

Preventing running injuries

Practical approach for family doctors

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ABSTRACT

OBJECTIVE To present a practical approach for preventing running injuries.

QUALITY OF EVIDENCE Much of the research on running injuries is in the form of expert opinion and comparison trials. Recent systematic reviews have summarized research in orthotics, stretching before running, and interventions to prevent soft tissue injuries.

MAIN MESSAGE The most common factors implicated in running injuries are errors in training methods, inappropriate training surfaces and running shoes, malalignment of the leg, and muscle weakness and inflexibility. Runners can reduce risk of injury by using established training programs that gradually increase distance or time of running and provide appropriate rest. Orthoses and heel lifts can correct malalignments of the leg. Running shoes appropriate for runners' foot types should be selected. Lower-extremity strength and flexibility programs should be added to training. Select appropriate surfaces for training and introduce changes gradually.

CONCLUSION Prevention addresses factors proven to cause running injuries. Unfortunately, injury is often the first sign of fault in running programs, so patients should be taught to recognize early symptoms of injury.

RÉSUMÉ

OBJECTIF Proposer une façon pratique de prévenir les blessures de course.

QUALITÉ DES PREUVES Une bonne partie de la recherche sur les blessures de course se présente sous la forme d'opinion d'experts et d'essais par comparaison. Les revues systématiques récentes résumant les travaux portant sur les orthèses, les étirements avant la course et les interventions qui peuvent prévenir les lésions des tissus mous.

PRINCIPAL MESSAGE Les facteurs les plus souvent impliqués dans les blessures de course sont les mauvaises méthodes d'entraînement, les surfaces d'entraînement et les chaussures inappropriées, les défauts d'alignement des jambes, et le manque de force et de flexibilité musculaires. Le risque de blessure peut être minimisé en utilisant des programmes d'entraînement reconnus comportant une augmentation graduelle de la distance et du temps de course et des périodes de repos appropriées. Les défauts d'alignement peuvent être corrigés par des orthèses et des talonnettes. Les espadrilles doivent être adaptées au type de pied de chacun. Il y a lieu d'ajouter des exercices pour augmenter la force et la flexibilité des membres inférieurs, de choisir des surfaces d'entraînement appropriées et de progresser lentement.

CONCLUSION La prévention repose sur la connaissance des facteurs responsables des blessures de course. La blessure est souvent le premier signe d'un programme d'entraînement inapproprié; il importe donc d'enseigner au patient à reconnaître les symptômes précoces de blessure.

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Family physicians are well positioned to help their patients attain and maintain good health. Exercise reduces risk of all-cause mortality, coronary artery disease, hypertension, type 2 diabetes mellitus, stroke, osteoporosis, colon cancer, and breast cancer.¹ Running is an attractive option to many because it is affordable and flexible. Running can cause musculoskeletal injuries, however, and exacerbate known or expose latent medical conditions.

This article focuses on preventing musculoskeletal injuries related to running. The principles of injury prevention are similar for new and experienced runners. It is generally accepted that running injuries result from any combination of extrinsic and intrinsic factors that exceed a runner's capacity to withstand injury. Extrinsic factors include training methods, training surfaces, and running shoes; intrinsic factors are muscle strength, flexibility, and malalignment of the leg. We reiterate the principles of preventing running injuries² and highlight advances and controversies reported in the literature.

Quality of evidence

Appropriate articles were identified through the databases Sport Discus and MEDLINE. A key word search was conducted using combinations of "run," "injury," "prevention," "treatment," "training," "alignment," "pronation," "supination," "muscle," "strength," "flexibility," "shoes," and "surface." Additional articles were identified from references of selected articles. Much of the research is in the form of expert opinion (level III evidence) and comparison trials (level II evidence). Recent systematic reviews (level I evidence) have summarized research dealing with orthotics, stretching before running, and interventions to prevent soft-tissue running injuries. Habitual runners constitute the majority of study participants, which could introduce bias because risk of injury is lower with more experienced runners.³ Where no proven practices exist, suggestions are based on the experience of physicians at the Allan McGavin Sports Medicine Centre where more than 1000 runners have been treated yearly over the past 20 years.

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Training methods

Appropriate training is essential because 60% of all running injuries are the result of doing "too much, too soon."^{4,5} A training program should expose tissues to appropriately dosed and graduated stress interspersed with adequate rest (usually 24 to 48 hours). Clement states, "the timing of recovery is just as important as the loading of exercise."⁶ Suitable recovery prevents running injuries, which are the result of overloading a tissue's capacity to adapt. Training programs are typically derived from this coaching principle (level III evidence).

