A PROSPECTIVE SURVEY ASSESSING CAUSATIVE FACTORS, OUTCOME, AND COMPLIANCE WITH TREATMENT IN INJURED RUNNERS AT THE ALLAN McGAVIN SPORTS MEDICINE CENTRE

by

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Abstract

The Allan McGavin Sports Medicine Centre has tracked the trends in running injuries over the past twenty years with three retrospective surveys. Associations of extrinsic and intrinsic factors with certain running injuries were also detailed. Outcome of running injuries and compliance with management has not been studied previously.

The purpose of this thesis was to:

1. track the diagnoses of overuse running injuries and identify changing trends as compared to previous retrospective research conducted at the clinic over the past 20 years
2. assess causative factors related to overuse running injuries, and
3. assess the outcome of overuse running injuries and compliance with treatment by injured runners.

The methodology involved three surveys generated specifically for this study. Injured runners completed one survey at their initial visit to the clinic detailing their injury and usual training program and a follow-up survey assessing their injury outcome and compliance with treatment. Physicians completed a survey at the initial visit detailing injury diagnosis, causes of injury, and suggested management plan.

Over the course of the studies at the Allan McGavin Sports Medicine Centre, there has been an increase in the average age of patients as well as the female to male ratio. This likely can be attributed to the change in population demographics and increased female participation in running, respectively. Changes in injury location and specific diagnoses were described and reasons for the changes were identified.

Errors in training were the most common contributing factors to running injury. Overall, intrinsic outnumbered extrinsic causes. This analysis reinforced the belief that running injuries are multi-factorial.

The outcome analysis suggested that injury status was most likely to improve and least likely to reach pre-injury level or worsen. Cross training ability was more likely to improve and reach pre-injury level and least likely to worsen as compared to running ability.

Correlation analysis of outcome measures with duration of symptoms, injury severity, follow-up interval, and overall compliance to the management plan provided further insight into their importance in running injuries.

Opinions are offered on improving compliance as well as future approaches to compliance and running injury research.

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DEDICATION

This thesis is dedicated to my ever-loving and always present family.

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To mom and dad, providing added motivation to finishing by asking the question "when are you going to finish the thesis?"

To Liam, for his input and timely distractions.

To Rita, thanks for enjoying this time with me.

CHAPTER I INTRODUCTION

Annual incidence of overuse running injuries is estimated to be 65% (Bitomsky, 2001). A running injury is fundamentally defined by a decrease in the ability to run a desired distance. It is generally accepted that a running injury results from any combination of extrinsic and intrinsic factors exceeding an individual's capacity to withstand injury. Extrinsic factors include training methods, training surfaces, and running shoes, while intrinsic factors involve muscle strength, flexibility, and lower extremity malalignment.

Overuse injuries can occur to most tissues (ie. bone, muscle, tendon, ligaments) from the low back to the feet. A diagnosis is based on a clinical assessment (history and physical examination). Investigations are often used to confirm a diagnosis. Treatment of running injuries generally involves three phases:

1. decreasing pain and inflammation
2. restoring muscle flexibility and strength
3. returning gradually to running (Taunton et al., 1987)

The Allan McGavin Sports Medicine Centre has tracked the trends in running injuries over the past twenty years with three retrospective surveys (Clement et al., 1981; Macintyre et al., 1991; Taunton et al., submitted for publication). Associations of extrinsic and intrinsic factors with certain running injuries were also detailed. Outcome of running injuries and compliance with exercise rehabilitation has not been well studied previously.

The purpose of this thesis is to:

1. track the diagnoses of overuse running injuries and identify changing trends as compared to previous retrospective research conducted at the clinic over the past 20 years
2. assess causative factors related to overuse running injuries, and
3. assess the outcome of overuse running injuries and compliance with treatment by injured runners.

CHAPTER II LITERATURE REVIEW

A literature review was used:

1. to discuss risk factors related to running injury and
2. to assess measures of compliance with treatment.

II.1 Factors related to running injury

This section has been submitted for publication. The reference citation is listed below. Johnston CAM, Taunton JE, Lloyd-Smith DR, McKenzie DM, Clement DB. Prevention of running injuries: A practical approach for family doctors. Submitted to Canadian Family Physician.

Family physicians are well-positioned to help their patients initiate health-promoting behaviours. Exercise reduces risk of all-cause mortality, coronary artery disease, hypertension, type 2 diabetes mellitus, stroke, osteoporosis, colon cancer, and breast cancer (Marshall, 2000). Running is an attractive option to many because of its affordability and flexibility.

However, running may cause a musculoskeletal injury and also may exacerbate known or expose latent general medical conditions.

This article focuses only on the prevention of musculoskeletal injuries related to running.

The principles of injury prevention are similar for new and currently active runners. It is generally accepted that a running injury results from any combination of extrinsic and intrinsic factors exceeding an individual's capacity to withstand injury. Extrinsic factors include training methods, training surfaces, and running shoes, while intrinsic factors are muscle strength, flexibility, and lower extremity malalignment. Van Mechelen (1995) identifies a lack of randomized controlled trials addressing the prevention of running injuries. Here, we reiterate the principles of running injury prevention (Clement and Taunton, 1980) and highlight subsequent advances and current controversial areas in the literature. Where no proven practises exist, suggestions are made based on the experience of the physicians at the Allan McGavin Sports Medicine Centre at the University of British Columbia where over 1000 runners have been treated yearly over the past 20 years.

II.1.1 Training methods

We emphasize the relative importance of appropriate training since 60% of all running injuries are the result of doing "too much, too soon" (James et al., 1978). A training program should expose tissues to an appropriately dosed and graduated stress interspersed with adequate rest (usually 24-48 hours). Tissues adapt and strengthen during recovery. Clement (1982) states, "the timing of recovery is just as important as the loading of exercise." Suitable recovery prevents running injuries, which are the result of stresses overloading a tissue's capacity to adapt.

A walk-run program is recommended for patients who have never run or are currently injured and will return to running (Table 1). Medical conditions which contraindicate participation in a running program are discussed by McKenzie (1988). We recommend novice runners run at a pace at which they can converse with no sense of breathlessness (talk test). On off days, cross-training with non-impact exercise is acceptable.

Advanced runners typically want to increase either distance or frequency of their running. No training program is given since the demands of experienced runners are too diverse to address here. Resources available to these patients include running clinics operated through running stores and books with sample training programs (Noakes, 1992; MacNeill, 1999). Unfortunately, training programs are evaluated usually based on a runner's performance and not on the absence of injury. To minimize risk of injury, our general rule is to increase either training volume or intensity in isolation by no more than 10% per week over the previous week's training.

Currently, our clinic is currently investigating the safety of MacNeill's training program. The goal of his 13 week training program is to complete the 10 km Vancouver Sun Run injury-free. The injury rate of all program participants is 30%, ranging from 16-48% among the seventeen clinics.

When implementing a program, common errors that may result in injuries are:

1. accelerating the progress of a program which exceeds the ability of tissues to adapt and
2. not backing down from pain, which is an indication of the body's inability to adapt to stresses placed on tissues.

In summary, a graduated approach should be taken to achieve running goals. We are currently investigating a group of runners enrolled in a "safe" running clinic to make recommendations regarding appropriate training at all experience levels.

II.1.2 Lower extremity malalignment

This section discusses the biomechanics of running and its relation to injury. Also, we examine the use of orthotics and heel lifts as injury prevention measures. McKenzie et al. (1985) speculate that under-appreciation of biomechanical abnormalities represents the single most overlooked factor in the treatment and prevention of running injuries.

There are three common foot arch types: relatively normal feet, pes cavus (high-arched or supinated feet), and pes planus (flat-footed or pronated feet) (Subotnick, 1975) (Figure 1). Pronation and supination are normal phenomena. When they are excessive either in time or magnitude, compensatory rotation occurs in the tibia and stress is further transmitted to the femur and pelvis. This may contribute to foot, ankle, knee, hip or lower back pain in the pronated or supinated runner (McKenzie et al., 1985). An orthotic prescription is intended to promote biomechanical efficiency during the weight bearing stance phase of gait. Muscular activity can then absorb the impact of ground strike and hopefully minimize the risk of overuse injury (Subotnick, 1985). Orthotics were "very effective in providing symptomatic relief of lower extremity complaints". A "high degree of satisfaction" is noted based on the observation that 90% of patients continued to use their orthotics after their symptoms resolved. The outcome is independent of diagnosis and activity level (Gross et al., 1991). Despite considerable previous work, there exists little consensus on correlation of foot type and injury as well as the effectiveness of orthotics in injury prevention or treatment. A recent literature review indicates further standardized research is required (Razeghi and Batt, 2000).

Leg length inequality is a relatively common biomechanical abnormality, which results in a muscle imbalance around a joint contributing to altered stresses within the joint and thus injury. Leg length inequality is characterized as either anatomical (difference in bone length), functional (secondary to a rotated pelvis due to muscle weakness or inflexibility), or environmental (running on banked surfaces) (McCaw, 1992).

Issues related to measuring leg length include 1. the accuracy of tape measure use and landmarks, 2. the lack of sensitivity in cases of structural shortening distal to the malleolus, and 3. inequalities present only when standing. A subjective method involves pelvic tilt assessment: if a leg length difference exists, inserting a heel lift of 5 mm under the short/long leg reduces/exaggerates the pelvic tilt. X-rays and ultrasound are considered more accurate but typically are not used (McCaw, 1992).

Leg length inequalities are more likely to be treated in our clinic if they are greater than 10 mm and associated with signs of skeletal compensation including pelvic tilt, scoliosis, hip and knee joint malalignment, and excessive unilateral pronation (Figure 2).

In summary, the biomechanical assessments of runners should at minimum consist of measuring leg length, determining arch type, and examining wear pattern of their running shoes. The widespread use of orthotics and heel lifts is not supported fully in the literature although it seems plausible that achieving good lower extremity biomechanics may help prevent injury.

II.1.3 Running shoes

Running shoe selection is the initial step in optimizing the patient's running biomechanics (Figure 3). We emphasize that running shoes are unique and distinct from other shoes such as cross-training and court shoes. A foot assessment is essential for selecting the most appropriate running shoe. Shoe features appropriate for different foot types are listed in table 2.

Running in the wrong shoes may adversely affect lower extremity alignment making that individual more susceptible to injury. Predisposing factors include: a shoe that twists easily, insufficient heel height, and a worn or rigid sole (Kvist,1994).

Relatively few papers address the relationship of proper footwear and injury prevention motivating our forthcoming survey of injured runners in our clinic. We are assessing the appropriateness of shoe for foot type and mileage run in the given shoes. Running shoes should be replaced after 500-700 kilometres to prevent loss of their shock absorbing abilities (Fredericson, 1996).

In summary, shoes should be selected to match the runner's feet. Attention should be paid to regularly replacing running shoes at appropriate intervals. Our clinic will characterize the running shoe tendencies of injured runners in an upcoming survey.

II.1.4. Muscle strength and flexibility

Typically, running preferentially strengthens certain muscles. Biomechanics and running styles, especially when patients are returning from injury, may adversely affect this pattern. Muscle inflexibility (Clement et al., 1981) and weakness of the hip abductors (Taunton and Clement, 1980), quadriceps, and the gastrocnemius and soleus group (Clement et al., 1981) have been associated with injury. Johansson (1992) hypothesizes muscle fatigue leads to an inability to sustain impacts resulting in injury to weaker structures. Runners should incorporate both stretching and strengthening programs to prevent injury.

Eccentric strength training (contraction of a lengthening muscle) most closely simulates muscle action during running (Fyfe and Stanish, 1992). Muscle strengthening exercises prescribed in our clinic include the drop squat (Figure 4), heel drop (Figure 5), and hip abduction exercise (Figure 6).

Progression of the drop squat program involves increasing the speed of the drop and adding weights to the patient's hands. Initially, the patient should perform a slow "drop" and return to the starting position in a slow manner. The patient progresses to a quick "drop", where the knees collapse before the quadriceps contract to stop the motion similar jumping from a height and absorbing the impact. The patient should straighten slowly before the next drop. The quick drops are advanced by adding weight to the patient's hands in 5 pound increments up to a 20 pound per hand maximum.

Advancing the heel drop program is achieved by performing them fast enough that at the end of the drop, the patient feels a bouncing motion. A similar sequence of slow to quick drops can then be done on each leg.

In the hip abduction exercise, both sides need strengthening. Initially, done with the ankle unweighted, the program is advanced in 1 pound increments to a 10 pound maximum.

For each exercise, 3 sets of 20 repetitions are done consecutively and daily. After five consecutive days of pain-free exercise, the patient may advance the exercise level. If pain occurs subsequently, then it is important to regress to the previous comfortable level and progress again after two pain-free sessions. After program completion, these exercises should be performed three times per week at their most difficult level as a maintenance program.

Stretching (quadriceps for the drop squat, calf with the knee bent and straight for the heel drop) is recommended after the program.

Clinical evidence suggests there is no improvement of injury rates with a before-exercise stretching program and in fact there be a higher injury rate in those who stretched. The basic science literature suggests stretching damages muscle at the cellular level, decreases the ability of muscle to absorb subsequent forces, and masks muscle pain (Shrier, 1999).

We recommend a series of lower extremity stretches (Figure 7) performed after exercise. Stretches for improving muscle flexibility must generate a stretch sensation not pain.

In summary, muscle weakness and inflexibility patterns are associated with certain running injuries. The lower extremity strengthening and stretching programs outlined above should be incorporated into an overall training program to minimize injury. We emphasize stretching before exercise may in fact increase the risk of injury.

II.1.5 Training surface

Injuries associated with harder training surfaces include patello-femoral pain syndrome and tibial stress syndrome (Clement et al., 1980). Running on loose surfaces is linked to meniscal injuries. Hill running is related to patellar tendinitis and iliotibial band friction syndrome (Taunton et al., submitted for publication). From clinical experience, injuries may occur when rapidly introducing new surfaces (i.e. harder, cambered, or uneven surfaces and hill or track running). In fact, most runners in Canada must run on pavement due to the weather. Similar to our advice regarding training volume, time spent on any new training surface should increase by no more than 10% per week over the previous week's training.

II.1.6 Conclusion

We have attempted to provide a practical guide for the prevention of running injuries. Where the literature is found inconclusive or insufficient, the experience of the physicians at the Allan McGavin Sports Medicine Centre is substituted. Current research at our clinic will further our understanding of injury prevention.

The process of prevention is to optimize each etiologic factor. Still, it is difficult to predict injury because the combination of intrinsic and extrinsic factors which cause injury in one runner may not necessarily do so in another. Injury is often the first sign of fault in a given running program. In this case, the patient should be educated to recognize early symptoms of injury. Then treatment can be initiated and etiologic factors assessed.

By making a patient's running experience as structured and safe as possible we can ensure patients continue their program maximizing the benefits of aerobic exercise, while minimizing the negative consequences of the intervention. Running injury prevention can be summarized as follows:

1. Establish a graduated training program which allows tissues to adapt to the stresses of running,
2. Optimize running biomechanics by using orthotics and heel lifts to correct specific lower extremity malalignments when present,
3. Select running shoes appropriate to the runner's foot type,
4. Emphasize the need to incorporate a lower extremity strength and flexibility program, and
5. Select appropriate surfaces for training and introduce any changes gradually.

II.2 Summary of study design used in running injury research

This brief section summarizes the study designs used in running research instead of describing all the factors determined to be significantly associated with a certain running injury (table 3).

The two main study designs are:

1. descriptive (ie. cross-sectional) – events are described which then leads to hypothesis formulation and
2. analytical (ie. case control, cohort) – groups are compared in order to understand events and test hypotheses. Analytic studies are considered observational where the natural course of events is observed or interventional where an intervention is used.

Descriptive studies constitute the majority of overuse running injury research. It is considered the weakest study design in determining causation. Analytical research is less used in this field and it is interesting to note that randomized controlled trials which are considered the strongest study design have not been used in this area. The strength of an individual study design is also assessed by whether a stronger study design could have been used to answer the same research question. Advantages and disadvantages of each specific study design are listed in table 4.

II.3 Measures of compliance with treatment

Compliance research began thirty years ago with the work of Drs. Haynes, Taylor, and Sackett. Compliance was defined as "the extent to which a person's behaviour (in terms of taking medications, following diets, or executing lifestyle changes) coincides with medical or health advice" (Haynes, 1979). Cegala et al. (2000) emphasized the importance of this research since non-compliance is related to poorer health and financial strain on the health care system.

II.3.1 Quantification of non-compliance

Non-compliance with treatment is shockingly high. Compliance rates have been defined for taking medication, undertaking an exercise program and attending scheduled appointments. Patients were compliant with medication for an acute symptomatic problem in 75-80% of cases (Sackett and Snow, 1979; Sherbourne et al., 1992). Compliance with medical management for chronic disease varies depending on:

1. whether the patient is symptomatic (50%) or asymptomatic (30%) and
2. the time at which compliance is measured (94% after 1 year to 34% after 3 years) (Sackett and Snow, 1979; Sherbourne et al., 1992).

Pollock et al. (1991) commented that compliance with aerobic training studies in relatively healthy, older individuals was approximately 70%. Exercise programs initiated by sedentary individuals to improve their general health were stopped by approximately 50% of participants after 6 months (Robison and Rogers, 1994). Compliance with scheduled appointments was higher when initiated by patients (75%) than by doctors (50%) (Sherbourne et al., 1992). Literature was not found involving the compliance of runners to a rehabilitative exercise program.

II.3.2 Models of non-compliance

Several theories exist to explain non-compliant behaviour. Gordis (1979) categorized non-compliance as:

1. intent not to follow treatment and
2. factors other than intent not to follow treatment

One health belief model states that four factors increase the likelihood of a patient acting on treatment recommendations:

1. not following treatment has the potential for negative consequence,
2. potential consequences of not following treatment are serious,
3. benefits of following treatment outweigh the disadvantages, and
4. treatment is considered effective (Becker and Maiman, 1975).

Chao et al. (2000) summarized the unique challenges of prescribing physical activity in the context of health promotion:

1. More individual time and effort is required to learn and implement a training program.

2. In contrast to the perceived necessity and effectiveness of medication, exercise is "viewed not as preventive or therapeutic but recreational".
3. Health care professionals often provide non-specific instruction in terms of frequency, intensity, type, and amount of exercise. This may be partly based on the lack of consensus in the literature
4. There is no perceptible negative consequence to stopping exercise.

Other compliance predictors include previous non-compliance, distress about health, use of avoidant coping strategies, younger patients, and self-motivation which is considered unchanging (Sherbourne et al., 1992; Hartigan et al., 2000).

II.3.3 Issues related to compliance research

Sackett and Snow (1979) made a number of suggestions to optimize the reliability of measured compliance rates. Clear definitions of compliance and the appropriate study design should be used to answer the research question. Data collection must even include the least compliant patients who will most likely miss follow-up. Data analysis should consider the effect of patient characteristics on compliance. In addition, consideration should be given to measuring compliance over the course of follow-up.

II.3.4 Outcome measures used

Direct measures of compliance such as attendance at training and testing sessions are commonly used (Hartigan et al., 2000; Lee et al., 1996; Pollock et al., 1991). Robison and Rogers (1994) suggested that levels of compliance can be based on fulfillment of predetermined goals such as ratio of sessions attended to sessions planned to attend. Patients may also provide a self-assessment of their own compliance.

Sackett and Snow (1979) described the use of an outcome as an indirect measure of compliance. This applies only if the treatment being studied is the only variable that can mediate the outcome. Problems arise if multiple treatments are used or if there is an effect of external factors such as socio-economic status or cultural background on outcome. Both direct and indirect measures have been used simultaneously (Cegala et al., 2000; Hartigan et al., 2000; Lee et al., 1996).

Of the compliance tools reported in the literature, the most appropriate for this project was that used by Cegala et al. (2000). This tool was based on the premise that non-compliance is unintentional or intentional. Recall of treatment was used to measure the degree of unintentional non-compliance. Intentional non-compliance was assessed by having patients indicate their level of agreement with reasons for non-compliance. The validity of the results were optimized by asking questions in a non-threatening way and using an independent source for gathering the results.

