of lower extremity injuries in male US Army infantry basic trainees. \(^30\) They concluded that individuals within the highest or lowest quintiles of flexibility (measured by a sit-and-reach stretch), were more prone to injury (figure 5). This evidence is contradictory to the widely held belief that greater flexibility protects against injury.
In a case controlled study investigating the range of motion (ROM) of 16 male runners who had sustained an injury, against the same number of injury free controls, Van Mechelen concluded that runners who had experienced an injury had a significantly more restricted ROM of the hip joints. Unfortunately, these results correlate the relationship between lack of flexibility in runners who have already experienced an injury, therefore, can not prove causation.

2.3.1.11. Psychosocial and Behavioral Factors

While it may be accepted that biomechanical and training factors play a large role in determining risk factors for injury in running, it is thought that psychosocial aspects may still be involved in a small, but significant manner (figure 6). Van Mechelen speculates that more motivated runners could ignore the first signs of injury in the pursuit of performance, thereby experiencing a higher injury rate. In fact, studies by both Walter and Marti et al., found that competitive running, or runners who stated
<table>
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<th>Risk Factor</th>
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<tr>
<td>1  Experience of high levels of negative and/or positive life changes</td>
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<tr>
<td>2  Exhibition of high levels of Type A and Type C behavior, when such</td>
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<tr>
<td>behavior is found to be inconsistent</td>
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<tr>
<td>3  Exhibition of high levels of trait, state, and/or competitive trait</td>
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<tr>
<td>anxiety</td>
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<tr>
<td>4  Exhibition of poor reaction and movement times, due to poor attention</td>
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<tr>
<td>focus</td>
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<tr>
<td>5  Exhibition of either high or low tolerance for pain</td>
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<tr>
<td>6  Exhibition of high levels of either extraverted or introverted behavior</td>
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<td>7  Experience of conflict between passivity and aggression</td>
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<td>8  Exhibition of behavior which is associated with insecurity, overprotection</td>
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<td>and dependency</td>
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<td>9  Exhibition of behavior which reflects that the athlete feels little</td>
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<td>control over the athletic situation at hand</td>
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<td>10 Exhibition of behavior which reflects poor self-concept and poor self-</td>
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<td>esteem</td>
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<td>11 Exhibition of high levels of depression</td>
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that they run predominately to compete, are at a significantly greater risk of experiencing injury, in contrast to those who run for fitness and recreation. Through multivariate analysis, Marti et al. was able to prove this as an independent association; whereas, in the Walter et al. study, the higher risk of injury in competitive running is thought to be related to higher training mileage. Lysens et al. attempted to study the possible relationship between athletic injuries and the magnitude of perceived life changes. By incorporating the ‘Life Event Questionnaire’, consisting of 74 items, they were able to determine the degree of social readjustment needed for each life event experienced. It was found that students who had experienced a high level of life change were at a greater risk of sustaining acute injuries, than students who experienced a low amount of life change. However, the interaction between psychosocial factors and overuse injuries could not be demonstrated.

2.3.2. Extrinsic Factors

2.3.2.1. Running Distance

Running distance, usually measured over a weekly period, has frequently been cited as the most important contributing factor in running injuries. Macera et al, and Walter et al, report an increasing injury rate corresponding to increasing weekly distance beyond approximately 32km (20 miles). In a randomized trial, Pollock et al. found...
weekly running duration to be related to injuries, and Jacobs and Berson, Marti et al. and Bovens et al. all showed weekly distance to be significantly related to running injuries.\textsuperscript{6,9,16,28} One study, Watson and DiMartino did not find any significance between running distance, measured in exposure time, and injuries.\textsuperscript{17} It should be noted that the population in this study was different from the above mentioned studies in terms of age and participation in athletic events (i.e. high school track athletes in former, and recreational/competitive distance runners in latter).

As defined by van Mechelen, unstable training habits, such as sudden increase in weekly distance or sudden change to a specific form of training (e.g. hill training or interval work), may be a precursor to an increased risk of injury.\textsuperscript{3} Muscle tissue often lacks the capacity to adapt to such sudden changes in workouts, therefore an injury may develop.\textsuperscript{4} Evidence for this effect is apparent from injury studies among military recruits entering basic training regimens. Those who have not been running consistently prior to basic training are more likely to incur running injuries than those who have maintained a running program.\textsuperscript{30} Lysholm and Wiklander found that training errors (e.g. sudden change in training routine) were significantly associated with 60% of the running injuries reported.\textsuperscript{15} These findings suggest that sudden increases in running (at least from not running to some running) are related to injury, but they do not address whether the issue of whether those running a certain weekly mileage who suddenly increase that distance are at increased injury risk, over and above the increase associated with additional distance. Brill and Macera feel that given the potential for differences in population-based studies of recreational runners, we are not likely to sort out this issue using traditional methods and convenience samples in observation based research.\textsuperscript{4}
2.3.2.2. Running Frequency

Studies by Jacobs and Berson, and Walter et al. reported that increasing running frequency, over a weekly basis, will increase the risk of injury.\textsuperscript{5,6} These studies do not control for weekly distance. Marti et al. investigated whether the risk of injury is lower if the same weekly distance were run over many days, instead of a only a few.\textsuperscript{9} By examining a subgroup running the same distance in 2, 3 or 4 weekly sessions, they concluded no significant differences among any of the running groups. Consequently, it is felt that cumulative weekly distance is a better risk factor for predicting the incidence of running injuries.