Yeung and Yeung⁷ summarized the available randomized and quasirandomized trials on preventing running injuries. One study illustrated that novice runners who were prison inmates reduced their injury rate by running 1 to 3 days weekly (RR 0.19, 95% CI 0.06-0.66) and 15 to 30 minutes daily (RR 0.41, 95% CI 0.21-0.79) rather than 5 days weekly and 45 minutes daily.⁸ Studies of military recruits showed a reduction of running distance from 280 to 82 km in basic training over 12 weeks decreased the number of injuries (RR 0.70, 95% CI 0.54-0.91), especially of the knee.^{9,10} Yeung and Yeung⁷ concluded that, from the limited data available, "it is not possible to suggest an optimal training load (level I evidence)."⁷

Macera et al¹¹ identified distance running as a modifiable risk factor for habitual male runners. They suggested men who ran more than 64 km weekly would reduce risk of injury by 15% in 1 year if they ran 48 to 64 km weekly instead. Risk of injury would be further reduced due to the absence of previous injury, a non-modifiable risk factor. Too few female subjects were included to attain statistically significant results for them.

Our centre has developed a walk-run program designed for patients who have never run or are returning to running after injury (**Table 1**). We recommend novice runners run at a pace at which they can converse without breathlessness. On off days, cross-training with nonimpact exercise is acceptable. One study evaluated a 2-week graduated running program (our program is 5 weeks) and observed no reduction in injuries.¹²

Training programs for advanced runners will not be discussed because the demands of experienced runners are too diverse to address here. Clinics operated through running supply stores and books with sample training programs are good resources.^{13,14} Training programs are evaluated based on runners' performance and not on absence of injury. To minimize risk of injury, we recommend increasing training duration or intensity by no more than 10% per week (level III evidence).

Table 1. Sample walk-run program: *The walk-run program is started after a patient has demonstrated the ability to walk 30 minutes consecutively without injury 3 times weekly on alternate days. The goal is to run pain-free for 30 minutes 3 times weekly. It involves a total activity period of 30 minutes structured into six 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.*

WEEK	MONDAY	WEDNESDAY	FRIDAY
1	10-min walk	20-min walk	30-min walk
2	6x (4.5-min walk + 0.5-min run)	6x (4-min walk + 1-min run)	6x (3.5-min walk + 1.5-min run)
3	6x (3-min walk + 2-min run)	6x (2.5-min walk + 2.5-min run)	6x (2-min walk + 3-min run)
4	6x (1.5-min walk + 3.5-min run)	6x (1-min walk + 4-min run)	6x (0.5-min walk + 4.5-min run)
5	30-min run	30-min run	30-min run

Several studies show that decreasing distance run weekly can reduce injury (level I evidence). There are no studies of injuries among runners wanting to increase their distance. They should take a graduated approach to achieve their goals (level III evidence). When implementing a program, common errors that can cause injuries are accelerating the program beyond the ability of tissues to adapt and not backing down from pain, which indicates the body's inability to adapt.

Leg malalignment

McKenzie et al¹⁵ speculate that underappreciation of biomechanical abnormalities is the single most overlooked factor in treatment and prevention of running injuries. Arch type and leg-length differences are alignment factors that can be easily assessed in practice. Assessment of these alignment factors, their association with running injury, and the success of treatment with foot orthoses is outlined below.

There are three common foot arch types: a "normal" arch, pes cavus (high-arched or supinated feet), and pes planus (flat-footed or pronated feet) (**Figure 1**). Pronation and supination are normal phenomena. When they are excessive, compensatory rotation occurs in the tibia, and stress is transmitted proximally through the leg. This stress contributes to foot, ankle, knee, hip, or lower back pain in pronated or supinated runners.¹⁵

Cohort studies of habitual and marathon runners as well as military recruits suggest that types of static misalignment, including arch height and leg-length difference, are not major risk factors for injury (level II evidence).¹⁶⁻¹⁹ A study of dynamic biomechanical running variables illustrated that non-significant trends of greater pronation magnitude and velocity were not associated with injury and that increased knee movement was associated with injury.²⁰ Static alignment does not necessarily predict dynamic alignment (ie,

a pronated foot arch on clinical assessment does not always imply excessive pronation while running). Gait analysis to assess dynamic running variables should be the subject of future research to evaluate it as a clinical tool to identify those at risk of injury who could reduce that risk with an orthosis.