Self-report measurements are defined as "replies given by subjects in response to … questionnaires" (Cozby, 1985). These measures are considered most appropriate when evaluating varied forms of treatment simultaneously (Cegala et al., 2000). Factors affecting self-report responses include degree of self-awareness (lack of insight, self-deception), recall (recent, frequent, preferred), and response sets (social desirability, malingering, acquiescence, nay-saying, deviation), data interpretation, and self-monitoring. Issues related to social desirability, question design, and anonymity are felt to influence the validity of the results.

II.4 Summary and rationale for study

The literature clearly illustrates the prevalence and type of running injuries in certain sample populations. The Allan McGavin Sports Medicine Centre has tracked the changes in running injuries over the past twenty years. Some studies attempt to define the factors that are most responsible for a given injury. Study design has been predominantly cross-sectional though some case-control and cohort studies exist. Observation at our clinic suggests most injured runners are able to rehabilitate themselves so that they can return to running. Literature in this area is lacking.

With this project, it is intended to:

1. track the diagnoses of running injuries and comment on their evolution over the past twenty years,
2. identify factors associated with specific running injuries, and
3. assess the outcome of the injury and compliance with treatment by injured runners.

Table 1: Sample Walk-Run Program

Week	Monday	Wednesday	Friday
1	10 minute walk	20 minute walk	30 minute walk
2	6x (4.5 minute walk + 0.5 minute run)	6x (4 minute walk + 1 minute run)	6x (3.5 minute walk + 1.5 minute run)
3	6x (3 minute walk + 2 minute run)	6x (2.5 minute walk + 2.5 minute run)	6x (2 minute walk + 3 minute run)
4	6x (1.5 minute walk + 3.5 minute run)	6x (1 minute walk + 4 minute run)	6x (0.5 minute walk + 4.5 minute run
5	30 minute run	30 minute run	30 minute run

The walk-run program is started after a patient has demonstrated the ability to walk 30 minutes consecutively without injury 3 times per week on alternate days. The goal is to run pain-free 30 minutes 3 times per week. It involves a total activity period of 30 minutes structured into 6 sets of 5 minutes on alternate days. In each set, there is a combination of running and walking where the run component is increased after each session by 30 seconds.

Table 2: Shoe features appropriate for different foot types (Brukner and Khan, 1999)

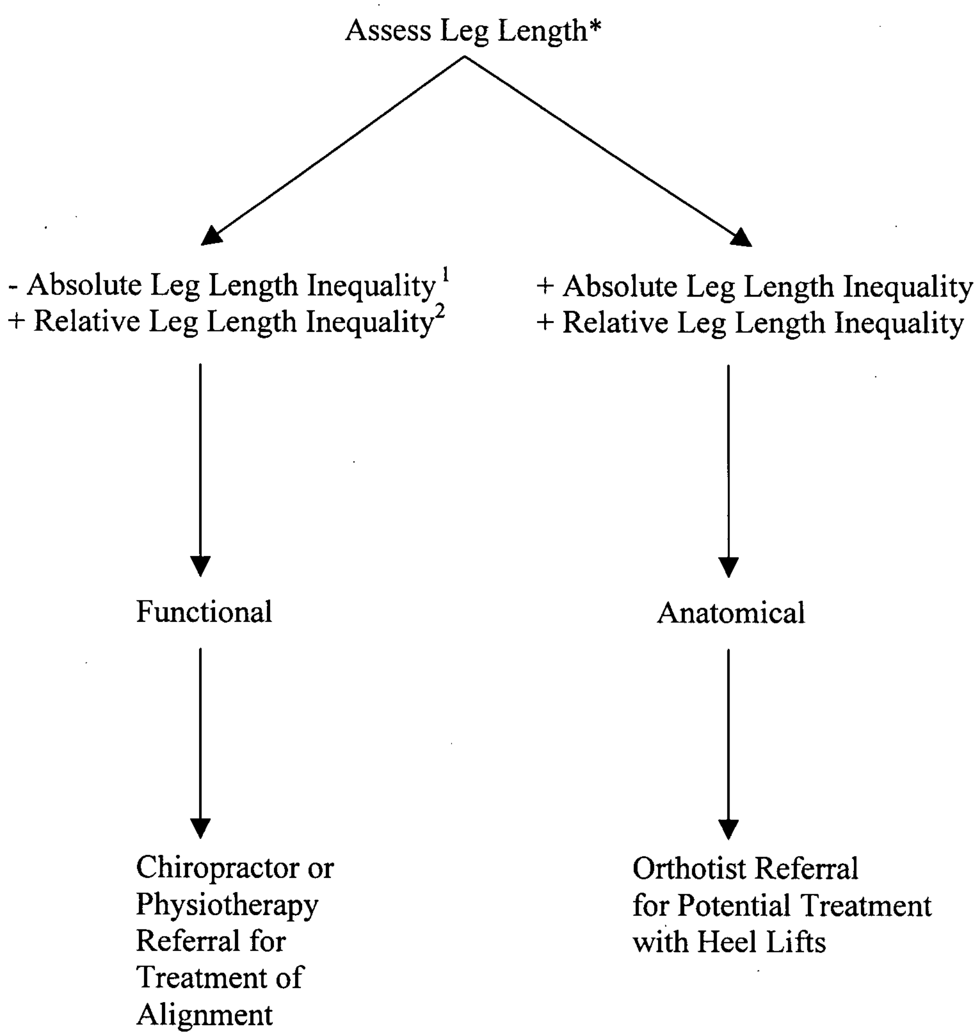
Shoe features	Excessive pronator	Normal	Excessive supinator
Heel counter	Rigid	Rigid	Rigid
Forefoot flexibility	Yes	Yes	Yes
Midsole density	Hard dual density	Intermediate	Soft
Last construction	Combination	Slip or combination	Slip
Shape of last	Straight or slightly curved	Slightly curved	Curved or slightly curved

Figure 1a: Normal foot type

Figure 1b: Pes planus (pronated) foot type

Figure 1c: Pes cavus (supinated) foot type

Figure 2: Treatment of leg length inequalities



* Treatment of leg length difference is dependent on clinical scenario including the presence of musculoskeletal symptoms and signs of skeletal compensation

[1]Absolute leg length = distance from anterior superior iliac spine to medial malleolus

[2]Relative leg length = distance from umbilicus to medial malleolus

Figure 3: Shoe selection based on foot assessment

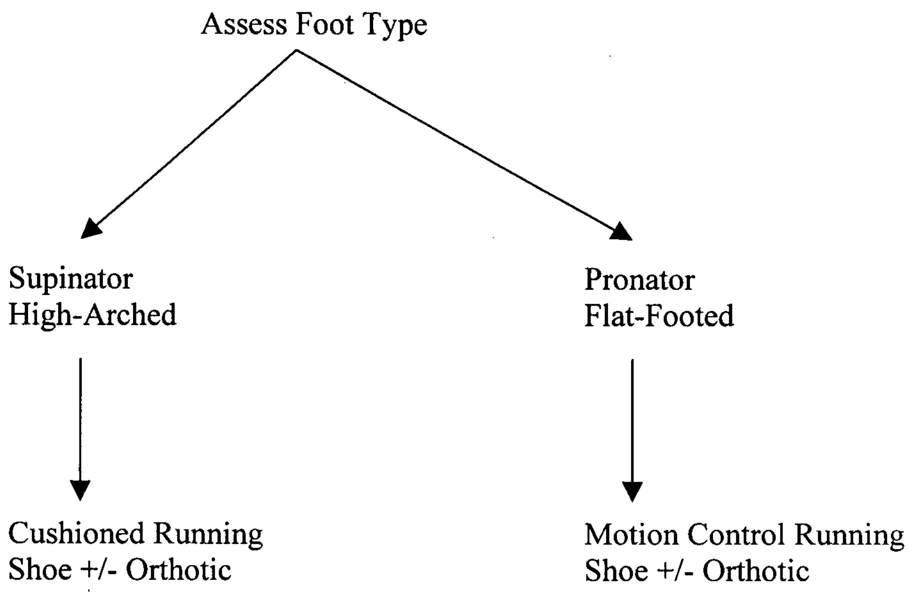
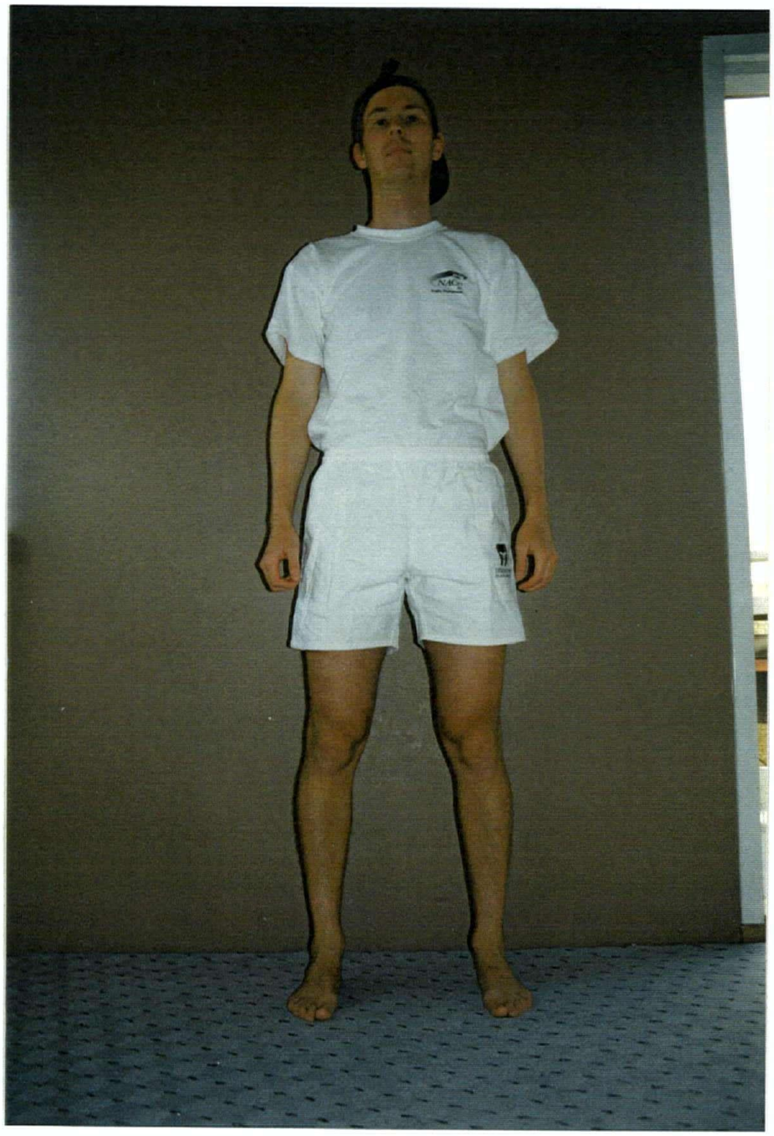


Figure 4a: Drop squat start position

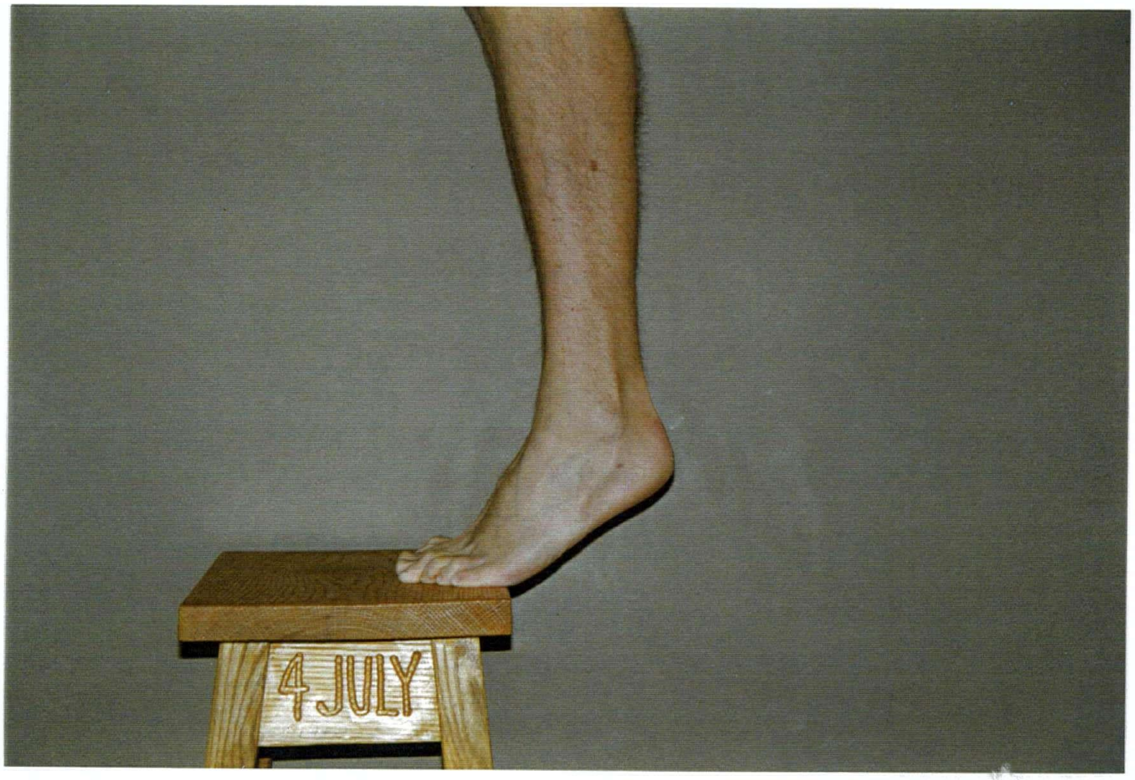


Start position: Feet should be shoulder width apart with kneecaps directly over the second toe.

Figure 4b: Drop squat finish position

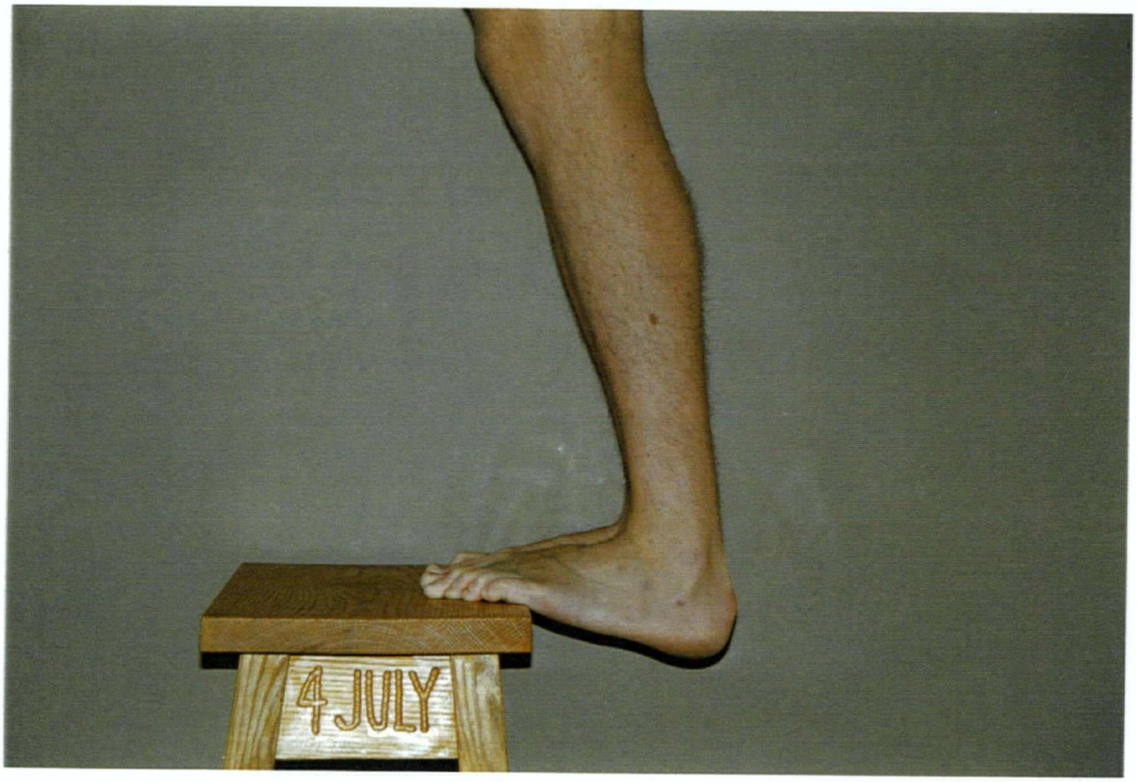
Finish position: The depth of squat should be between 45-75 degrees in a comfortable position. The patient should feel tightening of a working vastus medialis obliquus. If not, the knee may not be in a neutral position but instead be in a valgus or varus position.

Figure 5a: Heel drop start position



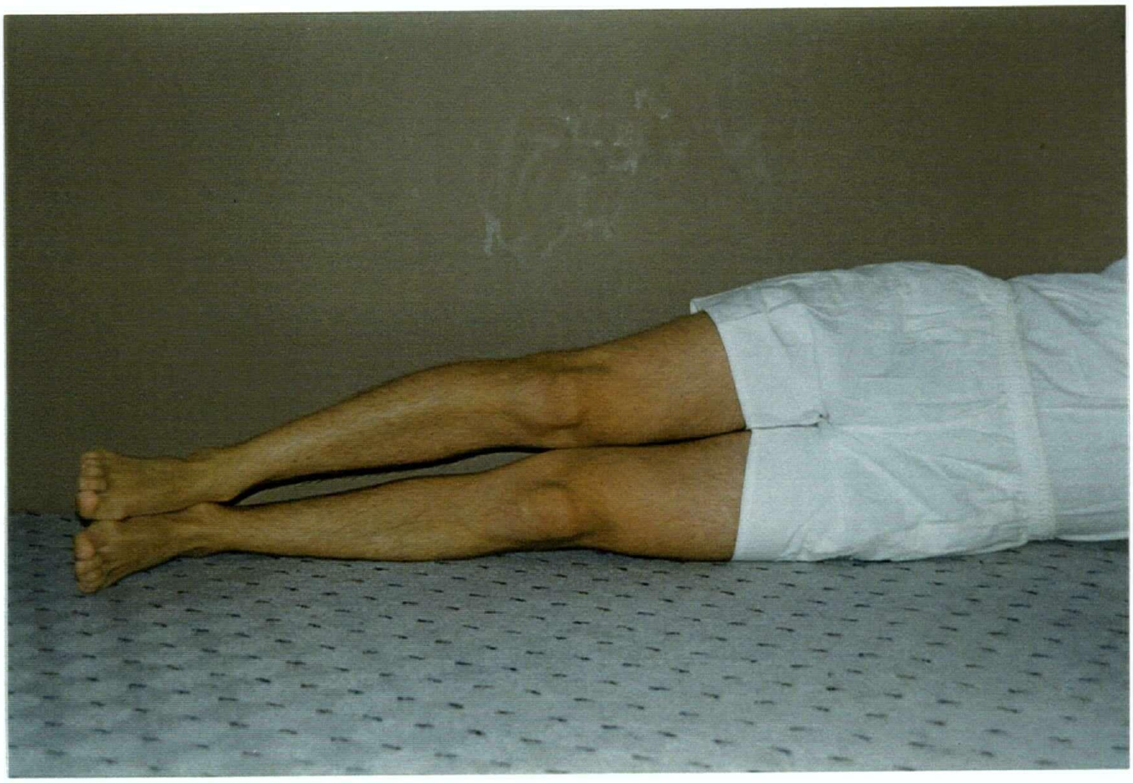
Start position: Feet should be shoulder width apart with kneecaps directly over the second toe and only the toes and balls of each foot resting on the step. It is essential to ensure that the toes are pointing straight and not off to one side.

Figure 5b: Heel drop finish position



Finish position: After reaching maximum plantar flexion, the patient lowers their heels to the maximum dorsiflexed position below the level of the step.

Figure 6a: Hip abductor strengthen start position



Start position: The patient is done in a side-lying position with the leg to be strengthened on top.

Figure 6b: Hip abductor strengthen finish position

Finish position: The leg to be strengthened is abducted between 30-45 degrees in a comfortable position.

Figure 7: A lower extremity stretching program

When the "stretching" sensation is achieved the position is maintained for 30-60 seconds. This is done a total of three times per stretching session. These stretches can be done on a daily basis provided the muscles are "warmed up".