2.3.2.3. Running Surface

Running surface is thought to contribute to an increased risk of injury due to either hard surfaces translating more of the mechanical shock, cambered roads creating a leg length discrepancy or softer surfaces tiring the muscles at a faster rate.\textsuperscript{3,39} Macera et al. found that in women, there is a significant difference in injury risk for running on a concrete surface.\textsuperscript{7} In fact, this group was at over 5 times the risk of women who predominately run on other surfaces. Other studies have not been able to reproduce any significance with running on different running surfaces.\textsuperscript{5,6,9} Yet, it may be impossible to determine the importance of surface or terrain because typical runners choose various surfaces to run on. Most studies classify runners by the surface they 'predominately' run on, thereby making it difficult to classify the exposure time appropriately.\textsuperscript{4}

While hill running has been implicated as an associated factor in running injuries, studies by Jacobs and Berson, Macera et al., and Walter et al. did not find any relation between hill running and increased risk of injury.\textsuperscript{5,6,7}
2.3.2.4. Running Pace or Speed

Increased physical stress may be placed on the lower extremity with a faster running pace, therefore, it is thought that this may contribute to a high risk of injury. However, none of the population studies of runners support this idea, after adjusting for total weekly distance.

2.3.2.5. Running Shoes

It is understood within the literature that proper footwear plays an important role not only in the comfort of running, but also in injury prevention. The understanding that poor shoes may contribute to running related injuries has led manufacturers to design shoes with added stability and motion control with the use of various components (such as last design, heel counters, lacing systems, fibreglass midsole plates, and various combinations on the density of the materials in the midsole). It is even felt by certain authors that modern running shoes are deficient in providing proper sensory feedback and shock moderation; consequently barefoot running has been recommended. In any event, there is reasonable consensus that a good running shoe must provide cushioning, support, and stability, yet maintain a reasonable degree of flexibility, softness and lightness. It is speculated that the average runner translates around 60 tonnes of force per kilometre through the thigh and leg musculature. As a result, as Cook et al. point out, runners should be aware of how the shock absorbing qualities of running shoes may change. Wet running shoes absorb significantly less force and all running shoes lose between 30 and 50% of their shock-absorbing characteristics after about 400 kilometers of running.

Marti et al. found that runners having no preference for any brand of running shoe sustained significantly fewer injuries than runners who had a preference for a specific brand. Runners who chose to wear expensive shoes (greater than $US90)
sustained significantly more injuries than those who chose less expensive pairs. The explanation put forward by Marti et al. was that injury-prone runners or high mileage runners are more predisposed to wear expensive shoes. The use of orthotics in this study was significantly related to both a positive history of injury, and with running related injuries during the period of study. Selection bias by injury prone runners towards orthotics was offered as a likely explanation. Walter et al. found that owning 2 pairs of shoes to be significantly related to an increase in injury incidence. However, the authors assert that the effect of owning more shoes reflects greater levels of training, and a higher weekly mileage.

2.3.2.6. Time of Day

It has been clinically suggested that early morning runs may prove hazardous to the musculoskeletal system, especially if the muscles are not properly warmed up. Investigations by Walter et al., Jacobs and Berson, Macera et al and Blair et al. did not find any significant difference in injury incidence between individuals who chose the early morning to run versus those who run at other times of the day.

2.4 Prevention of Running Injuries: Health Education

It is apparent from data in the literature that there are many factors that may either act individually or in unison to form the physiological basis of a running injury. Some of these factors appear more convincing than others, namely weekly distance and prior history of injury, versus time of day and running surface. Yet a majority of the epidemiological studies conducted focus on factors that are important only for a mass population of runners; therefore, many contradicting or unclear risk factors may undoubtedly be causative for some individuals. As suggested by Marti et al. running
injuries are so multi-factorial and diverse that any specific single measure proposed would probably be of help to only a small minority. In order to effectively prevent running injuries, the measures incorporated must not only be effective against the population en mass, but must also address the significant portion of runners with ‘unique’ characteristics. Essentially, every runner must be treated as an individual, with distinct biomechanical, musculoskeletal and training characteristics that are to be addressed collectively.

One clear solution for effective running injury prevention is by providing information through health education. By properly educating runners, especially neophytes, strong risk factors such as excessive weekly distance, lack of experience and running to compete may be controlled. A health education program should instill the following guidelines: training should be built up gradually (10% per week); running speeds should be such that the runner can continue to speak without shortness of breath; the untrained should start their training gradually, e.g. on alternate days; in group training each individual should have their own training program (this is helped by a division into groups of more or less equal performance). In dealing with previous injury as a risk factor, complete rehabilitation and early recognition of symptoms of overuse injuries are very important. A rehabilitation program can not be considered complete until the sportsman is free from pain; muscle strength has returned to about pre-injury level; and articulatory mobility has recovered to pre-injury level. With respect to early recognition of symptoms, a runner should be taught to listen and respect ‘the language of their body’ and reduce or temporarily stop, rather than continue to increase running when suffering from pain or stiffness of joints and tendons.
Chapter 3

3.0 Methodology

3.1 Sample Description

The subjects for this investigation include participants enrolled in 29 of the 46 In Training clinics throughout the greater Vancouver area. A sub-sample of runners seeking medical attention from the Allan McGavin Sports Medicine clinic was examined through questionnaire.

3.2 In Training Protocol

This 13-week training protocol was designed by sport medicine physicians practicing at the Allan McGavin Sports Medicine Centre, and included two sections to accommodate novice and intermediate runners. Demographically, the novice group is comprised of primarily sedentary and de-conditioned individuals that were interested in establishing a running program for reasons likely related to improving health and fitness. The running program incorporated walk/run repeats that eventually lead to a continuous running session on the twelfth week (appendix A).

The intermediate program is designed for people who have completed the novice walk/run program and would like to safely and effectively increase their running endurance and intensity. Hill training, interval and fartlek sessions are implemented (appendix B).

Both training programs require the participants to run three times per week; two of these sessions are separate from the group run on the day of their respective clinic. It is recommended that participants allow for one day of rest (or cross training) between any two running sessions. As each training session is based on time, there may be
considerable variation in the distances covered on individual workouts. Training sessions vary in length from 35 to 66 minutes.