Figure 1. Foot arch types: A) Normal, B) Pes planus (pronated), C) Pes cavus (supinated).



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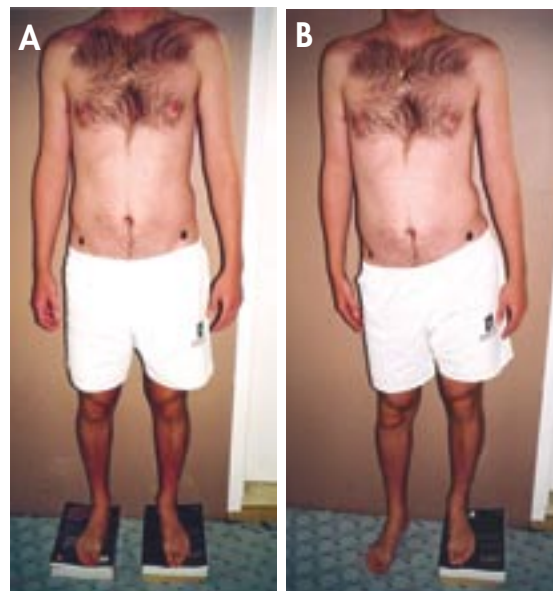
Orthotic devices are often prescribed for runners to promote biomechanical efficiency. Razeghi and Batt²¹ suggest that orthosis use is “somewhat empirical and frequently based on assumptions and insufficient clinical assessment” (level I evidence). Despite this suggestion, Nigg et al²² found that 70% to 80% of injured runners “respond positively to treatment to a variety of injuries with orthotics or inserts” in studies assessing outcome of orthotic treatments^{4,23-25} (level I evidence). D’Ambrosia²³ and Gross et al²⁵ observed that pes cavus feet and inappropriately fitted orthoses accounted for many failures of treatment (level II evidence). Nigg et al²² claim that an appropriate orthosis reduces muscle activity, increases muscle performance, and feels comfortable. Since muscle activity and performance are impossible to assess clinically, a patient’s subjective response to an orthosis could be the most appropriate monitoring method (level III evidence).

Yeung and Yeung⁷ cited experimental studies^{26,27} indicating that shock-absorbing insoles do not prevent overuse soft tissue injuries in military recruits and contradicting a recent Cochrane review.²⁸ Use of an orthosis has been shown to reduce incidence of specific stress fractures in military recruits (level II evidence).²⁹

Leg-length inequality is a common biomechanical abnormality, which results in a muscle imbalance that contributes to injury.³⁰ Observational studies have identified leg-length differences in injured³¹⁻³³ and uninjured³³ runners. Leg-length inequality is characterized as anatomical (difference in bone length), functional (secondary to a rotated pelvis), or environmental (running on banked surfaces).³⁰

Absolute leg length is the distance from the anterior superior iliac spine to the medial malleolus. Relative leg length is the distance from the umbilicus to the medial malleolus. Experts claim this diagnostic method is marred by inaccurate measurements and lack of sensitivity in identifying cases where structural shortening is distal to the malleolus or the difference is present only when standing. A subjective diagnostic method involves assessing pelvic tilt (the line connecting the right and left anterior superior iliac spines). If there is no leg-length difference, no abnormal pelvic tilt is present (**Figure 2A**). If a leg-length difference exists, inserting a 5-mm heel lift under the shorter or longer leg corrects or exaggerates the pelvic tilt (**Figure 2**). X-ray and ultrasound examinations are considered more accurate for diagnosis but typically are not used.³⁰

Figure 2. Pelvic tilt: A) Normal pelvic tilt expected if no leg-length difference exists or if heel lift is inserted under shorter leg correcting the leg-length difference. B) Exaggerated pelvic tilt expected if heel lift inserted under longer leg worsens the leg-length difference.



Only anecdotal literature describes treatment of leg-length differences. Leg-length inequalities are likely to be treated with heel lifts 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 3**).