Figure 7a: Quadriceps stretch

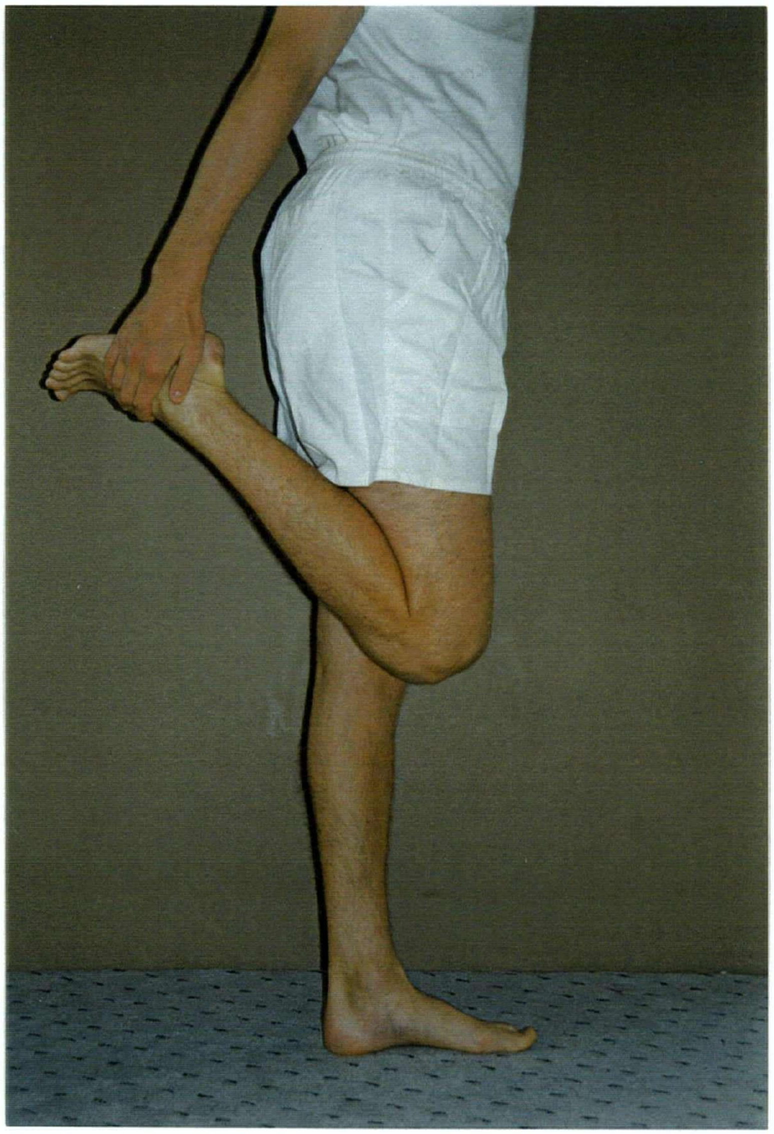


Figure 7b: Hamstring stretch

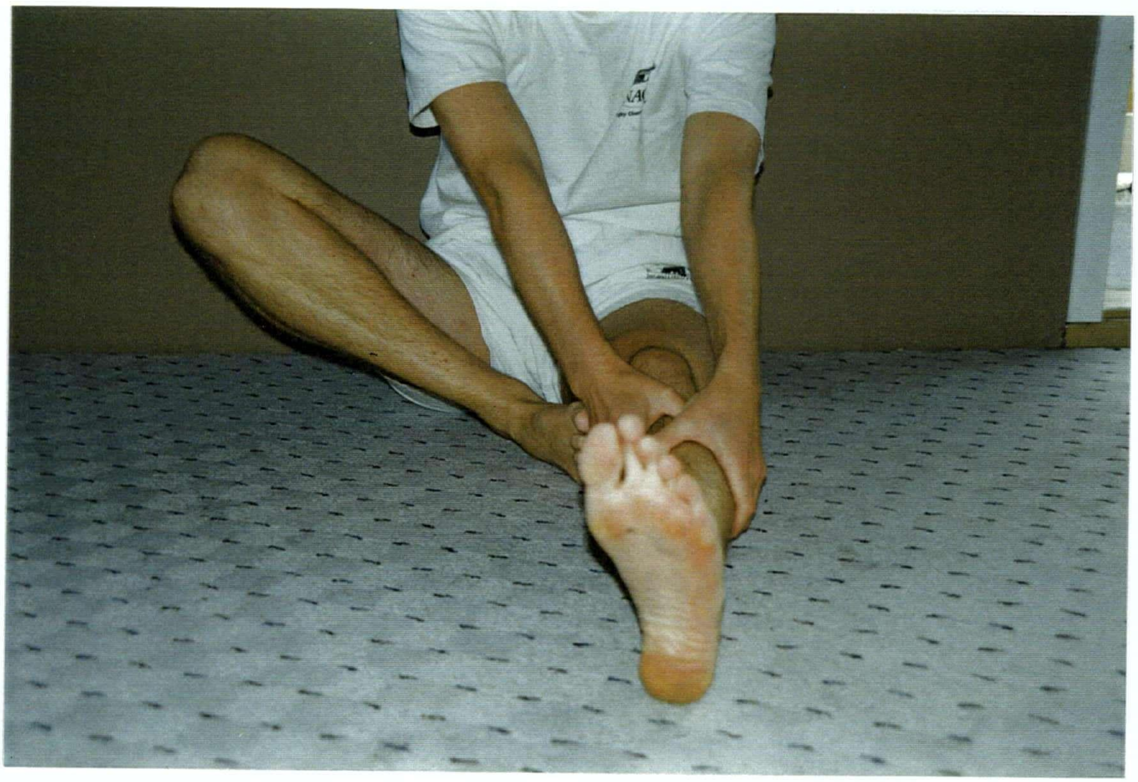


Figure 7c: Groin stretch

Figure 7d: Iliotibial band stretch

Figure 7e: Calf stretch – straight knee

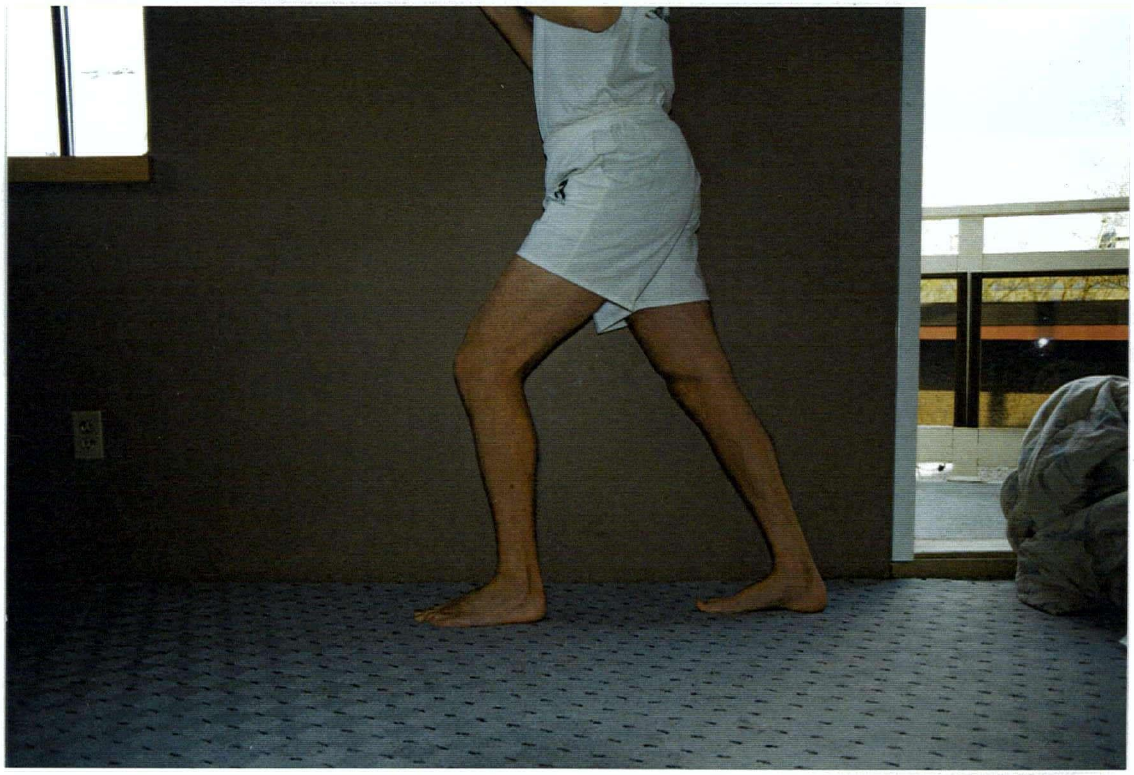


Figure 7f: Calf stretch – bent knee

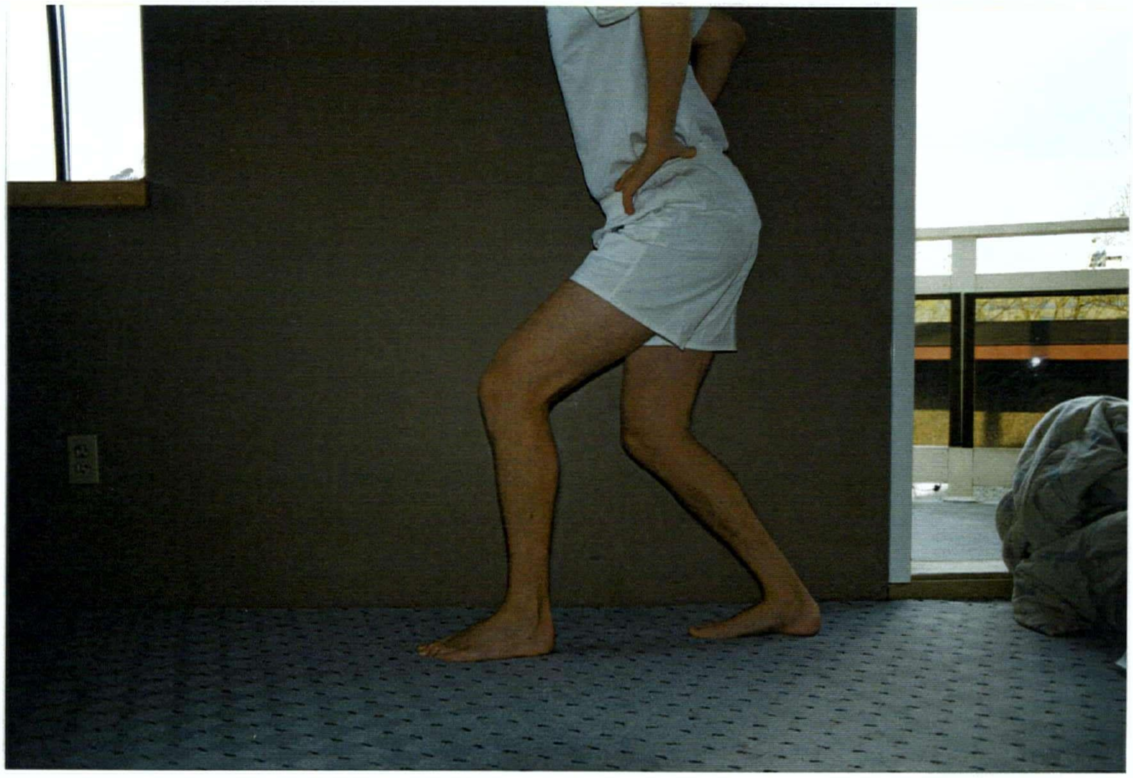


Table 3: Original research investigating factors related to running injury

First author, year	Title	Study type
Brunet, 1990	A survey of running injuries in 1505 competitive and recreational runners	cross-sectional
Clement, 1981	A survey of overuse running injuries	cross-sectional
Jacobs, 1986	Injuries to runners: A study of entrants to a 10,000 meter race	cross-sectional
Kretsch, 1984	1980 Melbourne marathon study	cross-sectional
Macintyre, 1991	Running injuries: A clinical study of 4173 cases	cross-sectional
Marti, 1988	On the epidemiology of running injuries: The 1984 Bern Grand-Prix study	cross-sectional
Taunton, submitted for publication	An analysis of running injuries: The Vancouver Sun Run	cross-sectional
Taunton, submitted for publication	A prospective study of running injuries: The Vancouver Sun Run training clinics.	cross-sectional
Taunton, submitted for publication	A retrospective analysis of 2002 running injuries	cross-sectional
McQuade, 1986	A case- control study of running injuries: Comparison of patterns of runners with and without running injuries	case-control
Van Mechelen, 1993	Prevention of running injuries by warm-up, cool-down and stretching exercises	case control
Lun, 2000	The incidence of running injury and its relationship to lower limb alignment in recreational runners	cohort
Lysholm, 1987	Injuries in runners	cohort

Macera, 1989	Predicting lower-extremity injuries among habitual runners	cohort

Table 4: Advantages and disadvantages of study designs used in running injury research

Study design	Advantages	Disadvantages
Cross-sectional	• Easy to do • Useful for hypothesis generation	• Does not offer evidence of temporal relationship between risk factor and disease (not assessed in same individual) • Not useful for hypothesis testing
Case control	• Easy to do, cheap • Can study many risk factors • Good for studying rare diseases	• Estimate of relative risk • Recall bias • Selection of controls difficult • Temporal relationship unclear • Only study one disease outcome at a time
Cohort	• Retrospective, prospective possible • Relative, absolute risks can be calculated • Good to study rare risk factors	• Time consuming, costly • Study only risk factors measured at beginning • Study only common diseases • Require greater numbers • Potential for lost follow-up

Deber et al., 1997

CHAPTER III METHODS

III.1 Survey content

A three-part survey was used in this study:
Part 1 involved the runner detailing the duration and severity of their current injury, other recent running injuries, demographics, and extrinsic factors related injury (ie. training methods, shoes, and training surfaces) (appendix 1).
Part 2 was a physician assessment of the runner's biomechanics, diagnosis, and treatment plan (appendix 2).
Part 3 detailed a runner's self-assessment of whether their injury improved or worsened and their compliance to the treatment plan (appendix 3).

III.2 Subject recruitment

An introduction letter with inclusion criteria and part 1 of the survey questionnaire (appendix 1) were given to all patients who presented with a new injury to the Allan McGavin Sports Medicine Centre. Patients self-selected themselves for this study if any one of the following inclusion criteria applied:

i. experience symptoms (includes pain, stiffness, numbness, tingling, weakness) during or immediately after a run
ii. experience symptoms within the time span of starting a new run program
iii. reduce your mileage, stop running or seek medical advice due to your symptoms
iv. feel your symptoms are related to running.

III.3 Timing of survey administration

The subjects completed part 1 of the survey prior to the sports medicine physician's assessment. Part 2 was done by the physician during his initial assessment. Part 3 was given to the patient at their next visit, prior to the physician's assessment. If the patient did not return for follow-up, the patient was telephoned and asked if they would answer the same questions over the phone.

Exclusion from the final data analysis occurred if any of the three parts of the survey were incomplete.

III.4 Item generation

After establishing the goals for each part of the survey, questions were generated *de novo* where there was no guidance from previous running-related surveys.

III.5 Item reduction

Prior to the implementation of the survey, a group of injured runners, the physicians at the sports medicine centre, the survey designer, an epidemiologist, and a statistician judged the appropriateness of the questions.

III.6 Response coding

Responses to questions predominantly included restricted or closed forms (parts 1 and 2) and likert scaling (part 3). The scales detailed by Cegala et al. (2000) and Sherbourne et al. (1992) were used in this study. The advantages and disadvantages of each method have been well described (Neutens and Rubinson, year).

III.7 Validity and reliability

The patient-directed questionnaires were piloted with injured runners to ensure the questions were clear and understandable. This process was also conducted for the physician-directed survey with each clinic physician. Reliability was guaranteed by the process of reviewing physician notes after the runner assessment to ensure that the chart information corresponded with the physician survey response.

III.8 Ethics approval

Ethics approval was obtained from the University of British Columbia Ethics Committee (B01-0233). Informed written consent was obtained for all participants prior to their participation in this study. All results were kept confidential.

III.9 Statistics

Appropriate descriptive statistics will be used to summarize the survey responses. A Spearman's correlation test will be used when comparisons between the outcome and compliance are made in those patients who did and did not return.

CHAPTER IV RESULTS

In the six month study period, 230 injured runners were assessed at the Allan McGavin Sports Medicine Centre. Sample sizes for each survey question and are reported as (n=number of respondents). Percentages apply to the number of respondents for each question.

IV.1 Characteristics of injured runners

Patient demographics are summarized in table 5. Females constitute a greater portion of the injured runners. Female subjects are on average younger than the male subjects. 54% of the runners (n=228) had a running injury previously, 19% had their past injury in the same area of the body as the current injury, and 10% did not have the symptoms of their past injury in the same area of the body resolve before the current injury. Grading of the current injury's worst stage is in figure 8. Over half of cases reduced or stopped their running activity as a result of the symptoms of their injury. Symptoms were present a mean of 28.1 $\pm$ 49.7 weeks (median 16, mode 8, range 1-560 weeks) (n=223) prior to their initial visit. Excluding nineteen individuals who presented with symptoms lasting more than one year, symptoms were present a mean of 18.3 $\pm$ 14.1 weeks prior to their initial visit. Almost all candidates rate themselves in "excellent" (50%), "very good" (35%) or "good" (13%) health (n=229).

Shoe preferences and their use are in figures 9-10. Asics, New Balance, and Nike account for almost three quarters of all running shoes used by injured runners. Over 80% of injured runners have used their shoes up to 600 kilometres and 9 months.

91% of respondents run between 5-64 km per week (figure 11). For each run, most respondents run 0-15 km (89%, n=222) for 0-90 minutes (92%, n=216). 46% (n=218) incorporate a long run into their weekly program. Over half of the respondents (n=220) run 3-4 times per week. Time in the current training program and total years running are in figure 12-13. Approximately a third of injured runners had been involved in their training program for over 7 months and 40% had been running for up to 5 years. Stretching is done "almost always" (68%) and "sometimes" (25%) (n=227). This occurs before (66%) and after (77%) a run and not so much during a run (18%). A profile of training surface preferences is in figure 14. The training surfaces used in order of popularity from highest to lowest are hard, uphill, downhill, soft, and track. Runners consider their level to be "recreational" (73%, n=228). The cross-training habits and percentage of time spent running related to total activity are characterized in figures 15-16. The spectrum of running involvement from being the sole activity to being one of many activities is evenly distributed among the study subjects. Walking, weight-training, and cycling are the most commonly preferred cross-training activities.

IV.2 Type and cause of running injuries

All provisional running injury diagnoses are listed in table 6. 268 running injuries comprising 47 diagnoses are present. The study did not allow for changes in the provisional diagnosis. Patellofemoral pain syndrome is the most common injury (40 cases, 13.5% of all running injuries) with equal distribution among males and females (20 cases each). Causes of running injuries in general as determined by the physician assessment are in figure 17. Errors in training were the most commonly identified cause of running injury. Causes of specific running injuries are detailed in table 7. The average number of causes per running injury is 2.3 ± 1.8. Patellofemoral pain syndrome has a mean of 2.3 ± 1.6 causes with the most common being training errors (18 cases or 45% of all cases with this condition) or related to alignment (17 cases or 43% of all cases with this condition).

IV.3 Investigations and treatment used in the management of injured runners

The total number of investigations and treatment suggested by physicians at Allan McGavin Sports Medicine Centre and the compliance of patients with them are in figures 18-21. The most commonly ordered investigations in order of decreasing frequency include x-ray, bone scan, ultrasound, gait analysis, and MRI. The most commonly suggested treatments in order of decreasing frequency include stretching and strengthening exercises, activity modification, gradual return to running, medication, ice, orthotics, and physiotherapy. The number of investigations ordered per patient was 1.0 ± 1.0 (range 0-4). The number of treatment options suggested per patient was 3.1 ± 1.4 (range 0-7).

IV.4 Follow-up of injured runners

Of the 230 patients who participated in the initial survey, follow-up surveys were obtained in 101 patients. Of the other 129 patients not assessed in the follow-up survey, the survey process was initiated after physician follow-up had occurred in 76 cases, 44 cases involved repeated telephone, email and fax contact to which there was no response, 6 could not be contacted by telephone or mail, and 3 declined participation.