3.3 Survey Administration

The questionnaire was administered during the sixth and twelfth week of clinic operation. The clinical investigation at the AMSMC was performed concurrent to the administration of In Training clinics. Patients seeking medical attention at the AMSMC for running related pain were asked to fill out the same questionnaire.

3.4 Questionnaire Format

3.4.1. Runner Profile

Quantification of the seven risk factors associated with running injuries was the primary aim for this section of the questionnaire (appendix C). A visual analogue scale (VAS) was used for item scaling in the first 6 questions to allow a continuous method of expression by which the subject may describe the magnitude for a given parameter. This scaling system is considered more accurate and sensitive than a categorical scale.

3.4.2. Training Profile

The training profile section was designed to produce a severity outcome measure for generalized running related injuries – the Training Function Score (T.F.S.). The items within the T.F.S. were derived from the Victorian Institute of Sport Assessment (VISA) severity scale initially developed for patellar tendinopathy patients, and has since been modified for Achilles tendon injuries. Within the training profile, the domains of pain and function are assessed with a total of three and four questions respectively, using a VAS for a description of the participant's subjective symptoms. The final domain of activity is assessed by a categorical rating system based on an incremental range of values for running time.
The weighting for all questions in the T.F.S. is the same. Questions one through seven are scored out of ten and question eight is scored out of 30; all scores are summed to produce a final score out of 100. Asymptomatic runners would score 100; someone who is symptomatic with at least preliminary signs of injury would score less than that.

3.5 Statistical Analysis

Basic descriptive statistics were used in the preliminary analysis. A one-way ANOVA was used to analyze the injury rate data across the In Training clinics, with Tukey’s Honestly Significant Difference (HSD) Test for post hoc analysis.

A univariate regression analysis was used to provide initial correlative data on each of the six predictor variables relative to the Training Function Score. A forward stepwise multiple regression model was then used to determine the relative importance of each predictor variable with respect to the explained variation in the T.F.S. In addition, the Pratt index was used in calculating the individual variable importance in this regression model.

A comparison of the T.F.S between uninjured, injured and clinically injured runners was conducted also through a one-way ANOVA, and Tukey’s HSD.

Univariate regression was utilized to examine the associative strength between the T.F.S. and the subjective definitions of injury in both the In Training and clinical populations. Apart from a descriptive analysis, no formal comparison between the inter-clinic mean injury rate and the corresponding T.F.S. value was performed.

The alpha was set at .05 for significance for all statistical calculations.
4.0 Results

A summary of the descriptive statistics for the In Training clinics can be seen in figure 7. From 26 clinics surveyed: 509 participants responded to the first trial on week six, and 421 to the second week 12, out of a possible 1635 participants registered with those clinics. On average, respondents to the survey indicated running for over two years and having a competitive motive, level of physical fitness and degree of rehabilitation from prior injury of 4.3, 5.0 and 8.3 out of ten respectively. The mean weekly running mileage for this sample was 15.0km over an average of 2.9 days of running per week.
Approximately thirty six percent (35.9%) of respondents during the first trial indicated they were 'currently experiencing an injury as a result of running' and 36.3% indicated they were injured by the second trial. Due to inconsistencies in survey returns (i.e. drop-outs within clinics), however, analysis of individual clinic injury rates was not conducted.
Approximately half (n=210, 49.8%) of the participants in the second trial indicated they had experienced an injury prior to the *In Training* program. Previous injury data is not available for the first trial.

### 4.2 Bivariate and Multivariate Regression Analysis of TFS and Predictor Variables

Initial univariate analysis reveals competitive motive, physical fitness, weekly distance, and degree of rehabilitation to be significantly associated with variations in the Training Function Score (T.F.S.). Degree of rehabilitation appears the strongest individual factor relating to the T.F.S. (r = .483) followed in order of decreasing correlational strength by weekly distance (r = .178), physical fitness (r = .158) and competitive motive (r = .086).

<table>
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<th>r - value</th>
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<td>Physical Fitness</td>
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<td>Weekly Distance</td>
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<td>Degree of Rehabilitation</td>
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<tr>
<td>Physical Fitness</td>
<td></td>
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*Via Pratt Index

Table 1. Regression results on bivariate and multiple regression analysis of predictor variables and TFS.

The multivariate regression model was significant (F(2,376) = 63.861, p-value <.001) for two (degree of rehabilitation and physical fitness) of the six predictor variables. The r squared for this model was .254, with 90.1% of that explained variation attributable to degree of rehabilitation.
There was no association between the 6 risk factors (degree of rehabilitation, weekly distance, running frequency, physical fitness, competitive motive, running experience) and the clinics with the highest and lowest recorded injury rates respectively.

4.3 Clinical Questionnaire Results

A total of 28 individuals responded to the questionnaire administered at the AMSMC. Of those who responded, the mean T.F.S. value was 46.29 out of possible 100 points. The univariate analysis of the T.F.S. and the subjective injury definition showed a significant association (p=.011, β = -.567) between decreasing T.F.S. values and increasing severity of subjective injury definitions.

4.4 T.F.S. & Subjective Injury Severity

![Figure 8. Scatterplot illustrating association between increasing subjective injury severity and TFS](image)

Comparison, via univariate regression analysis, of the training function score and increasing subjective definition of injury demonstrates a significant (p < .001) association (β = -.633) between a decreasing T.F.S. and increasing subjective severity of injury (figure 8) during the second trial only.
4.5 T.F.S. and Injury Rate

The association of the T.F.S. and the percentage of respondents indicating they were experiencing an injury are related in Figures 9 and 10 for trials 1 and 2 respectively. Formal statistical work-up relating these two variables was not performed for reasons relating to validity.

Figure 9. Graphical relationship between mean clinic T.F.S. and % of reported injuries for trial 1.
Clinic

Figure 10. Graphical relationship between mean clinic T.F.S. and % of reported injuries for trial 2.