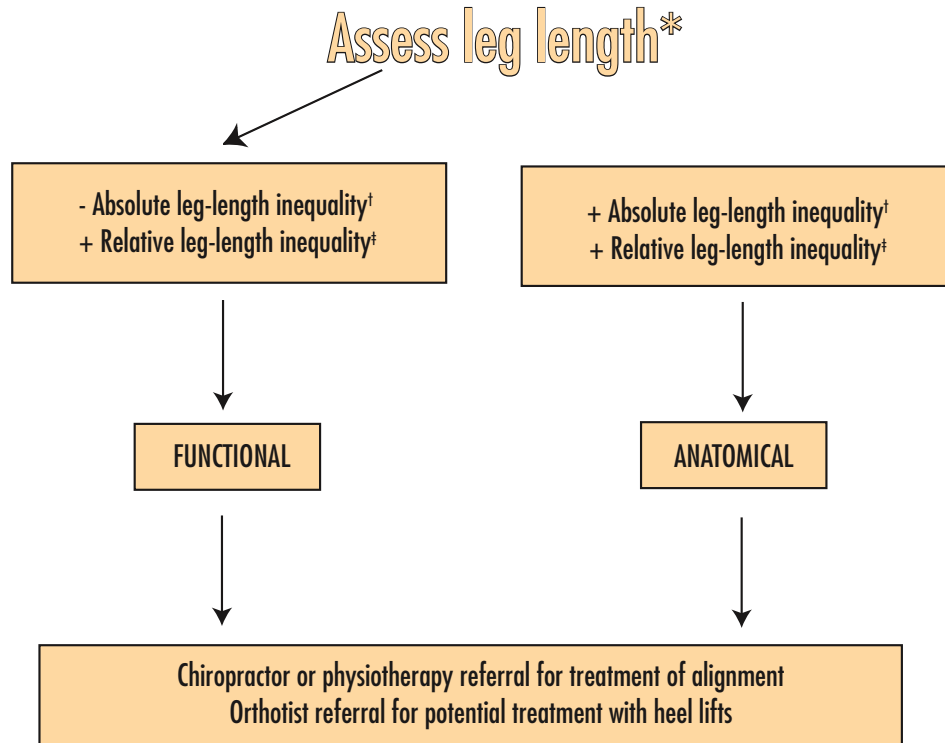
Biomechanical assessments of runners should at minimum consist of measuring leg length and determining arch type. Further research might support widespread use of orthoses and heel lifts in preventing leg injury among runners.

Running shoes

Selecting running shoes based on foot type is the initial step in optimizing patients’ running biomechanics. Specific shoe models appropriate for different foot types are listed in **Table 2**.^{34,35} Running shoes have specific combinations of support and stability designed for a high-impact heel-toe gait that are distinct from other shoes, such as cross-training and court shoes.³⁶

Running in the wrong shoes can adversely affect lower extremity alignment, making runners more susceptible to injury (level III evidence). For example, predisposing factors for Achilles tendon conditions include a shoe that twists easily, insufficient heel

Figure 3. Treatment of leg-length inequalities



* Treatment of leg-length difference is dependent on clinical signs, including musculoskeletal symptoms and signs of skeletal compensation.

† Absolute leg length = distance from anterior superior iliac spine to medial malleolus.

‡ Relative leg length = distance from umbilicus to medial malleolus.

Table 2. Shoe models appropriate for various foot types: Shoe models can vary annually. Referring patients to running shoe stores that keep abreast of these changes will optimize the shoe-selection process.

SHOE COMPANY	SHOE CATEGORY (FOOT TYPE)			
	MOTION CONTROL (EXCESSIVE PRONATOR)	STABILITY (MODERATE PRONATOR)	NEUTRAL SUPPORTIVE (NEUTRAL)	FLEXIBLE/CUSHION (UNDERPRONATOR)
Adidas	Calibrate	N/A	Supernova C	N/A
Asics	MC+*	Kayano*	Nimbus	Gel Cumulus
Brooks	Beast*	Vapor	Glycerin	N/A
Mizuno	Foundation	Alchemy*	Wave Creation	N/A
New Balance	1121*	764*	991*	N/A
Nike	Kantara	Max Moto	N/A	Pegasus
Saucony	Courageous*	Webb	Trigon*	Jazz

N/A—shoe company has no shoe model in the given shoe category.

Data from Moore.³⁵

*Shoe company has more than one shoe model in the given shoe category.

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height, and a worn or rigid sole.³⁴ Running shoes should be replaced after 500 to 700 km because they lose their shock-absorbing abilities.³⁷

In summary, shoes should be selected to match runners' feet. Regularly replacing running shoes at appropriate intervals is important.