Follow-up occurred at a mean of 15.3 ± 10.6 weeks (median 12, mode 4, range 2-44 weeks). 55 patients were seen in follow-up by a physician at the clinic. 46 patients responded to follow-up via mail, fax or email after telephone contact. Reasons for not returning to the clinic on follow-up are listed in table 8. Almost half of these reasons were because the injury had "improved enough or completely."

IV.4.1 Outcome of running injuries

Outcome was defined by responses to questions on the status of their injury as well as the ability to run and cross-train compared to the pre-injury level. The responses are graded using a five point Likert scale and are presented in figures 22-24. Over 60% of respondents noted improvement of the outcome measures as defined by measures 4 and 5 on the Likert scale.

IV.4.2 Compliance of injured runners with investigations and treatment suggested

Overall, patient compliance with the physician management plan (investigations and treatment) is in figure 25. Compliance with specific features of the investigations and treatment options is depicted in figures 18 and 20. Non-compliance with investigations in decreasing frequency was nerve conduction studies, bloodwork, gait analysis, x-ray, bone scan, and CT scan. Non-compliance with treatment in decreasing frequency was changing shoes, brace, gradual return to running, orthotic, medication, referral, ice, physiotherapy, activity modification, as well as stretching and strengthening exercises. Reasons for non-compliance with specific aspects of the management plan are described in table 9. This analysis was confounded by the fact statements of non-compliance were attached to a patient's management plan and not necessarily its individual components. In the case of x-ray, two respondents stated that non-compliance was due to having a "hard time doing what the doctor suggested". This comment may not be applicable to x-ray since it was only one aspect of a two part management plan in one case and a four part management plan in another case.

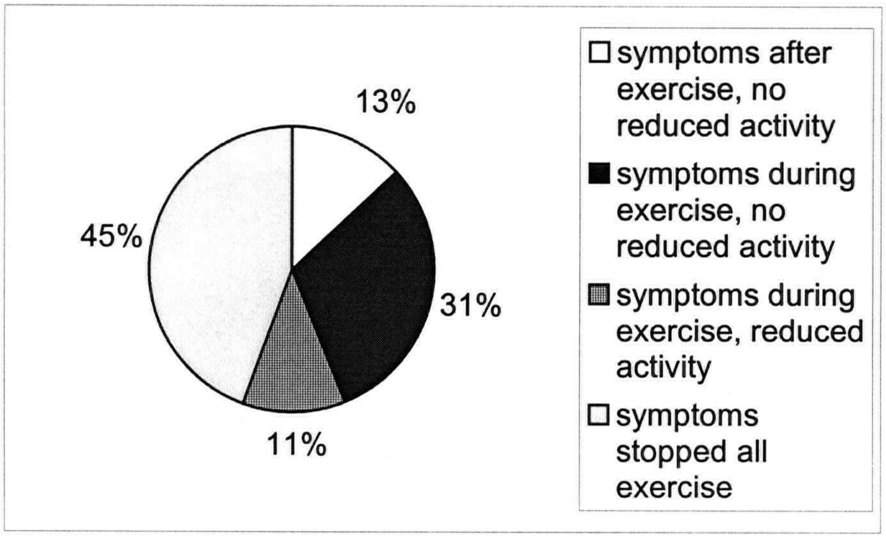
IV.5 Analysis of factors related to outcome

In an attempt to define features related to patient outcomes, several Spearman's correlation analyses are conducted and presented in table 10. Symptom duration at initial visit was significantly correlated with injury status (-.193, .056) (correlation coefficient, probability value), running ability (-.239, .017), and cross-training ability (-.252, .012) at follow-up. Time to follow-up was significantly correlated with running ability (.636, 0), and cross-training ability (.636, 0) at follow-up. Compliance with management plan at follow-up was significantly correlated with running ability (-.232, .023).

Table 5 Demographics of injured runners assessed at the Allan McGavin Sports Medicine Centre

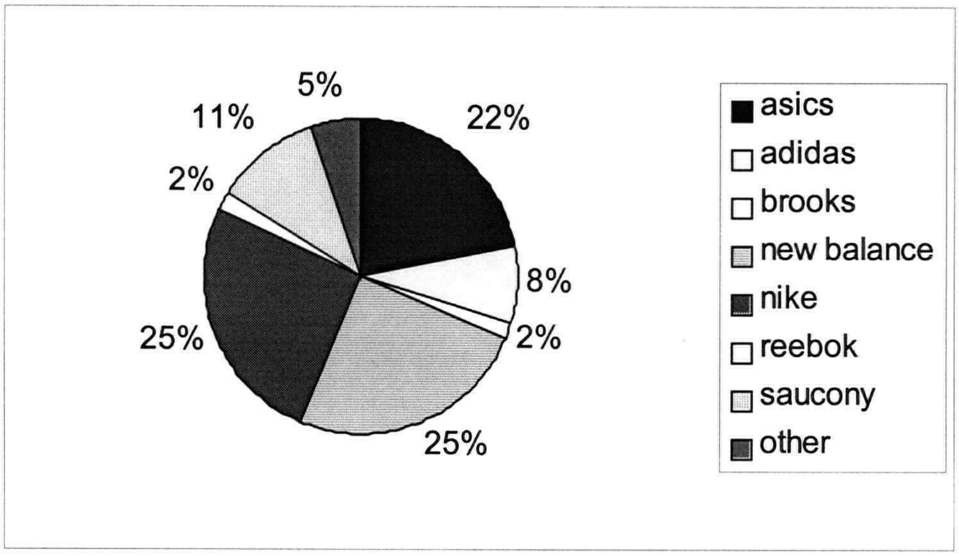
Gender	Age	Height	Weight
Male (n=101)	40.1 ± 14.6 (n=98)	70.5 ± 2.9 (n=101)	176.3 ± 27.2 (n=101)
Female (n=129)	36.8 ± 10.8 (n=127)	65.2 ± 2.6 (n=129)	132.9 ± 17.9 (n=126)

Figure 8 Level of disability in injured runners at the Allan McGavin Sports Medicine Centre



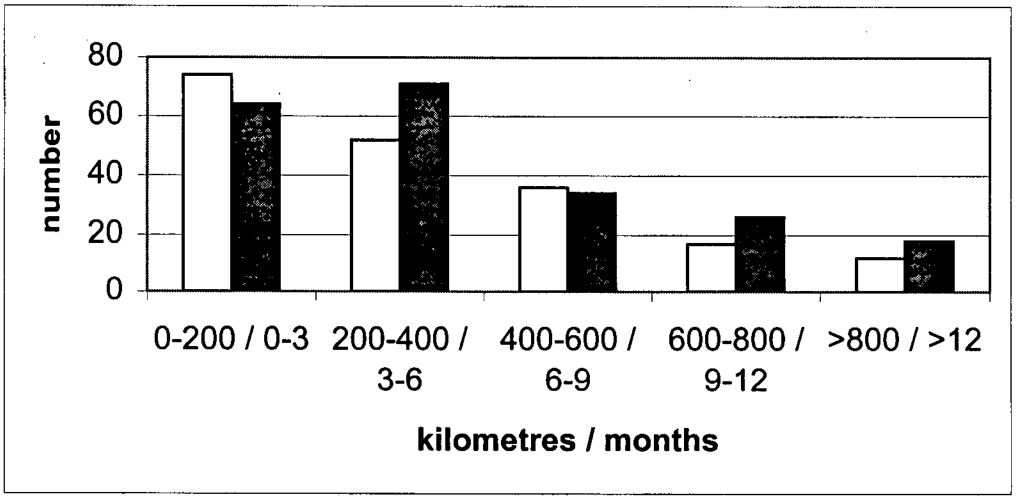
n = 227

Figure 9 Shoe preference of injured runners at the Allan McGavin Sports Medicine Centre



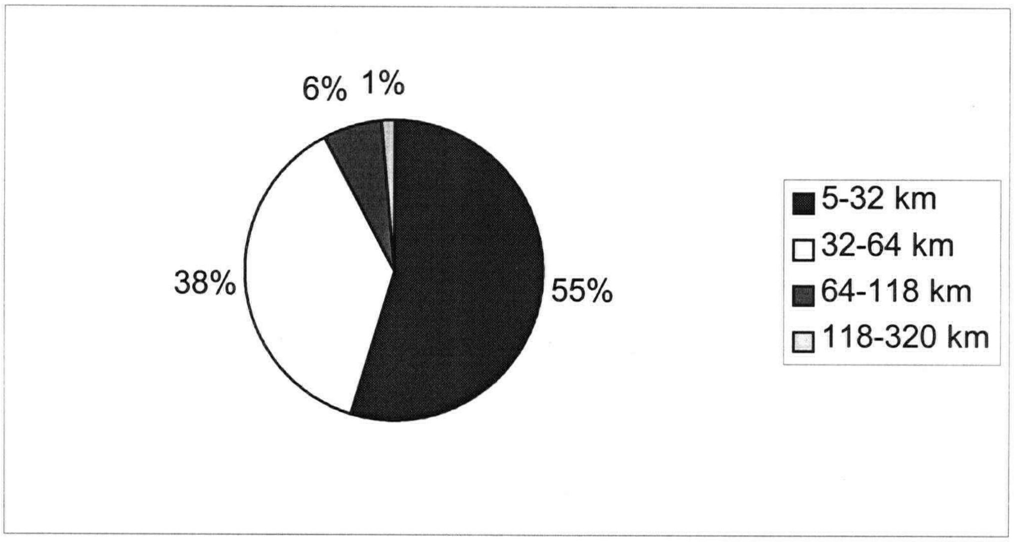
n = 223

Figure 10 Shoe use of injured runners at the Allan McGavin Sports Medicine Centre



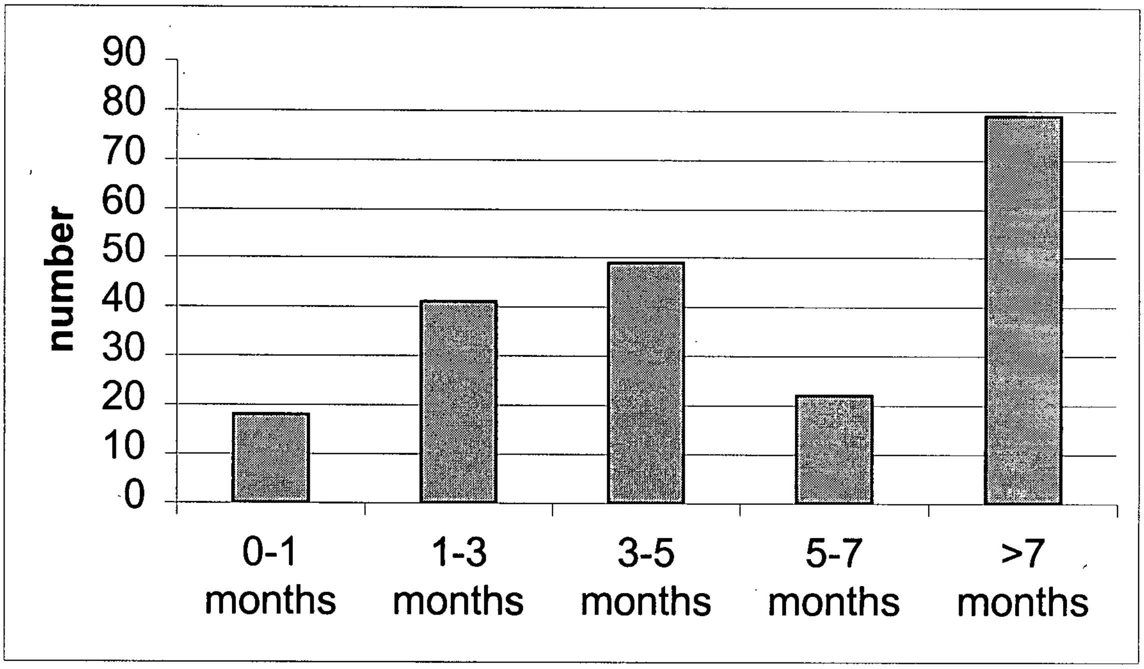
n = 195, 217

Figure 11 Weekly distance of injured runners at the Allan McGavin Sports Medicine Centre



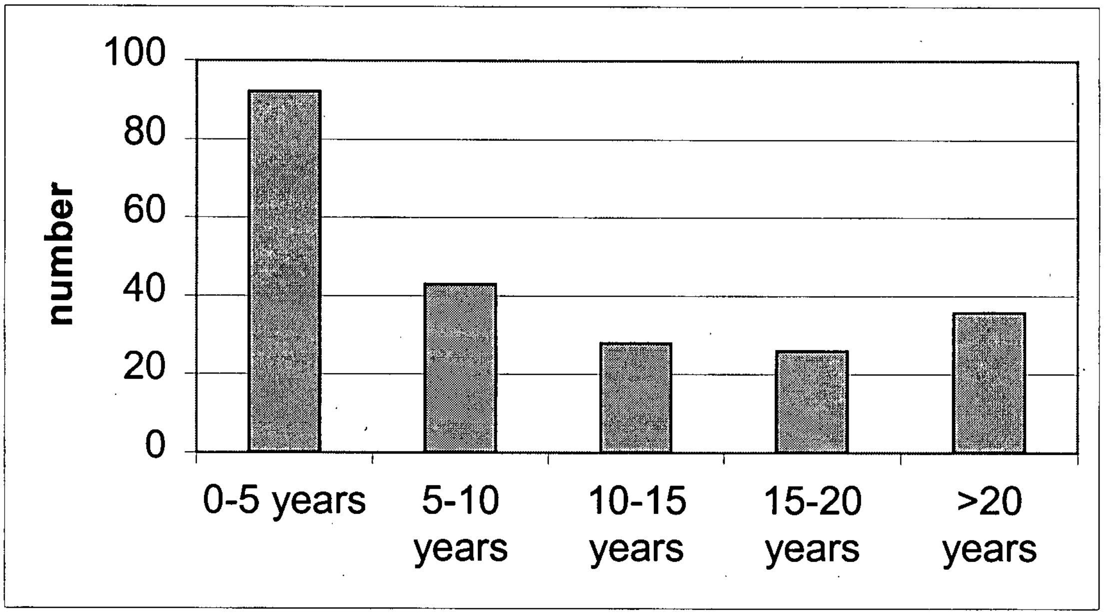
n = 226

Figure 12 Duration of current training programs of injured runners at the Allan McGavin Sports Medicine Centre



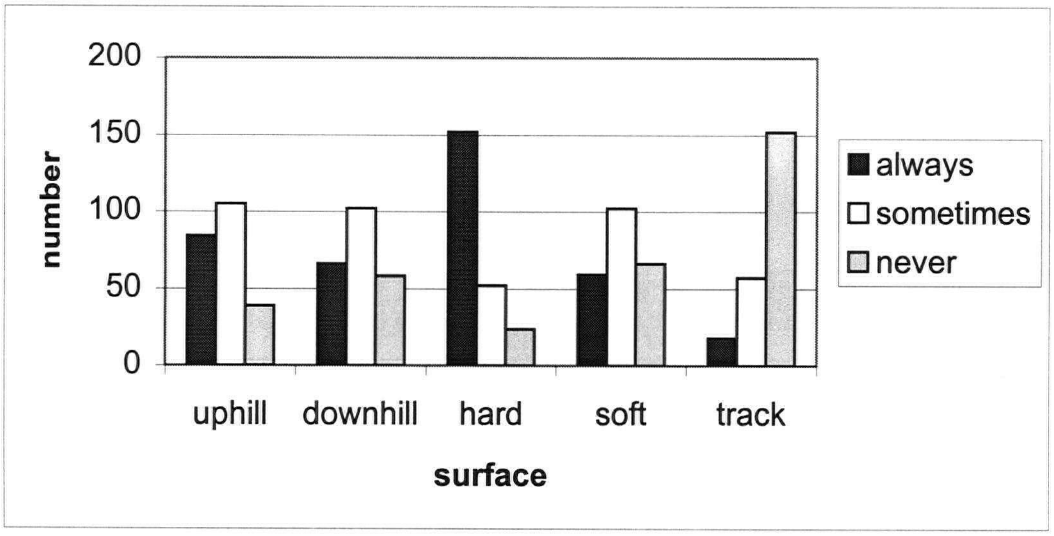
n = 209

Figure 13 Total years running of injured runners at the Allan McGavin Sports Medicine Centre



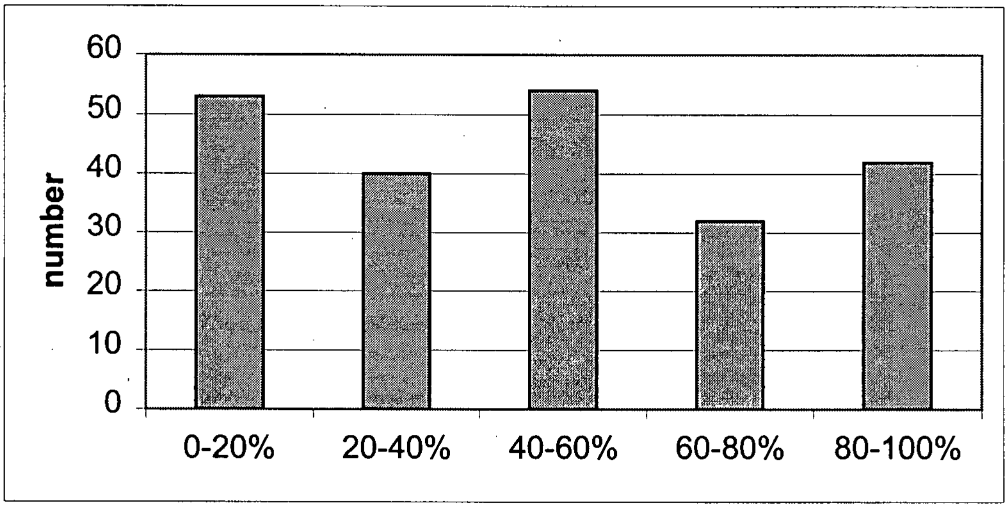
n = 225

Figure 14 Training surface preferences of injured runners at the Allan McGavin Sports Medicine Centre



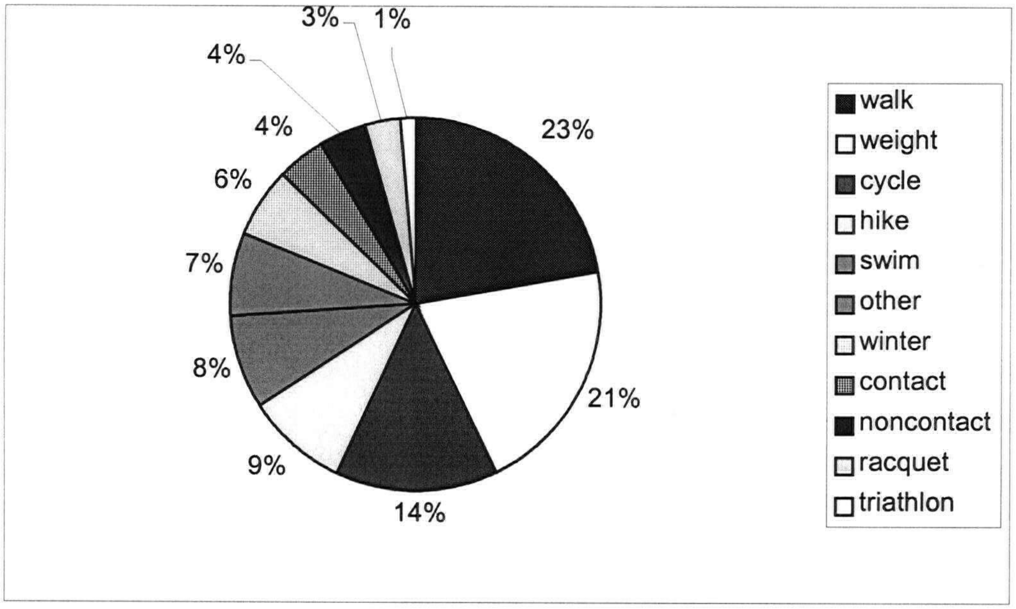
n = 228, 226, 228, 227, 227

Figure 15 Time spent running as part of total activity by injured runners at the Allan McGavin Sports Medicine Centre



n = 221

Figure 16 Preferred cross activities of injured runners at the Allan McGavin Sports Medicine Centre