4.6 T.F.S. Across Uninjured, Injured and Clinically Injured Runners

The T.F.S. value for uninjured runners in the In Training clinics was 82.91, whereas the value for injured runners in the training clinic setting was 64.56 out of a possible 100 points. Runners seeking medical consultation regarding their running related pain have a mean T.F.S. score of 46.29. The results from our one-way ANOVA test demonstrate a significant difference \[ F(2,911) = 191.18, p<.0001 \] between all three categories (uninjured, injured and injured at AMSMC) of runner within this study. Due to unequal group sizes, particularly the smaller sample in the clinical investigation, a harmonic mean was used in the calculation of the ANOVA results. Post-hoc analysis
significant difference exists between all possible runner categories (i.e. uninjured vs. injured, uninjured vs. clinically injured, and injured vs. clinically injured).
Chapter 5

5.0 Discussion

Population based epidemiological investigations on running injuries have used a variety of injury definitions to describe their population of interest. A consequence of this definitional variation is a lack of consistency with respect to the severity of the injury. In other cases, a broad or ambiguous definition provides equal uncertainty on this issue. Injuries that do not compromise run training in spite of symptoms would lie on one end of the severity spectrum \(^6\), while the other would restrict their definition to include only those runners who had a reduction in training for a period of over two weeks.\(^ {15} \) For example, in a recent study on injury patterns in the 2000 Vancouver Sun Run, an injury was defined as requiring an absence of running for a period of 7 days (1 week).\(^ {64} \) Two of the more comprehensive investigations on the subject classify those runners taking medications for relief of ‘running related pain’ as injured. Clearly there is tremendous variation in public use of medicines for analgesic or anti-inflammatory purposes, and deciding upon an injured population based on such criterion could adversely affect validity.

To date, a globally accepted definition for a ‘running injury’ has not been found despite numerous investigations on the topic. Studies thus far have dichotomized runners as either ‘injured’ or ‘non-injured’. However, it may be better to approach this issue from the standpoint of a continuum, rather than an all or none phenomenon. Coggon et al. perhaps phrases it best by suggesting that the real question in population based studies is not “Has the person got it?” but rather “How much of it has he or she got?”\(^ {56} \) As a result, the introduction of measures that take into account the quantitative nature of an injury is warranted.
The use of disease specific outcome measures has been increasing in popularity in the last twenty years. In particular, the Western Ontario McMaster Arthritis Index (WOMAC), the UCLA Shoulder rating scale, the Western Ontario Shoulder Instability Index (WOSI) and the Victorian Institute of Sport Assessment (VISA) scales for both patellar and Achilles tendinopathy have been used confidently by clinicians.\textsuperscript{56,57,58,59,60}

The introduction of such quantitative measures has provided researchers with a means of evaluating the effect of an intervention in determining the etiology or treatment path of a particular injury. In addition, the quantification process allows a greater degree of clarity for comparing the results of more than one study allowing clinicians a better perspective for the overall cause or treatment plan for a patient.

Unfortunately, large-scale population-based studies on running injuries do not have the luxury of diagnostic information for any given subject. It is often too impractical or costly to have the necessary medical consultation required for accurate diagnosis of a musculoskeletal injury. Consequently, the issue of “what is a running injury?” still persists in the minds of researchers studying this group of athletes and is further complicated by the many different bony and soft tissue disorders being classified under that name.

Due to the definitional ambiguity in running injury literature, it has been popular to classify an individual as injured based on the presentation of symptoms and/or loss of function. The symptomology is often similar among the majority of running injuries, consequently producing a similar affect on function, and thus giving validity to this common classification structure. A majority of pain that runners experience results from inflammation secondary to either musculotendinous, periosteal or articular degeneration.\textsuperscript{40,41} The degeneration, pain and loss of function will continue to increase in severity as long as the physiological stress placed on the injured structure is in excess of
any regenerative process. The manifestation of a particular injury is further dependent on how load forces (both internal and ground reaction) react with a given lower extremity alignment.\textsuperscript{40} The etiology of a given running injury is also dependent on a collection of factors not limited to musculoskeletal biomechanics, such as training pattern, running shoes, psychosocial factors and running surface. In essence, the cause of individual injury will vary considerably from runner to runner, but the presentation of that injury, with respect to pain, function and loss of activity, will be similar across runners and across most running injuries.

The comparable presentation of running injuries in most chronic overuse conditions could allow researchers to use that similar symptomology in the classification and quantification of running injuries for the purposes of large-scale population-based research.

The present study was designed to introduce a psychometric analysis of a generalized severity outcome measure for overuse running related injuries. One of the objectives of this study, therefore, is to suggest a critical review of how we examine the prevalence, incidence and etiology running injuries. It is the contention of this thesis that quantitative assessment of running related pain is not only possible, but also necessary. Yeung and Yeung\textsuperscript{65} recently determined through a meta-analysis of 8806 runners that intervention strategies in the prevention of lower-limb soft tissue injuries lack convincing evidence of their effectiveness. One of the reasons for this lack of efficacy could rest in the definitional ambiguity of a “running injury” with the studies in question. It is imperative that the framework for valid methodological comparisons is set before such scientific interventions are attempted. A standardized severity outcome measure for running related pain will bring us one step closer in establishing the criteria for valid intervention assessment.
Where this investigation provides optimistic prospects, however, considerable advances in measurement and research methodology must first be achieved before the overall objective of prevention of running injuries on a larger scale is realised. Over the last two decades, advances in biomechanical, physiological and clinical research have contributed to significant gains in the understanding of individual running related pathologies. Unfortunately, as this study indicates, we are as yet unable to produce a running program for a large group of predominantly middle aged, novice joggers where less than one third on the participants do not experience injury. Clearly this point requires further investigation.