Muscle strength and flexibility

Muscle inflexibility and weakness of the quadriceps and the gastrocnemius and soleus group have been associated with injury.³² Johansson³⁸ hypothesizes that muscle fatigue leads to an inability to resist impact that can result in injury.

Yeung and Yeung⁷ identified two studies where runners stretched some time before or after the running session^{12,39} and three studies where runners stretched immediately before running.⁴⁰⁻⁴² Reduced risk of injury was identified in only one of these studies when five sets of stretches some time before or after training were held for 30 seconds.⁴⁰ The other stretching protocols (one to three sets held for 10 to 30 seconds) did not affect risk of injury.^{12,40-42}

Shrier⁴³ reviewed controlled studies of stretching before exercise. All studies involving runners suggested that stretching before running did not prevent injury.^{11,31,42,44-47} There was a non-significant trend toward a higher injury rate in those who did stretch. The basic science literature on stretching and skeletal muscle strain offered explanations of this trend.

- Better compliance decreases the amount of energy that can be absorbed by muscles.
- Varying sarcomere lengths allows for injury during eccentric muscle contractions despite the fact that all sarcomeres are not stretched beyond their normal length.
- Mild stretching can cause damage at the cellular level.
- Stretching masks muscle pain.⁴³

We suggest that runners incorporate both strengthening and stretching programs to prevent injury (level III evidence). Eccentric strength training (contraction of a lengthening muscle) most closely simulates muscle action during running.⁴⁸ Muscle-strengthening exercises prescribed in our clinic include drop squat (**Figure 4**), heel drop (**Figure 5**), and hip abduction exercises (**Figure 6**).

Progression of the drop-squat program involves increasing the speed of the drop and adding weights to patients' hands. Initially, patients should perform a slow "drop" and return to the starting position slowly. Patients progress to a quick drop similar to jumping from a height and absorbing the impact. Quick drops

are advanced by adding weight to patients' hands in 2.25-kg, or 5-lb, increments up to a 9-kg, or 20-lb (per hand), maximum.

Figure 4. Drop-squat exercises: A) In start position, feet should be shoulder width apart with kneecaps directly over the second toe. B) In finish position, depth of squat should be between 45 and 75 in a comfortable position. Patient should feel tightening of a working vastus medialis obliquus muscle. If no tightening is felt, knee might not be in a neutral position but in a valgus or varus position.

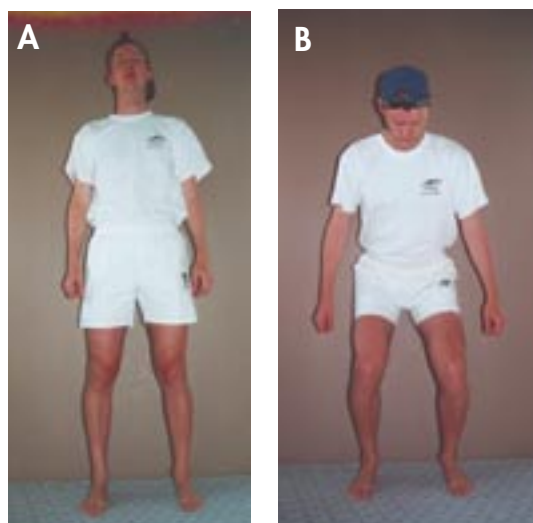


Figure 5. Heel-drop exercises: A) In start position, feet should be shoulder width apart with kneecaps directly over the second toe and only the toes and balls of each foot resting on the step. It is essential to ensure that toes are pointing straight and not off to one side. B) In finish position after reaching maximum plantar flexion, patients lower their heels to the maximum dorsiflexed position below the level of the step.

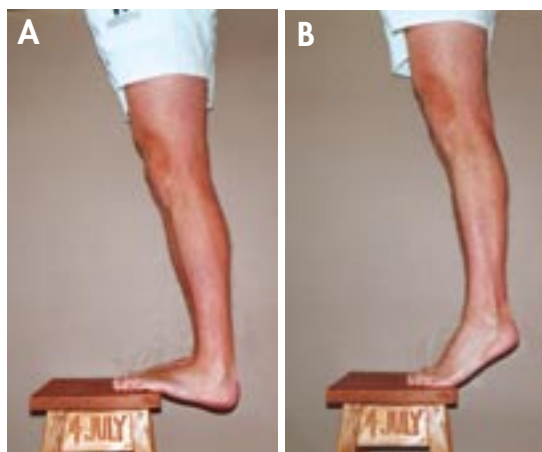


Figure 6. Hip abduction exercise: A) In start position, patients lie on their sides with the leg to be strengthened on top. B) In finish position, the leg to be strengthened is abducted between 30 and 45° in a comfortable position.