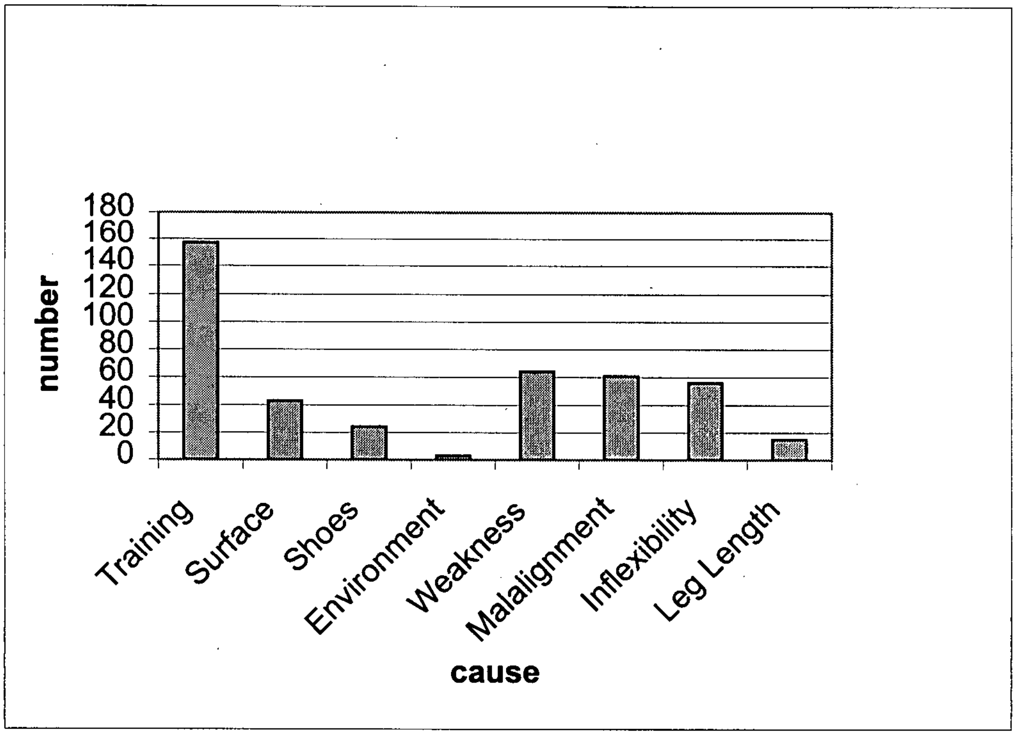
n = 230

Table 6 Diagnoses in injured runners at the Allan McGavin Sports Medicine Centre

Diagnosis	Total (male, female)	Percentage
KNEE		
Patellofemoral pain syndrome	40 (20,20)	13.5
Iliotibial band friction syndrome	36 (11,25)	12.1
Medial meniscus injury	22 (15,7)	7.4
Patellar tendinopathy	18 (10,8)	6.1
Lateral meniscus injury	3 (2,1)	1.0
Pes anserine tendinopathy	3 (2,1)	1.0
Knee osteoarthritis	2 (0,2)	0.7
Quadriceps insertion tendinopathy	1 (1,0)	0.3
Popliteus strain	1 (0,1)	0.3
LOWER LEG		
Achilles tendinopathy	16 (8,8)	5.4
Tibia stress fracture	9 (3,6)	3.0
Tibialis tendinopathy	9 (2,7)	3.0
Gastrocnemius strain	8 (4,4)	2.7
Compartment syndrome	5 (3,2)	1.7
Periostitis	5 (3,2)	1.7
Popliteal artery entrapment	3 (1,2)	1.0
Ankle inversion	3 (1,2)	1.0
Ankle arthropathy	2 (1,1)	0.7
Peroneal tendinopathy	1 (1,0)	0.3
Ankle impingement	1 (0,1)	0.3
Osteochondral talar injury	1 (0,1)	0.3
Tarsal tunnel syndrome	1 (0,1)	0.3
FOOT		
Plantar fasciitis	14 (5,9)	4.7
Stress fracture	6 (3,3)	2.0
Metatarsalgia	3 (0,3)	1.0
Morton's neuroma	1 (0,1)	0.3
Cuboid syndrome	1 (0,1)	0.3
Blisters	1 (0,1)	0.3
Toenail trauma	1 (0,1)	0.3
Foot osteoarthritis	1 (1,0)	0.3
HIP		
Gluteus medius weakness	17 (5,12)	5.7
Hip flexor tendinopathy/bursitis	6 (3,3)	2.0
Greater trochanter bursitis	5 (0,5)	1.7
Piriformis syndrome	5 (1,4)	1.7
Femoral stress fracture	4 (1,3)	1.3
Hip osteoarthritis	3 (1,2)	1.0
Osteitis pubis	1 (1,0)	0.3

Ischial bursitis	1 (1,0)	0.3
BACK		
Sacroiliac pathology	13 (1,12)	4.4
Facet osteoarthritis	3 (2,1)	1.0
Spinal stenosis	2 (2,0)	0.7
Disk herniation	1 (1,1)	0.7
Degenerative disk disease	1 (1,0)	0.3
Musculoligamentous strain	1 (0,1)	0.3
UPPER LEG		
Hamstring strain	13 (8,5)	4.4
Adductor strain	1 (1,0)	0.3
Other	1 (0,1)	0.3

Figure 17 Causes of running injuries in injured runners at the Allan McGavin Sports Medicine Centre



n = 423

Table 7 Causes of common running injuries at the Allan McGavin Sports Medicine Centre

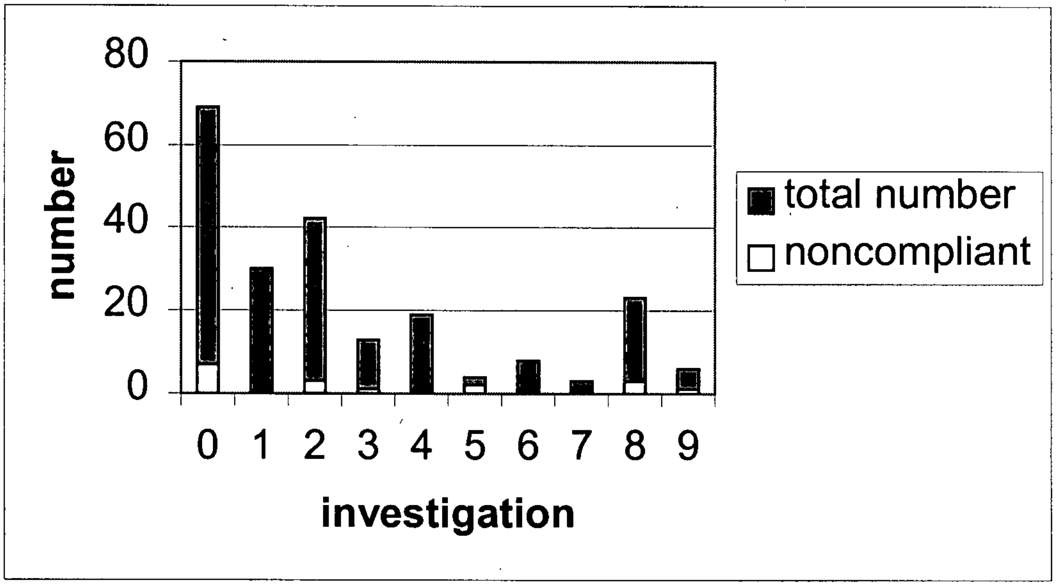
		Cause of injury							
Diagnosis	Number of Causes	1	2	3	4	5	6	7	8
Patellofemoral pain syndrome	2.3 ± 1.6	18 (45)	9 (23)	7 (18)	0	17 (43)	2 (5)	9 (23)	7 (18)
Iliotibial band friction syndrome	2.6 ± 1.5	23 (64)	3 (8)	5 (14)	0	13 (36)	2 (6)	23 (64)	16 (44)
Meniscal injury	2.0 ± 2.1	14 (56)	5 (20)	1 (4)	0	3 (12)	0	1 (4)	2 (8)
Patellar tendinopathy	2.4 ± 1.7	10 (33)	3 (10)	1 (3)	1 (3)	6 (20)	1 (3)	5 (17)	3 (10)
Gluteus medius insufficiency	2.5 ± 1.1	9 (23)	1 (3)	0	0	4 (10)	3 (8)	15 (39)	7 (18)
Achilles tendinopathy	2.6 ± 2.1	8 (50)	4 (25)	2 (13)	0	4 (25)	1 (6)	0	9 (56)
Plantar fasciitis	2.6 ± 2.0	6 (43)	4 (29)	4 (29)	0	6 (43)	1 (7)	2 (14)	6 (43)
Sacroiliac pathology	3.2 ± 2.5	5 (39)	3 (23)	1 (8)	0	7 (54)	4 (31)	4 (31)	3 (23)
Hamstring strain, tendinopathy	2.1 ±1.8	3 (23)	1 (8)	0	1 (8)	2 (15)	1 (8)	7 (54)	5 (39)
Tibial stress fracture	1.4 ± 0.7	8 (89)	0	0	0	2 (22)	1 (11)	0	1 (11)

Cause of injury

1 = training error
2 = surface
3 = shoes
4 = environment
5 = alignment
6 = leg length
7 = strength
8 = flexibility

X(Y)
X = number of cases with specific cause
Y = percentage of cases with specific cause

Figure 18 Investigations ordered and compliance with them by injured runners at the Allan McGavin Sports Medicine Centre

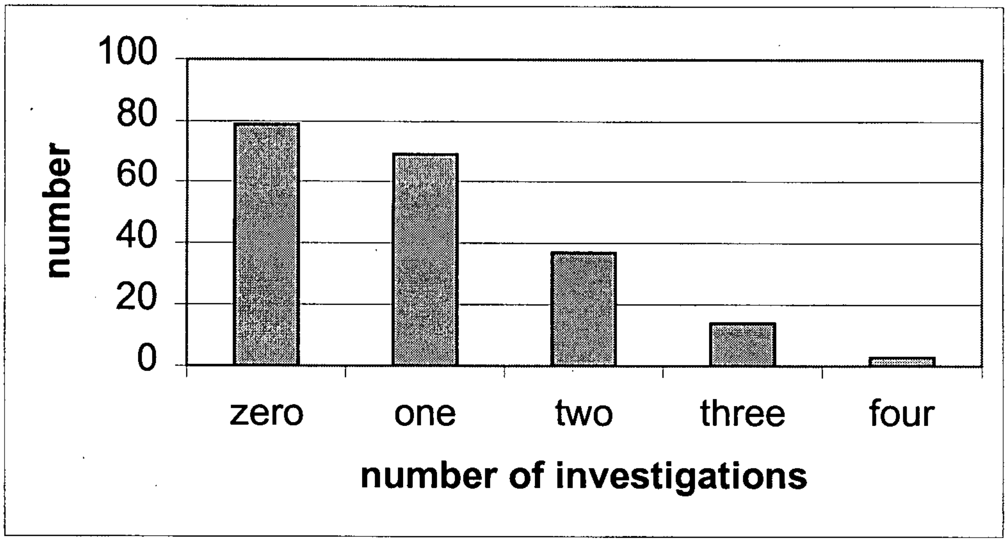


n = 200

Investigation

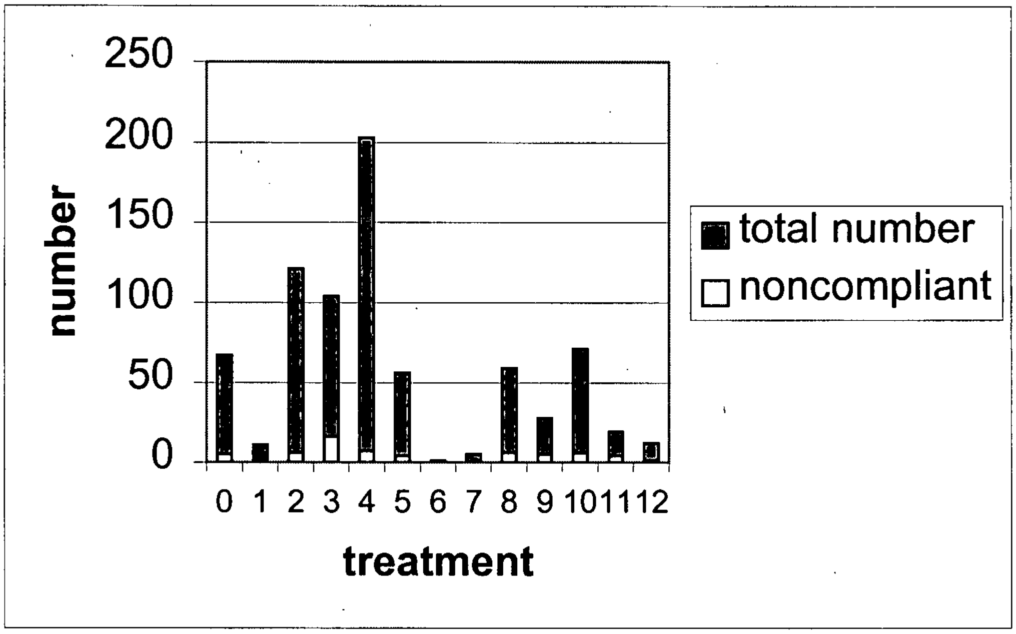
0 = x-ray
1 = ultrasound
2 = bone scan
3 = CT scan
4 = MRI
5 = nerve conduction studies
6 = doppler vascular studies
7 = compartment pressure studies
8 = gait analysis
9 = bloodwork

Figure 19 Number of investigations ordered per injured runner at the Allan McGavin Sports Medicine Centre



n = 212

Figure 20 Treatment options suggested and compliance with them by injured runners at the Allan McGavin Sports Medicine Centre

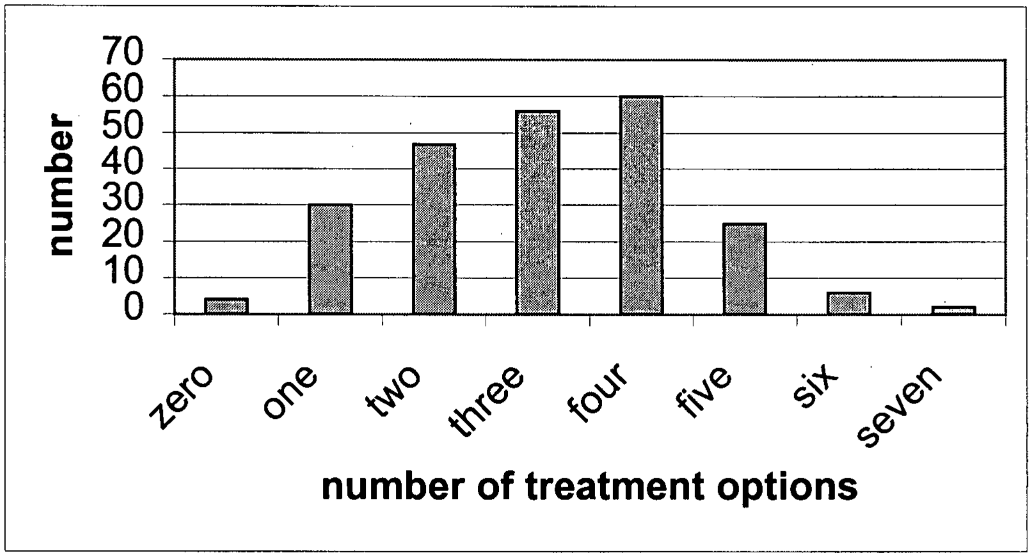


n = 697

Referral was made to surgeons (orthopedic and vascular) in 10 cases and a physiatrist in 1 instance. Medication treatment consisted of NSAIDs (topical 25, oral 17), glucosamine (26), calcium (8), and vitamin D (3). Other treatments recommended initially in isolated cases include night splint, sonorex, blister care, carbohydrate loading, electromagnetic bone stimulation, compression shorts, and bursal aspiration.

Treatment
0 = ice
1 = relative rest
2 = activity modification
3 = gradual return to running level
4 = stretching / strengthening exercise
5 = physiotherapy
6 = chiropractor
7 = massage therapy
8 = orthotic
9= brace
10 = medication
11 = change shoes
12 = referral

Figure 21 Number of treatment options suggested per injured runner at the Allan McGavin Sports Medicine Centre



n = 230

Table 8 Reasons for not returning to the Allan McGavin Sports Medicine Centre for follow-up

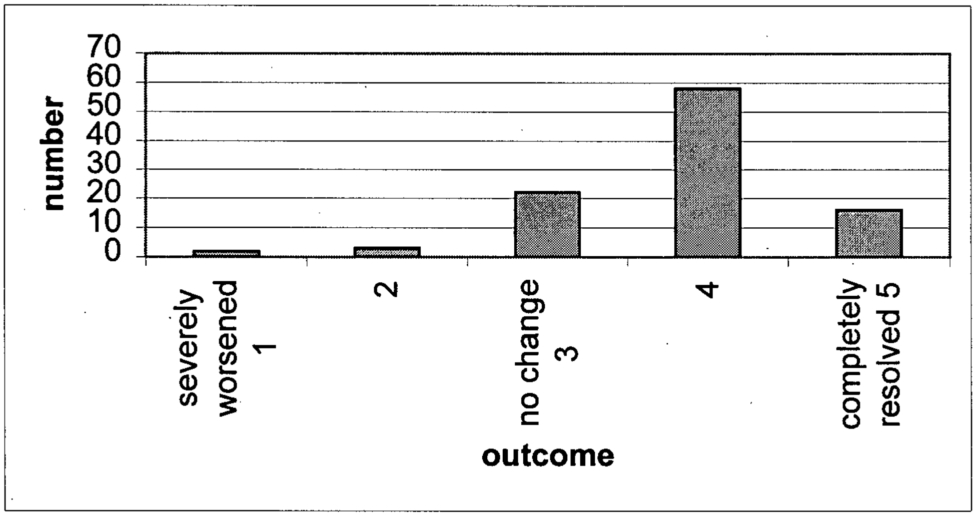
Respondents	Statement
29[a]	"my injury had improved enough or completely"
6	"my injury did not improve and I am seeing another health professional"
1	"the doctor did not understand my problem"
1	"the doctor did not have a good treatment plan"
7[b]	"too busy to return to the clinic"
11[c]	"other reasons"

[a] 16 treatment was effective, 4 treatment was not effective

[b] 4 planning to return to the clinic in the near future, 3 planning not to return to the clinic in the near future

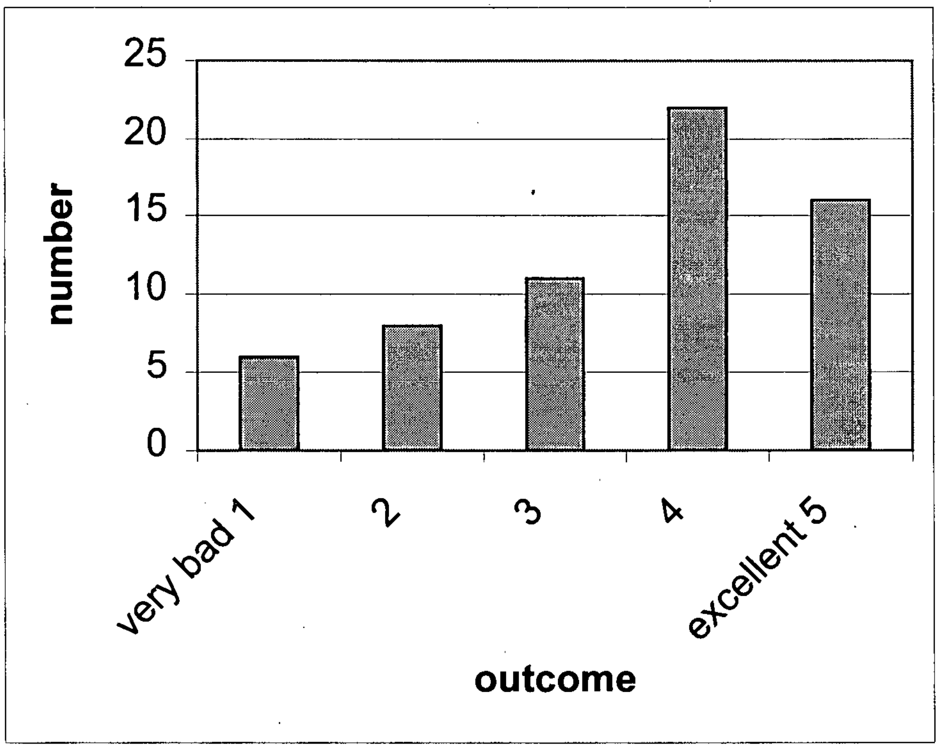
[c] 3 physician did not say to follow-up,
1 no further treatment options were available unless condition worsened,
1 stopped running because of other musculoskeletal injury,
1 stopped running because of other non-musculoskeletal medical condition,
1 attended another physician for treatment of pelvic imbalance with symptom resolution,
1 no change with treatment, waiting for change before returns for assessment,
1 symptom resolution following sonorex treatment and now doing walk-run program after a flare of symptoms,
1 chose to increase other activity and stop running
1 strengthening exercises worsened condition and symptoms improved when discontinued exercises