Concerning the specific results of this study, a few points deserve attention. As with any epidemiological investigation, it is important to present the results in the context of the study population for valid and critical assessment. The subjects involved in this running program would be best described as novice or introductory runners with little or no running experience, average physical fitness, average competitive drive and experiencing a least vestigial effects from a prior injury. The mean running experience of 2.4 (+/- 2.6) years in this study is the lowest compared with other large population based investigations, and the weekly distance of 15.0 (+/- 8.5) km is also the lowest recorded among other authors. These two points speak to the type of individual that is likely registering in these In Training clinics. However, due to the paucity of running injury literature with a similar demographic, an adequate comparison of this data is lacking.

Univariate analysis in this study indicates that degree of rehabilitation, physical fitness, weekly distance and competitive motive were significantly associated with a decreasing Training Function Score. Unfortunately, there are numerous explanatory
variables that work in concert with each other, rather than independently, to determine an individual’s risk of injury. For instance, increasing weekly distance could affect a runner more with a prior history of injury, low physical fitness may be unassociated with injury unless it is linked with high competitive motive or perhaps competitive, or unfit runners not completely rehabilitated from a prior injury could more likely experience re-injury. By determining the associative role of an individual predictor variable in the context of all other predictor variables at the same time, it is felt that a multivariate, versus a bivariate, regression model better addresses the issues surrounding variable association. In addition, the multivariate model allows analysis of individual variable importance through statistical techniques such as the Pratt analysis. Detailed mathematical explanation of this technique is offered by Thomas, Hughes and Zumbo (1998).

The multivariate model in this study demonstrated that lack of complete rehabilitation explained almost all (90.1%) of the explained variation in the T.F.S. While the implication that a prior history of injury is associated with re-injury is hardly a novel one, up until this study researchers have yet to attach to it any objective measure of importance. In a study conducted on the In Training clinics in 2000, approximately 50% of the individuals who experienced an injury during the 13-week period had a prior history of injury. These consistent results indicating the importance of proper and complete rehabilitation for novice runners entering a training program suggest that follow up research should be directed in this area. In particular, we need to determine the relative importance for attainment of pre-injury levels of such rehabilitative outcome measures as range of motion, flexibility, strength and neuromuscular control (proprioception and kinesthesia).

Of course the results from this regression model need to be taken in the context of the validity limitations of this study. In particular, the drop out rate from first trial to
second, and for both trials compared to overall clinic attendance (total clinic participants for 26 clinics is 1635) is potentially cause for concern. While maintaining adequate correspondence with drop-out subjects in large population based studies is expensive and inconvenient, care should be taken in the design of future studies on this population to correct for this uncertainty. Guyatt (1997) identifies an increased likelihood of non-compliance, missing items and misunderstanding with the use of a self-administered questionnaire. Rather, interviews with subjects either over the phone or in person could improve the credibility and validity of the item responses in future investigations of this nature.

The lack of previous validation of the severity outcome measure used in this study is important to address. There are other existing confounds that could account for the variability in the T.F.S.: age, chronic disability (i.e. osteoarthritis, diabetes, etc.), prior motor vehicle accident and occupation involving heavy labour or prolonged standing. Future studies wishing to incorporate a continuous dependent variable for injury should devote considerable attention to the design and validation of an original outcome measure for the application in question.

The visual analogue scale used in the quantification of the six risk factors carries its own shortcomings. It is important to emphasize the self-selected nature of the ‘running profile’ section of the questionnaire used in this study. Clearly, a runner indicating a ‘5 out of 10’ for the assessment of physical fitness is considerably different, in terms of objectivity, reliability and validity, to a VO$_{2\text{max}}$ value. Similarly, competitive motive is a complicated psychological parameter difficult to accurately measure with multi-page questionnaires, let alone a VAS out of 10. Degree of rehabilitation can be assessed through range of motion tests, pain scales, histological samples and strength tests for valid indication of an athlete’s return to sport. It is difficult to consolidate these
parameters into a single VAS item. Like arguments could be made for the assessment of weekly distance, running experience and running frequency. Therefore, the reader is directed to view the generalizability of these results accordingly.

The above-mentioned T.F.S. and visual analog scale validity limitations likely play a significant role in the low $r^2$ value from the multivariate analysis. Expanding the value of the explained variation could be achieved through a cohort investigation incorporating baseline measurements and weekly-administered questionnaires. Parameters measured at base line should include: gait analysis (rear-foot movement, forefoot movement, internal tibial torsion), knee alignment (varus/valgus), Q-angle, height of the longitudinal arch, functional strength assessment (triceps surae, hamstrings, quadriceps, hip abductor/adductor, hip flexor/extensor and core stability), flexibility assessment (knee, ankle, hip) and physical fitness (Coopers test or Astrand cycle ergometer test).

The success of the above mentioned cohort investigation would determine the direction for an intervention. For instance, it may be beneficial to examine the administration of the program, rather than the program itself, for the cause of injury. Perhaps a lack of compliance, at the clinic level or at the individual level, with the program's guidelines may account for some of the discrepancy in the injury severity of these runners. Clearly an adequate understanding of the problem, should there be one, needs to be accomplished before steps are taken for its remedy.

As part of the psychometric analysis of the T.F.S., an assessment of the discriminatory and evaluative ability of this outcome measure is warranted. The discrimination of injured from non-injured runners was demonstrated by the significant ANOVA results of the T.F.S. for uninjured, injured and clinically injured runners. Evaluative psychometric assessment was performed by comparing the T.F.S. with six
subjective definitions of running related pain based on previous large-scale running injury studies. In both the clinical and the In Training clinic setting, there was a significant association between increasing pain, loss of function and reduced activity (i.e. lower T.F.S. score) and increasing subjective definition of injury. While this is encouraging data in the interests of one day having a standardized running injury severity continuum, the considerable intra-definitional variability in T.F.S. (figure 8) and lack of subject number homogeneity across the definitional scale suggest the need for a validated outcome measure for generalized running injuries.