The heel-drop program should be performed fast enough that, at the end of the drop, patients feel a bouncing motion. The program is advanced similarly to the drop-squat program.

In the hip abduction exercise, the program is advanced in 0.45-kg, or 1-lb, increments to a 4.5-kg, or 10-lb, maximum.

For each exercise, three sets of 20 repetitions are done consecutively and daily. After 5 consecutive days of pain-free exercise, patients may advance the exercise. If pain occurs, 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 weekly at their most difficult level as a maintenance program.

We recommend a series of lower extremity stretches (**Figure 7**) after exercise. A stretch sensation should be generated and the position held for 30 to 60 seconds.

In summary, muscle weakness and inflexibility are associated with certain running injuries. The leg-strengthening and stretching programs outlined above should be implemented to minimize injury. Stretching should occur after exercise.

Figure 7. Lower extremity stretching program: When the "stretching" sensation is achieved, the position is maintained for 30 to 60 s. Exercises are done three times per stretching session. Stretches can be done daily provided muscles are "warmed up" first. A) In a quadriceps stretch, the right hand grabs the right foot and pulls it behind the right buttock. The stretching sensation should be felt over the anterior thigh. B) In a hamstring stretch, both hands reach for the foot of the extended left leg. The right leg should be bent so that the sole of the foot is placed on the inner thigh of the leg being stretched. The stretching sensation should be felt over the posterior thigh. C) In a groin stretch, the soles of both feet are brought together toward the groin and the knees are allowed to fall to the ground until a stretching sensation is felt over the inner thigh.



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Figure 7 continued. Lower extremity stretching program: D) In an iliotibial band stretch, the left leg is crossed over the right leg. A stretching sensation should be felt over the lateral aspect of the distal right thigh. Exaggerated hip abduction to the right and leaning the upper body to the left should increase the stretching sensation. E) In a straight-knee calf stretch, patients should take a big step forward with the left leg and bend the knee for balance. With an extended right knee, the stretching sensation should be felt over the proximal calf. F) In a bent-knee calf stretch, patients should take a big step forward with the left leg and bend the knee for balance. With a flexed right knee, the stretching sensation should be felt over the distal calf.



Training surface

Macara et al¹¹ found running on sidewalks was a risk factor for injury among habitual runners. Patellofemoral syndrome and tibial stress syndrome were associated with harder training surfaces.³² Running on loose surfaces is linked to meniscus injuries. Running up and down hills is related to patellar tendinopathy and iliotibial band friction syndrome.⁴⁹ Clinical experience shows that injuries often occur when new surfaces are rapidly introduced. Most Canadian runners must run on pavement due to the weather. Similar to training duration, time spent on any new training surface should increase by no more than 10% weekly (level III evidence).

Conclusion

Prevention assesses each etiologic factor and tries to mitigate it. Still, it is difficult to predict injury because the combination of intrinsic and extrinsic factors that cause injury in one runner do not necessarily injure another. Injury is often the first sign of fault in any running program. Patients should be educated to recognize early symptoms of injury. Treatment can then be initiated and etiologic factors addressed.

Prevention of running injuries can be summarized as follows.

- Establish a graduated training program, which allows tissues to adapt to the stresses of running.

- Optimize running biomechanics by using orthoses and heel lifts to correct specific lower extremity malalignments.
- Select running shoes appropriate to runners' foot types.
- Emphasize the need to incorporate a lower extremity strength and flexibility program.
- Select appropriate surfaces for training, and introduce changes gradually. ❁

Competing interests

None declared

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References

1. Marshall KG. Benefits of exercise. In: *Mosby's family practice sourcebook*. St Louis, Mo: Mosby; 2000. p. 105.
2. Clement DB, Taunton JE. A guide to the prevention of running injuries. *Can Fam Physician* 1980;26:543-8.
3. Van Mechelen W. Can running injuries be effectively prevented? *Sports Med* 1995;19(3):161-5.
4. James SJ, Bates BT, Osternig LR. Injuries to runners. *Am J Sports Med* 1978;6:40-50.
5. Johnston CAM, Taunton JE, Lloyd-Smith DR, Zumbo B. A prospective survey assessing causative factors, outcome, and compliance with treatment in injured runners at the Allan McGavin Sports Medicine Centre. In press.
6. Clement DB. The practical application of exercise training principles in family medicine. *Can Fam Physician* 1982;28:929-32.
7. Yeung EW, Yeung SS. A systematic review of interventions to prevent lower limb soft tissue running injuries. *Br J Sports Med* 2001;35:383-9.