Figure 22 Injury outcome at follow-up of injured runners at the Allan McGavin Sports Medicine Centre



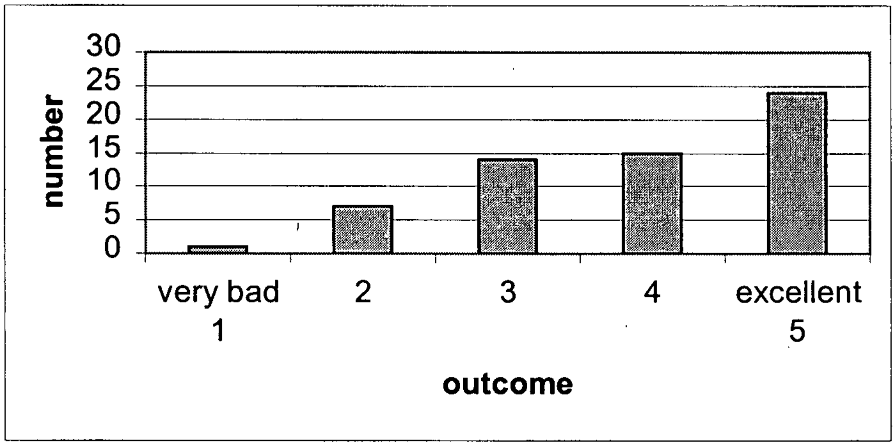
n = 101

Figure 23 Running ability as compared to pre-injury level at follow-up of injured runners at the Allan McGavin Sports Medicine Centre



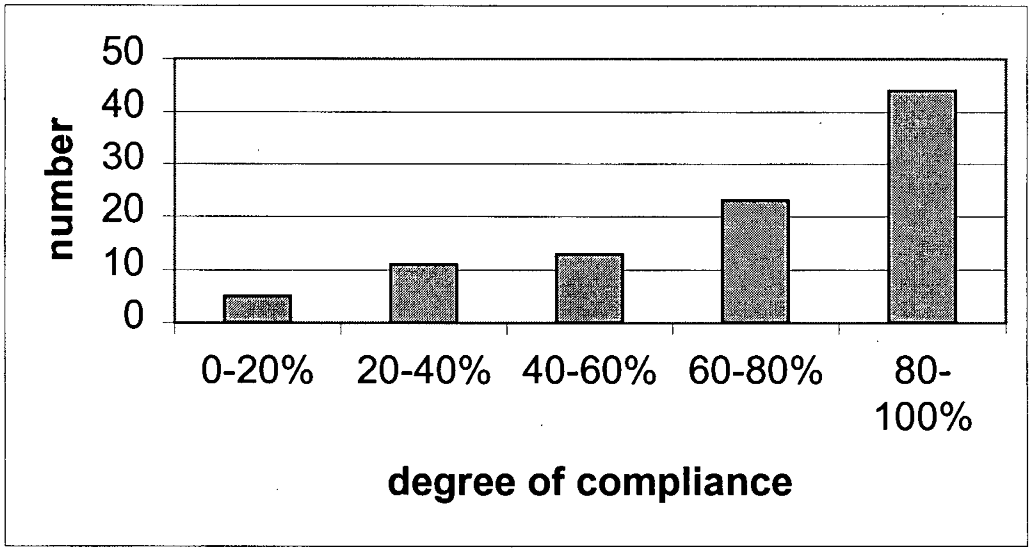
n = 63

Figure 24 Cross-training ability as compared to pre-injury level at follow-up of injured runners at the Allan McGavin Sports Medicine Centre



n = 61

Figure 25 Overall patient compliance with the physician prescribed management plan of injured runners at the Allan McGavin Sports Medicine Centre



n = 96

Table 9: Reasons for non-compliance with specific investigations and treatment options of injured runners at Allan McGavin Sports Medicine Centre

	Statement of non-compliance													
	a	b	c	d	e	f	g	h	i	j	k	l	m	n
Management option														
X-ray	2(1), 4(1)	4(1)	2(1)		2(1)			5(1)	4(1)			2(1)		
Ultrasound		5(1)		2(1)						5(1)		2(1)		
Gait study						3(1)	3(1)	5(1)				3(1)		
Ice	4(1)	4(1)							4(1)					
Gradual return to running	2(1), 3(1), 4(4), 5(1)	3(1), 4(2), 5(1)	2(1)	2(1)	2(2), 3(1), 4(1)	3(1)	3(1)	3(1), 5(1)	4(1)	4(1), 5(1)		2(2), 3(2)		3(1)
Activity modification	3(1), 4(1)	3(1), 4(1)			3(1), 4(1)			3(1)				3(1)		3(1)
Stretching, strengthening exercise	3(1), 4(2), 5(1)	2(1), 4(2), 5(1)			2(1), 3(1), 4(1)			3(1)	4(1)	4(1), 5(1)	3(1), 4(1)	3(1)		3(1)
Physiotherapy											3(1)			
Orthotic	1(1)					1(1)		1(1), 5(1)						
Brace	5(1)	5(1)						5(1)		5(1)				
Medication	4(1), 5(1)	4(1), 5(1)			4(1)	3(1)	3(1)				5(1)	3(1)		
Change shoes				1(1)							1(1)	1(1)		
Referral						1(1)						1(1)	1(1)	1(1)

a = “hard time doing what doctor suggested”
b = “unable to do what was necessary to follow my doctor’s treatment plan”
c = “difficulty understanding what to do”
d = “difficulty remembering what to do”
e = “felt better”
f = “afraid of possible side effects”
g = “do not like taking medication of any kind”
h = “too costly”
i = “did not think it would work”
j = “tried it and did not see any improvement”
k = “made me feel worse”
l = “inconvenient”
m = “interfered with other activities that are important to me”
n = “took too much time”

X(Y)
X = level of evidence
Y = number of responses

Level of evidence
Level 1 = 1 part management plan
Level 2 = 2 part management plan
Level 3 = 3 part management plan
Level 4 = 4 part management plan
Level 5 = 5 part management plan

Table 10 Correlation analysis summary

		Select variables		
Outcome variables	a	b	c	d
1	(-.100, .323)	**(-.193, .056)**	(.177, .078)	(-.065, .528)
2	(-.054, .593)	**(-.239, .017)**	**(.636, 0)**	**(-.232, .023)**
3	(-.072, .477)	**(-.252, .012)**	**(.636, 0)**	(-.173, .092)

Outcome variables

1 injury status at follow-up
2 running ability at follow-up
3 cross-training ability at follow-up

Select variables

a worst stage of injury
b symptom duration at initial visit
c time to follow-up
d compliance with management plan

(r, p)

r correlation coefficient
p probability value

(r, p) where $p < .05$

CHAPTER V DISCUSSION

V.1 Trends in running injuries over the past 20 years at the Allan McGavin Sports Medicine Centre

The Allan McGavin Sports Medicine Centre has conducted three large retrospective reviews of overuse running injuries in 1981, 1991, and 2001. The primary goal of this research was to highlight the current running injuries seen at the clinic and changes in them over time. The studies involved between 800-1000 patients per year over a two to five year study period. The current study involved a prospective assessment of 230 injured runners over six months. Patient demographics from these four studies are in table 10.

Accounting for the change in annual patient recruitment rates, it is not surprising that higher subject numbers are present in the retrospective reviews. The current prospective study required the cooperation of patients on two occasions and the attending physician at the initial visit. Running injury definition likely has no effect on recruitment since Taunton et al. (2001) and the current study used the same definition. Definitions used by Clement et al. (1981) and Macintyre et al. (1991) varied somewhat. Clement et al. (1981) required individuals to have a non-acute, non-traumatic injury and run 3 km three times per week. Macintyre et al. (1991) defined running as the activity that precipitated injury with runners further subdivided into middle distance (elite 800-5000m), marathon (at least 1 marathon per year) or recreational (the rest).

Table 11 highlights an increase in the average age of patients as well as the female to male ratio. The average age and age range has increased by ten and fifteen years respectively over the twenty year period from Clement et al. (1981) to the current study. These age-related changes are further illustrated in figure 26-27. This observation likely can be attributed to the change in population demographics. It is not possible to definitely account for whether the same population of injured runners seen in earlier studies have kept running. Support for this comment may come from the observation that approximately 40% of injured runners in this study have ten or more years of running experience.

The gender ratio changes could be attributable to any combination of 1. an increase in female runners 2. a decrease in male runners 3. an increase in female susceptibility to running injury 4. a decrease in male susceptibility to running injury. The theory of increased female participation in running is supported by two studies of Vancouver Sun Run entrants (Taunton et al., 2001; Johnston et al., submitted for publication). Evidence to date has not shown an overall increased risk of running injury related to gender.

Figure 28 identifies the location of overuse running injuries across each of the four studies. Sex differences did not vary more than 3.5% for a given injury location across the current study as well as those by Clement et al. (1981), Macintyre et al.

(1991) and Taunton et al. (2001). The two exceptions were hip injuries in the current study where the difference was 5% in favour of women and lower leg injuries in Taunton et al. (2001) where the difference was 4.3% in favour of men.

The changes in injury location over these studies suggest that the percentage of

1. injuries of the knee and upper leg have remained constant,
1. injuries of the lower leg and foot have decreased, and
2. injuries of the hip and back have increased.

In order to highlight the reasons for these changes, the injury rates of the top ten diagnoses from each study are presented in table 12.

Most diagnoses have remained relatively constant through the four studies. These include tendinopathies and stress injuries to bone with the exception of tibial stress syndrome. Joint injuries and muscle injuries have seen the most dramatic changes. In the low back, sacroiliac joint injuries were not diagnosed in the initial study and in the current study, they comprise 4.4% of all injuries. In the hip, gluteus medius weakness has increased by 5% since the original study. Hamstring strain and tendinopathy have increased to 4.4% of injuries. The most dramatic changes are in the knee. Patellofemoral pain syndrome accounted for one-quarter of all injuries initially but in the most recent study, the injury percentage has been reduced by half. Iliotibial band friction syndrome and meniscal injuries have increased from a combined 4.4% in 1981 to 20.5% of all injuries in 2001. The meniscus injuries are of a degenerative type and not of an acute, traumatic variety. In the lower leg, tibial stress injuries excluding tibial stress fractures have decreased from 13.2 to 3.4%.

A number of explanations can account for these changes. It could be due to a change in the referral pattern from the family physicians. Family physicians may become more familiar with certain running injury diagnoses and feel confident in their management plan. Patellofemoral pain syndrome and tibial stress injuries ("shin splints") could be examples of this. Criticism of this theory would stress this would apply to more than two conditions. A similar rationale may apply to a change in running injury profile from improved understanding in the prevention of certain running injuries. This could result from education through resources such as periodicals and running clinics or even experience in successfully treating these injuries previously.

These changes may be an accurate representation of true changes over the duration of these studies. In this case, age and/or sex-related changes in the injured population could be responsible for the changes seen. Kallinen and Markku (1995) suggest that "aging causes structural and functional changes" that make bone, cartilage, muscle, and tendon more susceptible to injury. However, it has been hypothesized there is a selection bias whereby those who sustain injuries early in their running program tend not to continue running. This leads to a "healthy runner" effect where fewer injuries are sustained. This could be related to decreased susceptibility to injury or decreased amount of training. Kallinen and Markku (1995) suggest amount of training is a more important predispositional factor than age alone. Van Mechelen (1995) also identifies positive injury association with weekly running distance and previous injury. A condition that is being appreciated more in older runners after years of activity is degenerative meniscus pathology. Taunton et al. (2001) noted an association of meniscal injuries with running on loose surfaces. The increase in back and hip injuries is related to the increase in ratio of injured female runners who constitute approximately 70% of these injuries. Since the average age of this group is 37 years old, a significant portion have delivered at least one child which is known to adversely affect pelvic support.

An element of diagnostic bias where greater awareness of the contribution of certain pathology to injury may be present. There seems to be a recent emphasis by therapists in the treatment of functional pelvic stability which when pathologic is often manifested at the sacroiliac joint. Treatment involves manual therapy and functional core stability exercises to treat imbalances of muscle strength and flexibility of muscles that arise and terminate about the pelvis. If treatment exists, then one may speculate, there would be increased attention to its diagnosis. Conversely, the increase in diagnosis may be due to age and/or sex-related changes in the sample of injured runners. This is a possible explanation for increases in sacroiliac pathology, gluteus medius weakness, and hamstring muscle strain and/or tendinopathy.

Macintyre et al. (1991) postulated that running shoe changes were responsible for the decrease in tibial stress injuries and an increase in iliotibial band friction syndrome injuries. Greater midsole cushioning as well as collapse of the dual density foam on the lateral aspect of the shoe and the resultant subtalar varus were the proposed mechanisms, respectively.

V.2 Causative factors related to running injuries

Causes of running injury were assigned by the physician following the initial history and physical examination. An average number of causes per running injury was 2.3 ± 1.8. Errors in training were the most common contributing factor to running injury. Intrinsic outnumbered extrinsic causes (277 vs.230) (figure 10). Table 7 (results section) show intrinsic and extrinsic causes are roughly equal in PFPS, patellar tendinopathy, Achilles tendinopathy, plantar fasciitis. Extrinsic causes greatly outnumber intrinsic causes in meniscal injuries and tibial stress fractures. In contrast, intrinsic causes greatly outnumber extrinsic causes in cases of iliotibial band friction syndrome, gluteus medius weakness, sacroiliac pathology, and hamstring strain and/or tendinopathy. The more common causes of injury are similar in the study by Clement et al. (1981) and our study (table 13). In this study, most running injuries have more causes associated with them. Clement et al. (1981) only list of causes of injury when cases numbered more than 20.

Several studies exist in the literature that determine causes associated with running injury. Taunton et al. (2001) analysis determined associations that are not unlike those in the current study. Alignment issues were significantly associated with patellofemoral pain syndrome, plantar fasciitis, and sacroiliac joint pathology. Leg length differences were associated with iliotibial band friction syndrome and gluteus medius insufficiency. Training errors were associated with patellofemoral pain syndrome, iliotibial band friction syndrome, plantar fasciitis, and tibial stress fracture. Training surface issues were associated with iliotibial band friction syndrome, mensical injuries and patellar tendinopathy. Shoes were associated with Achilles tendinopathy and plantar fasciitis. This type of analysis reported the strength of the association not in terms of percentage of patients with injury but with statistical significance $p < .01$ or .05.

Brunet et al. (1990) established causes of running injury in a similar fashion to the current study. Training errors were the most common cause of running injuries both by runner self-report and physician determination. When assessed by a physician, other causes (training surface, shoes, and biomechanics) were of equal importance in males and females with the exception of biomechanics being more important in women. When self-reported, runners felt in order of importance shoes, training surfaces, and alignment were responsible for injury. Location of injury (in terms of decreasing frequency, lower leg, foot, hips, heels, and femur) and demographics (in terms of a higher ratio of male participants, more involved training program) differed from the current study.

Lysholm and Wiklander (1987) studied 60 competitive sprinters, middle distance, and long distance runners. Study subjects were younger, less experienced and ran more often. 55 injuries were sustained by 39 runners. With long distance runners, there was a correlation between injury rate in a given month and distance covered in preceding month, most commonly in the spring and summer when training and competition was most intense. Injuries were located most commonly in the lower leg and then followed by the upper leg, knee, foot, hip, and back in decreasing frequency. In a retrospective analysis, causes were established in over half of all injuries. Training errors, malalignment as well as training surfaces and footwear were contributing causes in 71, 39, and 34% of injury, respectively. In approximately 40% of cases, the injury was multifactorial in origin.

Jacobs et al. (1986) and Kretsch et al. (1984) studied a cohort of runners that had both injured and uninjured runners. Demographics indicate the group studied by Jacobs et al. (1986) is made up of 80% males of a younger average age who train to a greater extent. 46% of runners injured over the two year study period were more likely to run more miles per week, more days per week, at a faster pace, and participate in more races per year, including marathons. They were more likely to stretch before runs and not participate in other sports. No association with injury was found with time running, training surfaces, foot type or training methods involving intervals, sprints or hills. Injured sites differ in that lower leg was the most common site of injury followed by the knee, upper thigh, and foot.

Kretsch et al. (1984) studied a group of predominantly male marathoners. The presence of training-related symptoms was 29%. No relationship was found between injury and training variables. Location of injury in decreasing incidence was the lower leg, knee, upper leg, foot, hip/buttock, and back.

Macera et al. (1989) followed a cohort of runners with similar characteristics as this study with a much higher percentage of male runners. Of the injured runners, there were three identified risk factors: running >64 km/week (OR 2.9), running < 3 years (OR 2.2), and injury in past 12 months (OR 2.7) which were more predictive for males than females. Injury was most commonly experienced in the knee and foot. The authors suggested that modifiable risk factors (in this case, weekly mileage) need to be addressed in order to prevent injury. It was proposed that if the runners who ran greater than 64 km reduced to 48-64 km, this would decrease injury by 15% over 2 years which would further minimize injury due to lack of previous injury.

In summary, the literature presents extrinsic and intrinsic causes based on survey based studies of injured runners alone or in conjunction with cohorts of uninjured runners. This analysis reinforces the theory that running injuries are multi-factorial. It can be theorized that before increasing the duration, intensity or frequency of the training program, optimization of alignment, leg length, running shoes, as well as muscle strength and flexibility should occur. However, injury is often the first indication that these issues require further management.

V.3 Outcome of overuse running injuries and compliance with treatment by injured runners

Of 210 injured runners in the study by Jacobs et al. (1986), (148/210) 70% were assessed by health professionals. This group consisted of orthopedic or sport medicine specialists (69), podiatrists (55), internist, general practitioners (27), chiropractors (22), and physiotherapists (21). Treatment consisted of complete rest (38% of cases), strength exercises (30%), change training (21%), orthotics (20%), and surgery (3%). Compliance was rated as: completely (36% of cases), mostly (45%), somewhat (20%), and not at all (4%). Of the cases who were completely or mostly compliant, 57% reported excellent results described as full pain relief and running at pre-injury levels. Of the cases who were somewhat or not at all compliant, 47% reported excellent results while (full pain relief, running as good as before), 19% still had restrictions in their running ability.
Compliance with treatment was related to favourable outcome. Reasons for lack of full compliance included improvement without prescribed treatment (18%), desire not to reduce distance or speed (9%), treatment was too time consuming (9%), and lack of trust in the treatment (7%).

To date, the current study is the most comprehensive assessment of outcome and compliance with management of injured runners. Injured runners most commonly present after 8 weeks to clinic including the usual 4 week waiting period after the referral is made. Half of runners either reduced or stopped their running programs. Investigations were used to confirm or rule out a diagnosis. The most commonly used treatments to facilitate return to symptom-free running were physician directed and patient administered. These include activity modification usually with non to low impact activities, gradual return to pre-injury running level as well as stretching and strengthening exercises. Approximately 60% of possible injured runners were assessed in follow-up. The majority of people who did not participate in follow-up chose not to do so after being contacted on several occasions by the thesis author. Injury status, running ability, and cross-training ability were used as outcome measures. This analysis suggested injury status was most likely to improve and least likely to reach pre-injury level or worsen. Cross training ability was more likely to improve and reach pre-injury level and least likely to worsen as compared to running ability. This is predictable since running involves higher impact than most of the cross-training activities identified in the survey respondents. Compliance with treatment was similar to that in Jacobs et al. (1986) though the current treatment options generally required more active patient participation.