The illustrated association between the T.F.S. and the mean clinic injury rate (figures 9 and 10) is also encouraging, but is ultimately compromised by the lack of consistent survey response rates for the involved clinics. For this reason a formal statistical work-up on this relationship was not conducted and the first two hypotheses can not be adequately addressed. The first hypothesis, stating a significant T.F.S. discrepancy between the clinics studied, requires greater homogeneity of survey returns for proper statistical work-up. Therefore, the second hypothesis, stating that the risk factors investigated in this study will significantly account for the proposed T.F.S. discrepancy in the In Training clinics, can not be completed based on its connection with the first hypothesis.

There is a possibility of bias in the participating clinics that would restrict the validity of inter-clinic comparisons. The inability to adequately understand the reason for 17 clinics (46 clinics total - 29 participating) not participating, suggests a possibility of bias on behalf of the participating coordinators in favor of better addressing their injury rate. This speculation should be confirmed through follow-up investigations.

A number of modifications were made in the design of the present study with respect to research on the 2000 In Training clinics. The significant changes made to the
questionnaire design include: a continuous outcome measure for running injury, a visual analogue scale for quantification of factors and a measure of exposure time to injury. These modifications allow us to improve the discrimination of injured runners from non-injured, better objectify the risk factors for injury in addition to providing information on variable importance, and improving the epidemiological merit of our results with respect to the running community. Furthermore, these fundamental changes in research design – rather than changes in the running population – likely account for the identified differences in the risk factors for injury between the present study and the research in 2000.

5.1 Conclusion

Analysis of the incidence, prevalence, and causative factors of running injuries has been extensively documented. A lack of definitional and methodological consistency compromises the scientific advances garnered from these investigations. The subjective classification structure for what defines a running injury will ultimately limit our ability to extrapolate experimental results to the general public. The development of a severity outcome measure for running injuries is one way of addressing this issue. Quantifying the extent of injury allows researchers the ability to perform better analysis on individual variable importance, as well as allow for a standardized injury definition. The results from this study suggest that an outcome measure for generalized running injuries is possible with respect to discriminating injured from non-injured runners and evaluating the severity of those injuries. While such an outcome measure for general running injuries is feasible, proper validation procedures and methodology must be established before such a scale is used formally.

The introductory model established in this investigation suggests that novice runners – who are beginning a training program to complete a 10 kilometre run after 13-
weeks – should be aware that lack of full rehabilitation from a prior injury accounts for nearly one-quarter of the decrease in ‘training function’ experienced during the In Training clinics. The extent of an individual’s physical fitness upon entering a training program should also be considered, albeit at a lower priority. The somewhat low value in R² or explained variation in the T.F.S. with respect to the predictor variables is difficult to interpret due to a lack of reference base in this subject area. Nevertheless, optimizing this analysis procedure is encouraged through either a more objective measurement system of the existing risk factors, and/or the inclusion of a greater number of predictor variables felt to contribute to the risk of injury.

Based on the success of the T.F.S. in this study to discriminate and evaluate aspects of running injuries in this population, follow-up research is this area is encouraged. Firstly, an original and validated severity outcome measure should be developed to exclusively quantify the restriction in pain, function and activity resulting from running related pain. Once this tool for objectifying running injuries is complete, a cohort investigation of the Sun Run In Training clinics is warranted for a valid and accurate indication of 1) running injury incidence and prevalence during the 13 weeks and 2) risk factors associated with injury. Using Pratt analysis to determine individual variable importance, experimental research should test interventions based on the identified significant risk factors in the above cohort investigation. Testing the efficacy of these interventions in a population-based setting will provide the literature with valuable data on limiting the rate of injury in novice runners training for a 10 kilometre run.
References

1. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A Prospective Study of Running Injuries: The Vancouver Sun Run In Training Clinics. Pending final review for British Journal of Sport Medicine


Appendix
Appendix A: The 13-Week Walk/Run Program

Week 1
Session 1 (35 minutes)
Run 30 seconds. Walk 4 minutes and 30 seconds. Do this 7 times.
Session 2 (40 minutes)
Run 30 seconds. Walk 4 minutes and 30 seconds. Do this 8 times.
Session 3 (40 minutes)
Run 30 seconds. Walk 4 minutes and 30 seconds. Do this 8 times.

Week 2
Session 1 (45 minutes)
Run 1 minute. Walk 4 minutes. Do this 9 times.
Session 2 (40 minutes)
Run 1 minute. Walk 4 minutes. Do this 8 times.
Session 3 (40 minutes)
Run 1 minute. Walk 4 minutes. Do this 8 times.

Week 3
Session 1 (50 minutes)
Run 1 minute and 30 seconds. Walk 3 minutes and 30 seconds. Do this 10 times.
Session 2 (40 minutes)
Run 1 minute and 30 seconds. Walk 3 minutes and 30 seconds. Do this 8 times.
Session 3 (50 minutes)
Run 1 minute and 30 seconds. Walk 3 minutes and 30 seconds. Do this 10 times.

Week 4
Session 1 (55 minutes)
Run 2 minutes. Walk 3 minutes. Do this 11 times.
Session 2 (45 minutes)
Run 2 minutes. Walk 3 minutes. Do this 9 times.
Session 3 (50 minutes)
Run 2 minutes. Walk 3 minutes. Do this 10 times.

Week 5
Session 1 (60 minutes)
Run 2 minutes and 30 seconds. Walk 2 minutes and 30 seconds. Do this 12 times.
Session 2 (50 minutes)
Run 2 minutes and 30 seconds. Walk 2 minutes and 30 seconds. Do this 10 times.
Session 3 (50 minutes)
Run 2 minutes and 30 seconds. Walk 2 minutes and 30 seconds. Do this 10 times.
**Week 6**
Session 1 (65 minutes)
Run 3 minutes. Walk 2 minutes. Do this 13 times.
Session 2 (50 minutes)
Run 3 minutes. Walk 2 minutes. Do this 10 times.
Session 3 (55 minutes)
Run 3 minutes. Walk 2 minutes. Do this 11 times.