8. Pollock ML, Gettman LR, Milesis CA, Bah MD, Durstine L, Johnson RB, et al. Effects of frequency and duration of training on attrition and incidence of injury. *Med Sci Sports Exerc* 1977;9:31-6.
9. Rudzki SJ. Injuries in Australian army recruits. Part I. Decreased incidence and severity of injury seen with reduced running distance. *Mil Med* 1997;162:472-6.
10. Rudzki SJ. Injuries in Australian army recruits. Part II. Location and cause of injuries seen in recruits. *Mil Med* 1997;162:477-80.
11. Macera CA, Pate RR, Powell KE, Jackson KL, Kendrick JS, Craven TE. Predicting lower-extremity injuries among habitual runners. *Arch Intern Med* 1989;149:2565-8.
12. Andrich JT, Bergfeld JA, Walheim J. A prospective study on the management of shin splints. *J Bone Joint Surg Am* 1974;56:1697-700.
13. MacNeill I, 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, BC: Greystone Books; 1999. p. 133-60.
14. Noakes T. Training. In: *Lore of running*. Capetown, South Africa: Oxford University Press; 1992. p. 323-58.
15. McKenzie DC, Clement DB, Taunton JE. Running shoes, orthotics and injuries. *Sports Med* 1985;2:334-47.
16. Lun VMY, Meeuwisse WH, Stergiou P, Stefanyshyn DJ, Nigg BM. The incidence of running injury and its relationship to lower limb alignment in recreational runners. In: CASM Research Committee, editors. *CASM/Sport Med 2000 Annual Symposium Research Session*. Toronto, Ont; 2000 May 11-13. p. 20.
17. Wen DY, Puffer JC, Schmalzried TP. Lower extremity alignment and risk of overuse injuries in runners. *Med Sci Sports Exerc* 1997;29:1291-8.
18. Wen DY, Puffer JC, Schmalzried TP. Injuries in runners: a prospective study of alignment. *Clin J Sports Med* 1998;8:187-94.
19. Rudzki SJ. Injuries in Australian army recruits. Part III. The accuracy of a pretraining orthopedic screen in predicting ultimate injury outcome. *Mil Med* 1997;162:481-3.
20. Stefanyshyn DJ, Stergiou P, Lun VMY, Meeuwisse WH. Dynamic variables and injuries in running. In: Hennig E, Stacoff A, editors. *Proceedings of the 5th Symposium on Footwear Biomechanics*. Zurich, Switzerland; 2001. p. 74-5.
21. Razeghi M, Batt ME. Biomechanical analysis of the effect of orthotic shoe inserts: a review of the literature. *Sports Med* 2000;29(6):425-38.
22. Nigg BM, Nurse MA, Stefanyshyn DJ. Shoe inserts and orthotics for sport and physical activities. *Med Sci Sports Exerc* 1999;31(7 Suppl):S421-8.
23. D'Ambrosia RD. Orthotic devices in running injuries. *Clin Sports Med* 1985;4:611-8.
24. Donatelli R, Hurlbert C, Conway D, St Pierre R. Biomechanical foot orthotics: a retrospective study. *J Orthop Sports Phys Ther* 1988;10:205-12.
25. Gross ML, Davlin LB, Evanski PM. Effectiveness of orthotic shoe inserts in the long distance runner. *Am J Sports Med* 1991;19(4):409-12.
26. Schweltnus MP, Jordaan G, Noakes TD. Prevention of common overuse injuries by the use of shock absorbing insoles. *Am J Sports Med* 1990;18:636-41.
27. Smith W, Walter J, Bailey M. Effects of insoles in Coast Guard basic training footwear. *J Am Podiatr Med Assoc* 1985;75:644-7.
28. Gillespie WJ, Grant I. Intervention for preventing and treating stress fractures and stress reactions of bone of the lower limbs in young adults. In: *The Cochrane Library* [database on disk and CD-ROM]. The Cochrane Collaboration. Oxford, Engl: Update Software; 1999. Issue 4.
29. Simkin A, Leichter I, Giladi M, Stein M, Milgrom C. Combined effect of foot arch structure and an orthotic device on stress fractures. *Foot Ankle* 1989;10:25-9.
30. McCaw ST. Leg length inequality: implications for running injury prevention. *Sports Med* 1992;14(6):422-9.
31. Brunet ME, Cook SD, Brinker MR, Dickinson JA. A survey of running injuries in 1505 competitive and recreational runners. *J Sports Med Phys Fitness* 1990;30:307-15.