In contrast to other studies regarding compliance with treatment, our management plans are multifaceted. Injured runners were mostly compliant in 70% of cases. Compliance with aerobic exercise programs was 50-70% with lower levels found in sedentary individuals. Compliance with medication was 30-80% with lower rates if the condition is chronic or asymptomatic or with longer follow-up periods.

The correlation analysis of outcome measures (injury status, running ability, cross-training ability) with duration of symptoms, injury severity, follow-up interval, and overall compliance to the management plan highlights several issues. Outcome measures were more likely to improve if patients were treated sooner after symptom development. The severity of the symptoms did not affect the outcome measures. Use of a modified VISA score for running injury severity, developed by our clinic, as well as increased subject numbers could provide confirmation of this relationship. Both running and cross-training ability were likely to improve if time to follow-up was longer. This may correspond with the practise of encouraging injured runners to gradually progress the impact of their cross-training activities and the return to their previous running level. There was no corresponding improvement in injury status. This may suggest that injury improvement occurs over a longer time than this study period while function in terms of running and cross-training ability is a more immediate benefit. Compliance to the management plan at follow-up was indirectly related to running ability. Interpretation of this result suggests that compliance with treatment:

1. may decrease as outcome improves,
2. is unimportant, or
3. is even harmful.

The result may bring into question the validity of the compliance measure or in fact, may be an accurate representation of actual events. Initially, injured runners may be reluctant to adopt treatments perceived to slow them down such as a walk-run program or increased cross-training. Instead, these runners may use other suggested treatment options. Ultimately, failure of the injury to resolve may result in the use of treatments initially recommended. Confirmation of this dynamic relationship between outcome and compliance requires repeated follow-up. Increased subgroup numbers are necessary to provide further support to the appropriate conclusions.

The current study described compliance of injured runners to their management plan including follow-up. The incomplete follow-up of survey respondents likely underestimates non-compliance rates but provides an adequate portrayal of the relative importance of reasons for non-compliance. Recall of treatment was not part of this compliance analysis.

The main reason for non-compliance with follow-up was predominantly due to the fact that the "injury had improved enough or completely". Similar reasons may apply to those individuals who did not respond to the follow-up survey but the percentage to which this applies cannot be determined with certainty.

Reasons for intentional and unintentional non-compliance with the management plan were approximately equal. Patient responses "I had a hard time doing what doctor suggested" and "I was unable to do what was necessary to follow my doctor's treatment plan" were the most common unintentional reasons for non-compliance. "I decided not to follow the recommended treatment because I felt better" and "because I was afraid of possible side effects" were the most common intentional reasons for non-compliance.

Non-compliance was identified with all investigations except ultrasound, MRI, doppler and compartment studies. Investigations are listed from highest to lowest rates of non-compliance: nerve conduction studies, bloodwork, gait analysis, x-ray, bone scan, and CT scan. Reasons for non-compliance with these investigations are unknown. Non-compliance was identified with all treatment options except relative rest, chiropractic care, and massage. Treatments are listed from highest to lowest rates of non-compliance: changing shoes, brace, gradual return to running, orthotic, medication, referral, ice, physiotherapy, activity modification, as well as stretching and strengthening.

Definite reasons for non-compliance with these investigations and treatment options are difficult to determine. The exceptions are when reasons for non-compliance are identified in cases where there was only one part to the management plan. In 2 cases, orthotic prescriptions were not filled because they were "too costly" and the individuals were "afraid of side effects." Changing running shoes was not carried out because "it made me feel worse", was "inconvenient", and because of "difficulty remembering what to do." Injured runners stated that referral to an orthopedic surgeon "took too much time" and "interfered with other activities important to me." Other concerns with this referral were that it was "inconvenient" and "I was afraid of side effects."

Other points regarding these results include the more an investigation or treatment option was suggested, the less frequently patients were non-compliant. The main exception to this was a gradual return to running. This could be explained by the fact that of the outcome measures, running ability was graded most often as worsening or not changing as compared to initial assessment. Non-compliance with the most commonly suggested treatments (activity modification, gradual return to running as well as strengthening and stretching exercises) was most commonly attributed to the injury improving. Less common reasons included lack of improvement, inconvenience, and the time commitment required.

Improving rates of non-compliance with management options is important if it can be result in improved outcome. This relationship has not been confirmed in the current study but as noted previously, small subgroup numbers may be the limiting factor. The degree of non-compliance is highlighted by the fact that 55% of injured runners are compliant with less than 80% of physician suggested management options. Reviewing the principles of compliance in general and issues as they relate to exercise prescription will provide insight as to how to improve compliance. Reasons for compliance are 1. not following treatment has the potential for adverse consequence that are serious, 2. advantages of following treatment outweigh the disadvantages, and 3. the treatment is considered effective. Specific to exercise prescription, compliance is complicated by the fact that exercises:

1. require more time and effort to implement,
2. generally are perceived as recreational more than preventive or therapeutic,
3. are accompanied by non-specific instruction and
4. when discontinued are perceived to result in no negative consequence (Chao et al., 2000).

Dealing with the principles encouraging compliance, adverse consequences of not following treatment would presumably imply persistence of the running injury. These injuries are non-life threatening but the adverse effects are the result of inactivity. Providing information on the advantages and disadvantages of treatment to the patient is the role of the primary care sports medicine physician. Research should be encouraged in those areas where the information is lacking. If sports medicine physicians are prescribing treatment then it is important to know the efficacy and adverse effects of each treatment and if possible, have the potential to predict who may or may not benefit based on the injury and patient characteristics. It is important to realize that this process should ideally take place for each treatment option and thus, compliance is likely to be more difficult when increasing number of treatment options are prescribed. Weighing those advantages and disadvantages of treatment is a personal decision for the patient.

With regards to treatment of injured runners, it is unavoidable that the prescribed exercises require time and initiative. However, specific instruction is given regarding their benefit and the progression of the exercises.

Cegala et al. (2000) suggested that resolution of unintentional non-compliance may be improved through enhanced physician-patient communication. By explaining treatment options and providing supplemental patient handouts, physicians at the Allan McGavin Sports Medicine Centre optimize this communication. Other possible methods to enhance compliance may include encouraging those who are uncertain of their management program to return to the clinic earlier than their scheduled follow-up or involve physiotherapists to monitor the rehabilitative exercises. Establishing the effectiveness of these suggestions is beyond the scope of this study.

Barriers to improvement should be also identified. This may include a patient's perceptions of their injury and what is likely to generate benefit or harm. Perceptions can be based on their own experience with the injury to date and information from sources such as their family physician, acquaintances, or reference materials.

Table 14 summarizes factors that likely affect patient compliance with treatment

Table 11 Injured runner demographics of 4 studies conducted over 20 years at the Allan McGavin Sports Medicine Centre

Study	n (subject number)	% male	age male (years)	% female	age female (years)
Johnston et al. (unpublished)	230	44	40	56	37
Taunton et al. (2001)	2002	46	40	54	34
Macintyre et al. (1991)	4173	57	32	43	27
Clement et al. (1981)	1650	60	30	40	26

Figure 26 Age and gender distribution of injured runners at the Allan McGavin Sports Medicine Centre in 1981

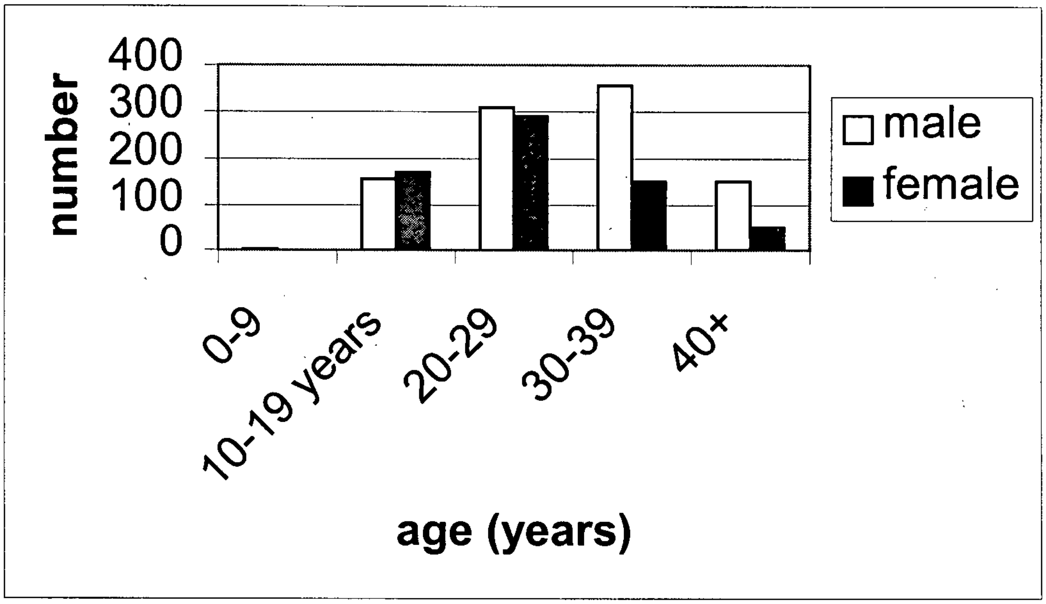


Figure 27 Age and gender distribution of injured runners at the Allan McGavin Sports Medicine Centre in 2001

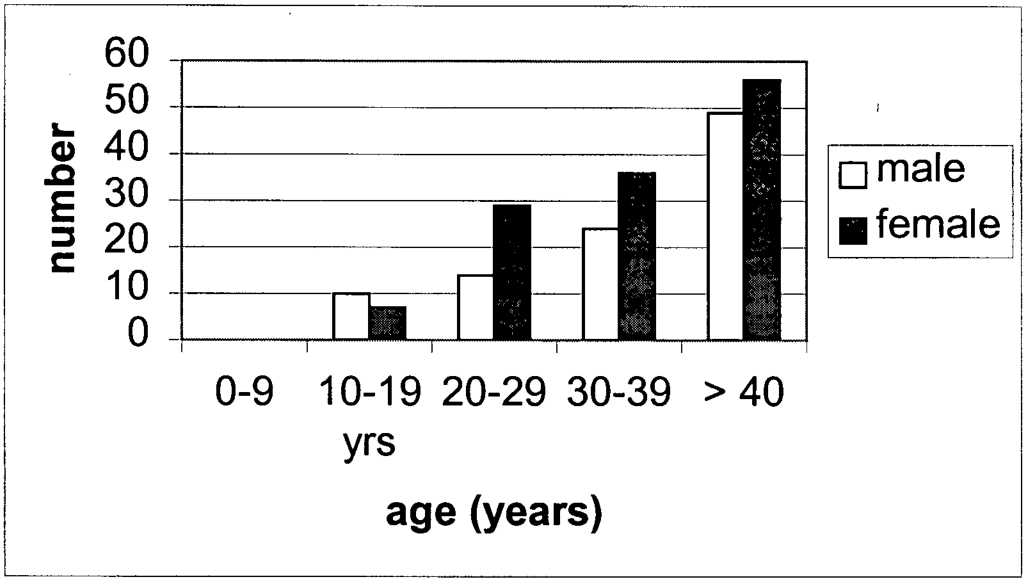
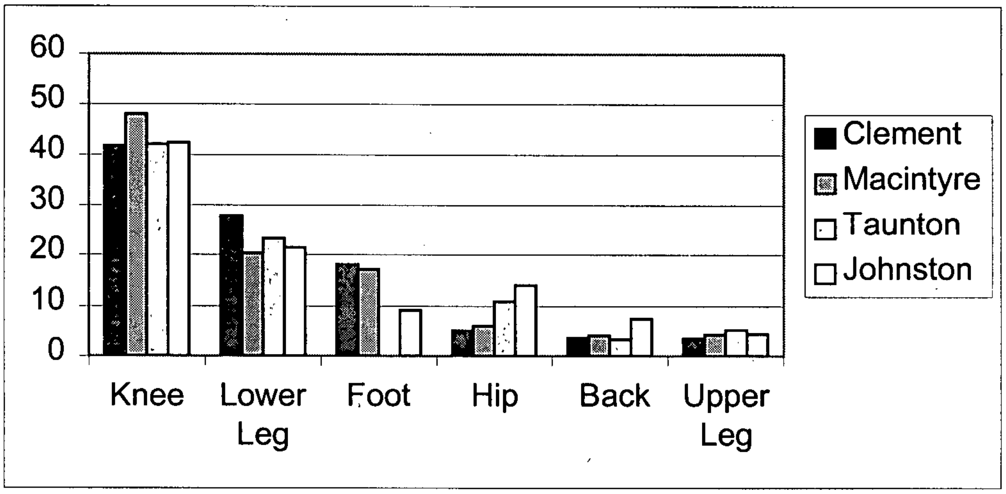


Figure 28 Location of overuse running injuries from 4 studies conducted over 20 years at the Allan McGavin Sports Medicine Centre



* Taunton et al. (2001) had foot/ankle and Achilles/calf as injury location categories. For the purpose of this figure, they are combined under the lower leg category.

Table 12 Common overuse running injury diagnoses from 4 studies conducted over 20 years at the Allan McGavin Sports Medicine Centre

		Percent		
Diagnosis	Clement	Macintyre	Taunton	Johnston
Patellofemoral pain syndrome	25.8	26.6	16.5	13.5
Tibial stress syndrome	13.2	5.7	4.9	3.4
Achilles tendinopathy	6.0	3.8	4.8	5.4
Plantar fasciitis	4.7	4.7	7.9	4.7
Patellar tendinopathy	4.5	4.2	4.8	6.1
Iliotibial band friction syndrome	4.3	7.5	8.4	12.1
Metatarsal stress syndrome	3.2	3.4	1.8	1.7
Tibial stress fracture	2.6	3.3	3.3	2.7
Tibialis posterior tendinopathy	2.5	2.3	0.5	3.0
Peroneal tendinopathy	1.9	na	0.6	0.3
Ankle sprain	0.9	2.0	0.9	1.0
Meniscal injuries	0.1	na	5.0	8.4
Gluteus medius insufficiency	0.7	1.3	3.5	5.7
Spinal injuries	3.7	na	2.3	2.0
Sacroiliac pathology	na	na	1.1	4.4
Hamstring strain/tendinopathy	1.3	0.4	2.2	4.4

na = not able to ascertain from the published paper

Table 13 Comparison of causes of most common injuries in 1981 and current study

Diagnosis	Clement Causes (% of cases)	Johnston Causes (% of cases)
Patellofemoral pain syndrome	training errors 18.5%	training errors 45%
	strength 11.1%	alignment 42.5%
	alignment 8.5%	strength 22.5%
	shoes 8.5 %	training surface 22.5%
	training surface 6.7%	shoes 17.5%
Iliotibial band friction syndrome	training errors 56.4%	training errors 63.9%
	leg length 15.4%	strength 63.9%
		alignment 36.1%
		shoes 13.9%
		training surface 8.3%
		leg length 5.6%
Patellar tendinopathy	strength 19.8%	training errors 33.3%
	training errors 14.5%	alignment 20%
		strength 16.7%
		training surface 10%
		shoes 3.3%
		leg length 3.3%
Achilles tendinopathy	flexibility 37.6%	flexibility 56.3%
	training errors 22%	training errors 50%
	shoes 10%	alignment 25%
	alignment 5.5%	training surface

		25%
		shoes 12.5%
		leg length 6.3%
Plantar fasciitis	flexibility/strength 13.3%	flexibility/strength 42.9%
	training errors 11.4%	training errors 42.9%
	alignment 10.5%	alignment 42.9%
		training surface 28.6%
		shoes 28.6%
		leg length 7.1%
Hamstring strain/tendinopathy	flexibility/strength 50%	flexibility/strength 53.8%
	training errors 25%	training errors 23.1%
		alignment 15.4%
		training surface 7.7%
		leg length 7.7%
		environment 7.7%
Tibial stress fracture	training errors 55%	training errors 88.9%
	flexibility/strength 40.4%	alignment 22.2%
	leg length 6%	flexibility/strength 11.1%
		leg length 11.1%

Table 14 Factors affecting patient compliance with treatment

Injury factors	**Patient factors**	**Physician factors**
Duration of symptoms	Perception of the injury severity (ie. injury status, training ability)	Understanding of the treatment (injury and patient factors predictive of response to treatment)
Injury severity	Perception of the treatment options (ie. effective, harmful, immediate or delayed benefit, cost)	Information provided to the patient on the injury and the effect of treatment
	Ease of treatment implementation	Specificity of instructions for each treatment option

CHAPTER VI. CONCLUSION

The Allan McGavin Sports Medicine Centre has tracked the trends in running injuries over the past twenty years with three retrospective surveys (Clement et al., 1981; Macintyre et al., 1991; Taunton et al., 2001). Extrinsic and intrinsic causes of injury have been identified for certain running injuries. Outcome of running injuries and compliance with management plan has not been well studied previously.

Using a survey design, this thesis:

1. tracked the diagnoses of overuse running injuries and identified changing trends as compared to previous retrospective research conducted at the Allan McGavin Sports Medicine Centre over the past 20 years
2. assessed causative factors related to overuse running injuries, and
3. assessed the outcome of overuse running injuries and compliance with treatment by injured runners.

Over the course of the studies at the Allan McGavin Sports Medicine Centre, there has been an increase in the average age of patients as well as the female to male ratio. This likely can be attributed to the change in population demographics and increased female participation in running, respectively.

The changes in injury location suggest that the percentage of injuries of the knee and upper leg have remained constant, injuries of the lower leg and foot have decreased, and injuries of the hip and back have increased. Specific injury diagnoses that have increased include sacroiliac joint injuries, gluteus medius weakness, hamstring strain/tendinopathy, iliotibial band friction syndrome, and meniscal injuries. Diagnoses that have decreased include patellofemoral pain syndrome and tibial stress injuries. Possible explanations include age and/or sex-related changes in the population, changes in family physician referral patterns or the improved ability of runners and their health care providers in managing certain conditions.

Errors in training were the most common contributing factors to running injury. Overall, intrinsic outnumbered extrinsic causes. This analysis reinforced the belief that running injuries are multi-factorial.

The outcome analysis suggested that injury status was most likely to improve and least likely to reach pre-injury level or worsen. Cross training ability was more likely to improve and reach pre-injury level and least likely to worsen as compared to running ability. This is predictable since running involves higher impact than most of the cross-training activities identified in the survey respondents.

Correlation analysis of outcome measures (injury status, running ability, cross-training ability) with duration of symptoms, injury severity, follow-up interval, and overall compliance to the management plan provided further insight into their importance in running injuries.

VI.4. Future study

Individualized compliance questionnaires in future may better define reasons for non-compliance. At follow-up, the patient would be presented with each element of their particular management plan and asked if they were compliant. If compliance is relative and not absolute, attempts should be made to capture this. If patients were non-compliant, patients should be asked to identify all reasons for non-compliance from a validated list. Qualitative research may necessary to identify unique features encouraging compliance or non-compliance in a running population. Levels of compliance may vary over time and according to injury outcome. Thus it would be important to track both outcome and compliance data over the entire course of the injury. The goal of this research should be to establish factors predictive of compliance or non-compliance. Direct measures of compliance are preferred over indirect measures such as outcome. Indirect measures would be valid only if one treatment was used and compliance with treatment mediated outcome. Possible studies in this area include whether awareness of deficits associated with injury such as muscle weakness on examination or inappropriate shoes as defined by gait analysiscould improve outcome or compliance with corrective treatment.

The focus of running studies to date has been identifying and quantifying factors that are related to running injury. This has led to the widely held belief that running injuries are multi-factorial. Distance run per week has been the most appreciated risk factor. Reducing mileage is likely counter to the desire of many runners especially those training for marathons.