**Week 7**
Session 1 (60 minutes)
Run 4 minutes. Walk 2 minutes. Do this 10 times.
Session 2 (54 minutes)
Run 4 minutes. Walk 2 minutes. Do this 9 times.
Session 3 (54 minutes)
Run 4 minutes. Walk 2 minutes. Do this 9 times.

**Week 8**
Session 1 (60 minutes)
Run 5 minutes. Walk 1 minute. Do this 10 times.
Session 2 (48 minutes)
Run 5 minutes. Walk 1 minute. Do this 8 times.
Session 3 (54 minutes)
Run 5 minutes. Walk 1 minute. Do this 9 times.

**Week 9**
Session 1 (63 minutes)
Run 7 minutes. Walk 2 minutes. Do this 7 times.
Session 2 (54 minutes)
Run 7 minutes. Walk 2 minutes. Do this 6 times.
Session 3 (50 minutes)
Run 8 minutes. Walk 2 minutes. Do this 5 times.

**Week 10**
Session 1 (44 minutes)
Run 10 minutes. Walk 1 minute. Do this 4 times.
Session 2 (41 minutes)
Run 20 minutes. Walk 1 minute. Run 20 minutes.
Session 3 (45 minutes)
Run 22 minutes. Walk 1 minute. Run 22 minutes.

**Week 11**
Session 1 (51 minutes)
Run 25 minutes. Walk 1 minute. Run 25 minutes.
Session 2 (56 minutes)
Run 30 minutes. Walk 1 minute. Run 25 minutes.
Session 3 (51 minutes)
Run 40 minutes. Walk 1 minute. Run 10 minutes.
Week 12
Session 1 (66 minutes)
Run 45 minutes. Walk 1 minute. Run 20 minutes.
Session 2 (66 minutes)
Run 50 minutes. Walk 1 minute. Run 15 minutes.
Session 3 (45 minutes)
Run 45 minutes.

Week 13
Session (50 minutes)
Run 50 minutes.
Session 2 (40 minutes)
Run 40 minutes.
Session 3 (60 minutes)
Complete your first 10K run or run for 60 minutes!
Appendix B: The Intermediate Running Program

Week 1
Session 1 (30 minutes)
Run 30 minutes. Take the first 5 minutes slow and easy; focus on achieving a relaxed pace.
Session 2 (30 minutes)
Run 30 minutes. Take the first 5 minutes slow and easy; focus on keeping your shoulders square and relaxed.
Session 3 (35 minutes)
Run 35 minutes. Take the first 5 minutes slow and easy; focus on taking comfortable strides.

Week 2
Session 1 (35 minutes)
Run 35 minutes. Take the first 5 minutes slow and easy; focus on keeping your torso upright.
Session 2 (30 minutes)
Run 30 minutes. Take the first 5 minutes slow and easy; focus on keeping your breathing relaxed.
Session 3 (35 minutes)
Run 35 minutes. Take the first 5 minutes slow and easy; focus on driving your arms backwards as you run.

Week 3
Session 1 (40 minutes)
Run 40 minutes. Take the first 5 minutes slow and easy; focus on keeping your arms relaxed.
Session 2 (35 minutes)
Run 35 minutes. Take the first 5 minutes slow and easy; focus on keeping your elbows bent at a right angle.
Session 3 (35 minutes)
Run 35 minutes. Take the first 5 minutes slow and easy; focus on taking comfortable strides.

Week 4
Session 1 (40 minutes)
Run 40 minutes.
Session 2 (35 minutes)
Run 35 minutes.
Session 3 (40 minutes)
Run 40 minutes.
**Week 5**
Session 1 (45 minutes)  
Run 45 minutes. During the course of your run, include two 5-minute segments in which you run at a slightly faster pace.

Session 2 (45 minutes)  
Run 45 minutes.

Session 3 (40 minutes)  
Run 40 minutes.

**Week 6**
Session 1 (50 minutes)  
Run 50 minutes.

Session 2 (45 minutes)  
Run 45 minutes.

Session 3 (45 minutes)  
Run 45 minutes.

**Week 7**
Session 1 (55 minutes)  
Run 55 minutes.

Session 2 (50 minutes)  
Run 50 minutes.

Session 3 (50 minutes)  
Run 50 minutes.

**Week 8**
*Interval training is designed to increase your body’s capacity to carry oxygen and to improve your muscle endurance. You will be running at a slightly higher speed for a short time, followed by a recovery period during which you can walk or jog slowly.*

Session 1 (45 minutes; interval training)  
Run slow and easy for 10 minutes. Interval training: Run 3 minutes at medium-fast tempo; recover 3 minutes. Repeat interval training 5 times. Run slow and easy for 5 minutes.

Session 2 (40 minutes)  
Run 40 minutes.

Session 3 (50 minutes)  
Run 50 minutes.
**Week 9**

*Fartlek training is a series of random bursts done “as you fell like it” during a continuous run. These burst can range anywhere from 20 seconds to 3 minutes and are performed every 2 to 4 minutes, although there is no need to time the pieces. This type of training is well suited to outdoor runs over changing terrain.*

Session 1 (45 minutes; fartlek training)
- Run slow and easy for 10 minutes. Run 30 minutes, increasing your speed to medium-fast for approximately 30 to 45 seconds every 2 to 3 minutes. Run slow and easy for 5 minutes.
- Session 2 (50 minutes)
- Run 50 minutes.
- Session 3 (55 minutes)
- Run 55 minutes.

**Week 10**

*Running up hills will increase your body’s workload. Treat each hill as an individual workout and be sure to recover well before starting the next one.*

Session 1 (approximately 50 minutes; hill training)
- Run slow and easy for 10 minutes. Hill training: Run uphill for 1 minute; turn around and jog slowly back down. Repeat hill training 7 times. Run slow and easy for 10 minutes.
- Session 2 (45 minutes)
- Run 45 minutes.
- Session 3 (60 minutes)
- Run 60 minutes.