32. Clement DB, Taunton JE, Smart GW, McNicol KL. A survey of overuse running injuries. *Physician Sportsmed* 1981;9:47-58.
33. Gross RH. Leg length discrepancy in marathon runners. *Am J Sports Med* 1983;11:121-4.
34. Kvist M. Achilles tendon injuries in athletes. *Sports Med* 1994;18(3):173-201.
35. Moore P. The shoe update: quick reference guide. In: *The Shoe Update 2002*. Vancouver, BC: Ladysport; 2002. Available by contacting info@ladysport.bc.ca.
36. Moore P, Taunton J. Medically based athletic footwear design and selection. *N Z J Sports Med* 1991;19(2):22-5 edited 1993, 1997.
37. Fredericson M. Common injuries in runners: diagnosis, rehabilitation, prevention. *Sports Med* 1996;21(1):49-72.
38. Johansson C. Knee extensor performance in runners: differences between specific athletes and implications for injury prevention. *Sports Med* 1992;14(2):75-81.
39. Hartig DE, Henderson JM. Increasing hamstring flexibility decreases lower extremity overuse injuries in military basic trainees. *Am J Sports Med* 1999;27:173-6.
40. Pope RP, Herbert RD, Kirwan JD. Effects of flexibility and stretching on injury risk in army recruits. *Aust J Physiother* 1998;44:165-72.
41. Pope RP, Herbert RD, Kirwan JD, Graham BJ. A randomized trial of preexercise stretching for prevention of lower-limb injury. *Med Sci Sports Exerc* 2000;32(2):271-7.
42. Van Mechelen W, Hlobil H, Kemper HCG, Voorn WJ, de Jongh HR. Prevention of running injuries by warm-up, cool-down, and stretching exercises. *Am J Sports Med* 1993;21(5):711-9.
43. Shrier I. Stretching before exercise does not reduce the risk of local muscle injury: a critical review of the clinical and basic science literature. *Clin J Sports Med* 1999;9:221-7.
44. Jacobs SJ, Berson BL. Injuries to runners: a study of entrants to a 10,000 meter race. *Am J Sports Med* 1986;14:151-5.
45. Kerner JA, D'Amico JC. A statistical analysis of a group of runners. *J Am Podiatr Assoc* 1983;73:160-4.
46. Blair SN, Kohl HW III, Goodyear NN. Relative risks for running and exercise injuries: studies in three populations. *Res Q* 1987;58:221-8.
47. Walter SD, Hart LE, McIntosh JM, Sutton JR. The Ontario cohort study of running-related injuries. *Arch Intern Med* 1989;149:2561-4.
48. Fyfe I, Stanish WD. The use of eccentric training and stretching in the treatment and prevention of tendon injuries. *Clin Sport Med* 1992;11(3):601-25.
49. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A prospective study of running injuries: the Vancouver Sun Run "In Training" clinics. *Br J Sports Med* 2003;37:239-44.

Editor's key points

- Family physicians can reduce running injuries among their patients by following some basic principles. Training should gradually increase in duration and exertion, and runners should have adequate recovery time between sessions.
- Running biomechanics should be optimized with orthoses and heel lifts if indicated. Runners should choose shoes appropriate to the anatomy of their feet.
- Stretching and strengthening exercises should be a regular feature of training, and runners should be aware of differences in track materials and surfaces.

Points de repère du rédacteur

- Le médecin de famille peut réduire les blessures de course chez ses patients en suivant quelques principes de base. La durée et l'intensité de la course doivent augmenter graduellement et des périodes de récupération adéquates doivent être prévues entre les séances.
- Au besoin, on doit optimiser la biomécanique de la course par le port d'orthèses et de talonnettes. Les chaussures doivent être choisies en fonction de l'anatomie du pied du coureur.
- L'entraînement doit inclure des séances régulières d'étirement et de renforcement, et le coureur doit être conscient des différences entre les divers matériaux recouvrant les pistes et les autres surfaces.