Another approach to running research would be to determine if certain "treatments" could decrease injury rate. A recent review of interventions to prevent running injuries has been published (Yeung and Yeung, 2001). The review indicates that muscle strength is an under-emphasized component of training for runners in the prevention of injury. By standardizing training programs through marathon training clinics, it would be easier to isolate the effect of a generalized strength program of the lower extremity. Quantifiable measures of alignment should be obtained and this could include gait analysis to determine foot biomechanics.

BIBLIOGRAPHY

Becker MH, Maiman LA. Sociobehavioural determinants of compliance with health and medical care recommendations. Medical Care. 13(1): 10-24, 1975.

Bitomsky, Marilyn. Many causes for runners' overuse injuries. Medical Post. 57, February 6, 2001.

Brukner P, Khan K. Principles of injury prevention. In: Clinical Sports Medicine. Roseville: McGraw Hill, 67, 1999.

Brunet ME, Cook SD, Brinkler MR, Dickinson JA. A survey of running injuries in 1505 competitive and recreational runners. Journal of Sports Medicine and Physical Fitness. 30: 307-15, 1990.

Cegala DJ. Marinelli T. Post D. The effects of patient communication skills training on compliance. Archives of Family Medicine. 9: 57-64, 2000.

Chao D, Foy CG, Farmer D. Exercise adherence among older adults: Challenges and strategies. Controlled Clinical Trials. 21: 212-7, 2000.

Clement DB, Taunton JE. A guide to the prevention of running injuries. Canadian Family Physician. 26: 543-8, 1980.

Clement DB, Taunton JE, Smart GE, McNicol KL. A survey of overuse running injuries. The Physician and Sportsmedicine. 9(5): 47-58, 1981.

Clement DB. The practical application of exercise training principles in family medicine. Canadian Family Physician. 28: 929-32, 1982.

Cozby PC. Methods in behavioural Research. Mayfield Publishing Company: Mountain View, California. 119-29, 1985.

Deber R, Glazier R, Holness L. Community Health. In: 1997 MCCQE: Review notes and lecture series. University of Toronto. 1-44, 1997.

Fredericson M. Common injuries in runners: Diagnosis, rehabilitation, prevention. Sports Medicine. 21(1): 49-72, 1996.

Fyfe I, Stanish WD. The use of eccentric training and stretching in the treatment and prevention of tendon injuries. Clinics in Sport Medicine. 11(3): 601-25, 1992.

Gordis L. Methodologic problems in measuring patient compliance. In: Compliance in health care. The Johns Hopkins University Press. 23-45, 1979.

Gross ML, Davlin LB, Evanski PM. Effectiveness of orthotic shoe inserts in the long distance runner. American Journal of Sports Medicine. 19(4): 409-12, 1991.

Hartigan C, Rainville J, Sobel JB, Hipona M. Long term exercise adherence after intensive rehabilitation for chronic low back pain. Medicine and Science in Sports and Exercise. 32 (3): 551-7, 2000.

Haynes RB. Introduction. In: Compliance in health care. The Johns Hopkins University Press. 1-7, 1979.

Jacobs SJ, Berson BL. Injuries to runners: A study of entrants to a 10,000 meter race. American Journal of Sports Medicine. 14(2): 151-5, 1986.

James SJ, Bates BT, Osternig LR. Injuries to runners. American Journal of Sports Medicine. 6: 40-50, 1978.

Johansson C. Knee extensor performance in runners: Differences between specific athletes and implications for injury prevention. Sports Medicine. 14(2): 75-81, 1992.

Johnston CAM, Taunton JE, Zumbo B, Lloyd-Smith DR, McKenzie DC. Vancouver Sun Run: A study of the training habits and general health of its participants. Submitted for publication.

Kallinen M, Markku A. Aging, physical activity and sports injury: An overview of common sports injuries in the elderly. Sports Medicine. 20(1): 41-52, 1995.

Kretsch A, Grogan R, Duras P, Allen F, Sumner J, Gillam I. 1980 Melbourne marathon study. Medical Journal of Australia. 141: 809-814, 1984.

Kvist M. Achilles tendon injuries in athletes. Sports Medicine. 18(3): 173-201, 1994.

Lee JY, Jensen BE, Oberman A, Fletcher GF, Fletcher BJ, Raczynski JM. Adherence in the training levels comparison trial. Medicine and Science in Sports and Exercise. 28 (1): 47-52, 1996.

Lun VMY, Meeuwisse WH, Stergiou P, Stefanyshyn S, Nigg BM. The incidence of running injury and its relationship to lower limb alignment in recreational runners. Abstract presented at CASM/Sport Med 2000 Annual Symposium Research Session, Toronto, Ontario, May 11-13, 2000.

Lysholm J, Wiklander J. Injuries in runners. American Journal of Sports Medicine. 15(2): 168-71, 1987.

Macera CA, Pate RR, Powell KE, Jackson KL, Kendrick JS, Craven TE. Predicting lower-extremity injuries among habitual runners. Archives of Internal Medicine. 149: 2565-8, 1989.

Macintyre JG, Taunton JE, Clement DB, Lloyd-Smith DR, McKenzie, DC, Morrell RW. Running injuries: A clinical study of 4173 cases. Clinical Journal of Sport Medicine. 1(2): 81-7, 1991.

Marti B, Vader JP, Minder CE, Abelin T. On the epidemiology of running injuries: The 1984 Bern Grand-Prix study. American Journal of Sports Medicine. 16(3): 285-93, 1986.

MacNeill I and the Sport Medicine Council of British Columbia. The program, stretching exercises and training log. In: The beginning runner's handbook: The proven 13 week walk/run program. Vancouver: Greystone Books, 133-60, 1999.

Marshall KG. Benefits of exercise. In: Mosby's Family Practise Sourcebook. St. Louis: Mosby, 105, 2000.

McCaw ST. Leg length inequality: Implications for running injury prevention. Sports Medicine. 14(6): 422-9, 1992.

McKenzie DC, Clement DB, Taunton JE. Running shoes, orthotics and injuries. Sports Medicine. 2: 334-47, 1985.

McKenzie DC. A practical guide to the prescription of exercise. Canadian Family Physician. 34: 2712-5, 1988.

McQuade KJ. A case-control study of running injuries: Comparison of patterns of runners with and without running injuries. Journal of Orthopedic and Sports Physical Therapy. 8(2): 81-4, 1986.

Neutens JJ, Rubinson L. Survey Research. In: Research techniques for the health sciences. Allyn and Bacon: Toronto 2nd edition, 89-115, 1997.

Noakes T. Training. In: Lore of running. Capetown: Oxford University Press, 323-58, 1992.

Pollock ML, Carroll JF, Graves JE et al. Injuries and adherence to walk/jog and resistance training programs in the elderly. Medicine and Science in Sports and Exercise. 23 (10): 1194-2000, 1991.

Razeghi M, Batt ME. Biomechanical analysis of the effect of orthotic shoe inserts: A review of literature. Sports Medicine. 29(6): 425-38, 2000.

Robison JI and Rogers MA. Adherence to exercise programmes: Recommendations. Sports Medicine. 17(1): 39-52, 1994.

Sackett DL, Snow JC. The magnitude of compliance and non-compliance. In: Compliance in health care. The Johns Hopkins University Press. 11-22, 1979.

Sherbourne CD, Hays RD, Ordway L, DiMatteo MR, Kravitz RL. Antecedents of adherence to medical recommendations: Results from the medical outcomes study. Journal of Behavioural Medicine. 15(5): 447-68, 1992.

Shrier I. Stretching before exercise does not reduce the risk of local muscle injury: A critical review of the clinical and basic science literature. Clinical Journal of Sports Medicine. 9: 221-7, 1999.

Subotnick SI. The biomechanics of running: Implications for the prevention of foot injuries. Sports Medicine. 2: 144-53, 1985.

Taunton JE, Clement DB, Smart GW, McNicol KL. Non-surgical management of overuse knee injuries in runners. Canadian Journal of Sports Science. 12(1): 11-8, 1987.

Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR. A retrospective analysis of 2002 running injuries. British Journal of Sports Medicine (in press).

Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR. A prospective study of running injuries: The Vancouver Sun Run training clinics. Submitted for publication.

Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR. An analysis of running injuries: The Vancouver Sun Run. Submitted for publication.

van Mechelen W, Hlobil H, Kemper HCG, Voorn WJ, de Jongh R. Prevention of running injuries by warm-up, cool-down and stretching exercises. American Journal of Sports Medicine. 21(5): 711-9, 1993.

van Mechelen W. Can running injuries be effectively prevented? Sports Medicine. 19(3): 161-5, 1995.

Yeung EW, Yeung SS. A systematic review of interventions to prevent lower limb soft tissue running injuries. British Journal of Sports Medicine. 35: 383-9, 2001.

Patient form
Patient name: ______________________________

Please circle the appropriate selections and fill in the blanks for ALL questions.

1. Prior to this appointment, approximately how long have you had your symptoms (please fill in the blank):
   _____ weeks

2. Have you had a running injury before this injury (please circle one selection):
   i. yes → Please continue with question 3
   ii. no → Please continue with question 4

3. If you answered yes to question 2,
   a. did you have the injury you described in question 2 in the same joint or area of the body as your current injury (please circle one selection):
   i. yes ii. no

   b. did the symptoms of the injury you described in question 2 resolve completely before your current symptoms began (please circle one selection):
   i. yes ii. no

4. Which statement best applies to your current injury's worst stage (please circle one selection):
   i. symptoms only after exercise
   ii. symptoms during exercise **with no** reductions in distance or speed
   iii. symptoms during exercise **with** reductions in distance or speed
   iv. symptoms prevent all running

5. Two weeks prior to the start of your symptoms, how would you have rated your health (please circle one selection):
   i. excellent ii. very good iii. good iv. fair v. poor

Questions 6–12 apply to pre-injury training habits.
You will now be asked several questions about your usual training habits in the **TWO WEEKS BEFORE** the start of your symptoms.

6. Two weeks prior to the start of your symptoms, the shoes you wore were (please circle one selection):
   a. brand: i. Asics ii. Adidas iii. Brooks iv. New Balance v. Nike vi. Reebok vii. Saucony viii. other (please specify) __________
   b. model (if known): __________
   c. number of months worn: i.0-3 ii.> 3-6 iii.> 6-9 iv.> 9-12 v.>12
   d. kilometres worn: i.0-200 ii.>200-400 iii.>400-600 iv.> 600-800 v.>800

7. Two weeks prior to the start of your symptoms, the distance you ran per week (please circle one selection):
   i. 5-32 km per week
   ii. >32-64 km per week
   iii. >64-118 km per week
   iv. >118-320 km per week

Patient form
Patient name: ______________________________

8. Two weeks prior to the start of your symptoms (please circle one selection):
a. kilometres per run: i.0-5 ii.>5-10 iii.>10-15 iv.>15-20 v.>20

b. minutes per run: i.0-30 ii.>30-60 iii.>60-90 iv.>90-120 v.>120

c. **if applies,** kilometres per long run: i.0-5 ii.>5-10 iii.>10-15 iv.>15-20 v.>20

d. **if applies,** minutes per long run:i.0-30 ii.>30-60 iii.>60-90 iv.>90-120 v.>120

e. number of runs per week: i.1-2 ii.3-4 iii.5-6 iv.7

f. months running current training program: i.0-1 ii.>1-3 iii.>3-5 iv.>5-7 v.> 7

g. total years of running: i.0-5 ii.> 5-10 iii.>10-15 iv.>15-20 v.> 20

h. did you stretch: i. almost always ii. sometimes iii. almost never

i. when did you stretch in relation to your run (please circle all that apply):
i. before ii. during iii. after

9. Two weeks prior to the start of your symptoms, please respond to the following comments with regard to the training surfaces you ran on (please circle one selection):
a. did you include up hill running as part of your running program:
i.almost always ii.sometimes iii.almost never

b. did you include down hill running as part of your running program:
i.almost always ii.sometimes iii.almost never

c. did you include running on hard surfaces (ie. roads, sidewalks, sea wall) as part of your running program: i.almost always ii.sometimes iii.almost never

d. did you include running on soft surfaces (grass, nature trails) as part of your running program: i.almost always ii.sometimes iii.almost never

e. did you include running on a track as part of your running program:
i.almost always ii.sometimes iii.almost never

10. Two weeks prior to the start of your symptoms, please indicate:
a. your level of participation (please circle one selection):
i.recreational
ii.competitive (if competitive, please circle the most appropriate competitive level): local provincial national international

b. the distance(s) you participated in (please circle all that apply):
i. 5 km ii. 10 km iii. half marathon iv. marathon
v. other (please specify) __________

Patient form
Patient name: ______________________________

11. Two weeks prior to the start of your symptoms what other activities were you involved in (Please indicate if you were or were not involved in the listed activities. If you were involved in the activities, state the number of hours per week spent in that given activity.)
    a. hike i.yes/no ii.____ hours/week
    b. walk i.yes/no ii.____ hours/week
    c. cycle i.yes/no ii.____ hours/week
    d. swim i.yes/no ii.____ hours/week
    e. triathlon i.yes/no ii.____ hours/week
    f. weight training i.yes/no ii.____ hours/week
    g. fitness training (aerobic machines) i.yes/no ii.____ hours/week
    h. racquet sports (badminton, squash, tennis) i.yes/no ii.____ hours/week
    i. contact team sports (football, ice hockey, rugby, soccer) i.yes/no ii.____ hours/week
    j. non contact team sports (basketball, field hockey, ultimate frisbee, volleyball) i.yes/no ii.____ hours/week
    k. winter sport (downhill skiing, snowboarding, XC skiing) i.yes/no ii.____ hours/week
    l. other (please specify) ____________________ i.yes/no ii.____ hours/week

12. Please indicate percent of time spent running: ____%
i.0-20 ii.>20-40 iii.>40-60 iv.>60-80 v.>80-100

13. What is your date of birth (month/year): ___/___

14. Please indicate your sex: male female

15. Please indicate your height: ____ feet ____ inches

16. Please indicate your weight: ____ pounds

17. Are you now (please circle one selection):
i. married ii. widowed iii. divorced iv. never been married
v. not married but living with a sexual partner

18. What is the highest level of education you have attended (please circle one selection):
i. none
ii. elementary
iii. high school
iv. undergraduate university (please specify degree): ________
v. postgraduate/professional school (please specify degree) ________
vi. community college (please specify degree): ________
vii. trade school (please specify degree): ________

APPENDIX 2

MD form: Initial visit
Patient name: ______________________________

Biomechanical assessment (please circle all that apply)

a. spine alignment: kyphosis lordosis scoliosis in C, T or L spine
b. leg length discrepancy: true apparent ____ mm
c. femoral: anteversion retroversion
d. Q angle > 20 degrees
e. Patella: alta squint frog eye lateral patella tracking
f. knee alignment: neutral genu varum genu valgum
g. tibia torsion: internal external
h. arch height: pes planus pes cavus
i. foot abnormality: rearfoot varus > 8° forefoot varus > 5° hallux valgus hallux rigidus functional hallux limitus Morton's foot
j. gait pattern: pronation supination
k. orthotics: none rigid semi-rigid soft other foot orthosis (please specify): ____________
l. orthotics: adequate inadequate

Suspected causes:
Extrinsic factors (please circle all that apply):

1. Training errors
   excessive amount excessive duration excessive intensity sudden change inadequate recovery faulty technique
2. Surfaces
   hard soft cambered slippery
3. Shoes
   inappropriate worn out
4. Environmental
   hot cold

Intrinsic factors (please circle all that apply):

1. malalignment abnormality
2. leg length discrepancy
3. muscle weakness
4. muscle inflexibility

Actions taken:
1. Investigation (please circle all that apply):
x-ray bone scan CT MRI nerve conduction studies vascular studies
other (please specify): ________________

2. Treatment (please circle all that apply):
ice/heat cortisone injection
absolute rest activity modification gradual return to running
stretching and/or strengthening physiotherapy chiropractor massage
orthosis brace
medication (please specify): ______________
referral (please specify): ____________ other (please specify): ________________

MD form: Initial visit

Diagnosis (please circle all that apply):

1. Foot
    a. plantar fasciitis
    b. metatarsalgia
    c. Morton's neuroma
    d. osteoarthritis (please specify joint): ________________
    e. stress fracture (please specify bone): ________________
2. Ankle
    a. achilles tendinopathy
    b. osteoarthritis
    c. ankle inversion
    d. peroneal tendinopathy
    e. tibialis tendinopathy
    f. ankle impingement
    g. osteochondral talar injury
3. Shin/Calf
    a. compartment syndrome: anterior lateral posterior
    b. stress fracture: tibia fibula
    c. periostitis
    d. gastrocnemius strain
    e. popliteal artery entrapment
4. Knee
    a. PFPS
    b. ITBFS
    c. medial meniscus
    d. lateral meniscus +/- cyst
    e. patella tendinopathy
    f. osteoarthritis (please specify compartment): ______________
5. Thigh
    a. quadriceps strain
    b. hamstring strain
    c. hip adductor strain
6. Hip/Pelvis
    a. gluteus medius insufficiency
    b. osteoarthritis
    c. greater trochanter bursitis
    d. stress fracture (please specify bone): ___________________
    e. hip flexor strain, tendinopathy
    f. piriformis syndrome
7. Back
    a. degenerative disk disease
    b. disk herniation
    c. facet osteoarthritis
    d. spondylosis/spondylolisthesis
    e. sacroiliac pathology
    f. musculoligamentous strain
8. Other (please specify): ______________________

Patient form: Follow-up

#

1. Compared to your first visit to the Allan McGavin Sports Medicine Centre, how would you rate the condition of your injury (please circle one selection):

1	2	3	4	5
severely worsened		no change		completely resolved

2. For your injury please identify what you have done since your previous visit to the Allan McGavin Sports Medicine Centre (please answer each question):

Investigations	
a. x-ray	yes/still waiting/no
b. bone scan	yes/still waiting/no
c. CT	yes/still waiting/no
d. MRI	yes/still waiting/no
e. other	yes/still waiting/no
(please specify): ___________________	
Treatment	
a. ice or heat	yes/no
b. stopped running completely	yes/no
c. decreased amount of running	yes/no
d. gradually increased amount of running	yes/no
e. increased amount of other physical activity	yes/no
f. stretching	yes/no
g. strengthening	yes/no
h. physiotherapy	yes/no
i. chiropractor	yes/no
j. massage	yes/no
k. orthotics	yes/no
l. brace	yes/no
m. medication	yes/no
(if yes, please specify): _______________	
n. other	yes/no
(if yes, please specify): _______________	

3. Please respond to the following statements with regard to the treatment plan suggested by your doctor at your previous visit to Allan McGavin Sports Medicine Centre

a. I had a hard time doing what the doctor suggested.

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

b. I was unable to do what was necessary to follow my doctor's treatment plan.

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

c. I had difficulty understanding what to do.

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

d. I had difficulty remembering what to do.

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

e. I decided not to follow the recommended treatment *because I felt better.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

f. I decided not to follow the recommended treatment *because I was afraid of possible side effects.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

g. I decided not to follow the recommended treatment *because I do not like taking any kind of medication.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

h. I decided not to follow the recommended treatment *because it was too costly.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

i. I decided not to follow the recommended treatment *because I did not understand its purpose.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

j. I decided not to follow the recommended treatment *because I did not think it would work.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

k. I decided not to follow the recommended treatment *because I tried it and did not see any improvement.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

l. I decided not to follow the recommended treatment *because it made me feel worse.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

m. I decided not to follow the recommended treatment *because it was too difficult to do.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

n. I decided not to follow the recommended treatment *because it was inconvenient.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

o. I decided not to follow the recommended treatment *because it interfered with other activities that are important to me.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

p. I decided not to follow the recommended treatment *because it took too much time.*

1	2	3	4	5
strongly agree	agree	not sure	disagree	strongly disagree

Thank you very much for your time in completing the survey.

5. (NB. This question applies only to telephone follow-up of those patients who did not return) What are your reasons for not coming back to the Allan McGavin Sports Medicine Centre after your previous visit (please identify all that apply):

a. my injury improved enough or completely
b. my injury did not improve and I am seeing another health professional
   if yes, please specify the type of health professional: ______________
c. the doctor did not understand my problem
d. the doctor did not have a good treatment plan
e. the treatment plan was appropriate and the doctor who referred me was able to manage my follow-up care
f. too busy
   if yes, do you plan to return to the clinic in the near future: yes no
g. other reasons: yes no

if yes, please specify: _____