**Week 11**

Session 1 (52 minutes; interval training)
- Run slow and easy for 10 minutes. Run 2 minutes at medium-fast tempo; recover 2 minutes. Repeat interval training 8 times. Run slow and easy for 10 minutes.
- Session 2 (40 minutes)
- Run 40 minutes.
- Session 3 (50 minutes; hill training)
- Run slow and easy for 10 minutes. Run uphill for 30 seconds; turn around and jog slowly back down. Repeat hill training 12 times. Run slow and easy for 10 minutes.

**Week 12**

Session 1 (55 minutes)
- Run 55 minutes.
- Session 2 (45 minutes; fartlek training)
- Run slow and easy for 10 minutes. Run 30 minutes, increasing your speed to medium-fast for approximately 30 to 45 seconds every 2 to 3 minutes. Run slow and easy for 5 minutes.
- Session 3 (45 minutes)
- Run 45 minutes.
Week 13
Session 1 (35 minutes)
Run 35 minutes.
Session 2 (40 minutes)
Run 40 minutes.
Session 3 (45 minutes)
Run 45 minutes.
Appendix C: Questionnaire

Running Injury Survey This questionnaire is specific running related injuries only! If you are currently experiencing an injury you feel was caused by running but complicated through participation in another sport/activity, please indicate that sport here.

Note: If you are NOT experiencing an injury, please complete entire questionnaire - your input is still valuable!

Runner Profile
-For questions 1 – 6, please check the appropriate box

1. Please indicate how many years you have been running/jogging on a regular basis?

   1 Year
   Or Less
   1 2 3 4 5 6 7 8 9 10+ Years
   1 2 3 4 5 6 7 8 9 10+ Years

2. On a scale of 1 to 10, how would you rate your level of competitiveness (10 being very competitive and 1 being not competitive at all)?

   Not Competitive
   Very Competitive
   1 2 3 4 5 6 7 8 9 10

3. On a scale of 1 to 10, how would you rate your level of physical fitness upon commencement of the In training clinics (1 being extremely out of shape and 10 being extremely fit)?

   Extremely Unfit
   Extremely Fit
   1 2 3 4 5 6 7 8 9 10

4. How many kilometers would you typically run/jog in one week?

   4km or less
   40km or more
   4 8 12 16 20 24 28 32 36 40

5. How many days per week do you run, including your group run with the clinic?

   1 day
   5 days
   1 2 3 4 5

6. Please indicate on a scale from 1 to 10 how well you have recovered from any past injury (1 being haven't recovered at all; affected area is extremely weak and painful and 10 being complete recovery or no past injury at all)

   No Recovery
   Complete Recovery
   At all
   1 2 3 4 5
Training Profile
-For Questions 1 – 7 please check the most appropriate box!

1. How would you define your level of stiffness upon first getting up in the morning?
   - Strong, Severe
   - Pain/Stiffness
   - No pain/injury

2. After you are warmed up for the day, do you experience stiffness or pain in a particular body part/area?
   - Strong, Severe
   - Pain/Stiffness
   - No pain/injury

3. If you currently experience pain or stiffness in a particular body part/area, for how many weeks has your pain or stiffness persisted?
   - 9 or more
   - No pain/injury

4. If you currently experience pain or stiffness in a particular body part/area, is the affected body part/area painful after standing for extended periods of time?
   - Strong, Severe
   - Pain/Stiffness
   - No pain/injury

5. If you currently experience pain or stiffness in a particular body part/area, is the affected body part/area painful after walking on flat even surfaces (e.g. sidewalk or road) for extended periods of time?
   - Strong, Severe
   - Pain/Stiffness
   - No pain/injury

6. If you currently experience pain or stiffness in a particular body part/area, is the affected body part/area painful after walking on flat uneven surfaces (e.g. trails or beach) for extended periods of time?
   - Strong, Severe
   - Pain/Stiffness
   - No pain/injury

7. If you currently experience pain or stiffness in a particular body part/area, is the affected body part/area painful after walking downstairs at a normal pace?
   - Strong, Severe
   - Pain/Stiffness
   - No pain/injury
8. Please complete EITHER A, B, OR C in this question.

- If you have no pain while running please complete Q8a only.
- If you have pain while running but it does not stop you from completing your run, please complete Q8b only.
- If you have pain which stops you from completing your runs, please complete Q8c only.

8a. If you have no pain while running, for how long can you run/jog? (circle one)

<table>
<thead>
<tr>
<th>NIL</th>
<th>1-10 mins</th>
<th>11-20 mins</th>
<th>21-30 mins</th>
<th>&gt;30 mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
<td>14</td>
<td>21</td>
<td>30</td>
</tr>
</tbody>
</table>

OR

8b. If you have some pain while running, but it does not stop you from running, for how long can you run/jog? (circle one)

<table>
<thead>
<tr>
<th>NIL</th>
<th>1-10 mins</th>
<th>11-20 mins</th>
<th>21-30 mins</th>
<th>&gt;30 mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td>20</td>
</tr>
</tbody>
</table>

OR

8c. If you have pain that stops you from completing your run, for how long can you run/jog? (circle one)

<table>
<thead>
<tr>
<th>NIL</th>
<th>1-10 mins</th>
<th>11-20 mins</th>
<th>21-30 mins</th>
<th>&gt;30 mins</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>

9. Are you currently experiencing an injury as a result of running?

No ☐

Yes ☐

If you answered yes, please check the best description of how this injury has affected you. (Please check only one)

- Pain/or stiffness only after running  ☐
- Pain/or stiffness during running, but not limiting distance  ☐
- Pain/or stiffness during running and limiting distance for one week  ☐
- Pain/or stiffness during running and limiting distance indefinitely  ☐
- Pain/or stiffness preventing running for one week  ☐
- Pain/or stiffness preventing running indefinitely  ☐

Thank you for your valued participation!