Diagnosis, Treatment, and Prevention of Common Running Injuries

Ryan C. Enke, MD, and Jonathan E. Gallas, DPT, CSCS

ABSTRACT

- *Objective:* To provide an overview of the diagnosis and management of common running injuries for the primary care physician.
- *Methods*: Four common running injuries were selected and a literature review was performed regarding the management and prevention of these injuries.
- *Results:* Medial tibial stress syndrome, patellofemoral pain syndrome, iliotibial band syndrome, and Achilles tendinitis are common injuries experienced by runners. The accurate diagnosis and treatment of these injuries is important in returning the injured runner to sport in a safe and timely manner. Most running injuries are related to cumulative microtrauma. Predisposing biomechanical faults, improper footwear, environmental factors, and errors in training are also thought to play a role in running injuries. An individualized and comprehensive rehabilitation plan is crucial not only for treating these injuries, but also in preventing injury recurrence.
- *Conclusion:* Although a comprehensive assessment and treatment plan is necessary to manage common running injuries, further research is needed to refine current rehabilitation protocols and footwear selection recommendations.

Long-distance running is a popular form of exercise in the United States. The running boom launched several decades ago helped to grow road race and marathon participation to what it is today. Estimates have put the total number of runners in the United States at around 30 million [1]. The health benefits of regular exercise have been well documented [2]. However, with increased participation also comes an increased risk of injury. The yearly incidence of running injuries is estimated to be between 37% and 56% [1]. The accurate diagnosis and treatment of running injuries is important as to allow a safe and timely return to sport, given the numerous known health benefits of regular exercise. Although not all injuries are preventable, there are several risk factors that have been identified as predisposing runners to these injuries [3,4]. Cumulative microtrauma is thought to contribute to most running injuries [5,6]. Intrinsic as well as extrinsic factors such as the interaction of individual biomechanics with training routine and training surface have been linked to various injury patterns [3,5,7,8]. Several sources have also suggested an increased risk of injury associated with improper footwear [3,5–7]. However, at this point there is a lack of definitive evidence-based literature to support specific running shoe recommendations for injury prevention [9]. **Table 1** outlines the various types of running shoes widely available today. The cases that follow will outline a practical approach to the diagnosis, treatment, and prevention of common running injuries.

CASE 1: MEDIAL LEG PAIN

Initial Presentation and History

A 16-year-old female cross country and track runner presents with 1 month of bilateral medial shin pain. She also experienced similar pain last track season, although symptoms improved with rest. The most recent pain started after an indoor track workout. Her pain is worse at the start of her run, up to 6/10, and then improves as she warms up. Towards the end of her run, the pain begins to worsen again. She has stopped running for the past week due to the pain. She has no numbness, tingling, or weakness. She reports no pain at rest. She switches between various running shoes throughout the year, without a specific style or preference. Prior to her injury she was running 3 to 6 miles 6 days per week.

From the Department of Physical Medicine and Rehabilitation, University of Illinois College of Medicine at Rockford (Dr. Enke), and Accelerated Rehabilitation, Rockford, IL (Dr. Gallas).

Physical Examination

On physical examination the patient was noted to have a nonantalgic gait, with a pes planus arch type. She had normal strength, sensation, and reflexes in the lower limbs. Dorsalis pedis pulses were normal and symmetric. There was no calf tenderness or edema. She did have tenderness diffusely over the bilateral medial tibia. On single knee squat she did have some mild dynamic valgus instability. On flexibility screen she was noted to have tightness in the heel cords and iliotibial bands. Treadmill running analysis revealed calcaneal valgus and hyperpronation.

- **What is your differential diagnosis?**

There are several diagnoses to consider in a runner with medial leg pain. Medial tibial stress syndrome, tibial stress fracture, and chronic exertional compartment syndrome would be the most common etiologies. Vascular or neurologic sources of pain would be less likely in younger patients. Primary or secondary bone tumors would be a rare cause.

A tibia or lower leg stress fracture typically presents with sharp, well localized pain that worsens as a run goes on. Pain can be reproduced with a single leg hop test or placing a tuning fork over the malleoli. There is typically focal tenderness to palpation at the site of the stress fracture. The diagnosis can be confirmed with x-ray or in some cases magnetic resonance imaging (MRI) or bone scan.

Chronic exertional compartment syndrome occurs when the pressure within 1 of the 4 lower leg compartments exceeds the capillary perfusion pressure. Symptoms include pain, numbness, swelling, or weakness that occurs only after a certain period of running. Symptoms then resolve once the running has stopped. This can be diagnosed with pre- and post-exercise compartment pressure testing [10].

True claudication, lumbar radiculopathy, or tibial neuropathy would be in the differential diagnosis, but our patient in this case lacks the symptoms that would be associated with these conditions.

Medial Tibial Stress Syndrome

The above case outlines a typical presentation for medial tibial stress syndrome. Common symptoms include sharp, dull, or achy pain over the distal two-thirds of the posterior medial tibia. It is often painful to run, stand, walk, and perform other repetitive weight-bearing activities [11–13]. It can be painful to point toes downward or descend stairs. Pain often disappears when the activity stops. Unlike a stress fracture, the pain from medial tibial stress syndrome can improve initially during a run. This injury is more common in females [12]. It is possibly related to periostitis at the medial or anterior lateral border of the distal tibia [11–13]. Possible predisposing factors include overpronation, which can be correlated with a pes planus arch type, abrupt changes in training surfaces or intensity, tightness in calf muscles, and weakness in pre-tibial muscles [11–13].

Table 1. Common Running Shoe Styles

Motion control: most rigid shoe, consider for hypermobile pes planus arch
Stability: elements of stability and cushioning
Cushioned: highest shock absorption capacity, consider for pes cavus arch
Newton: promotes forefoot strike
Racing flat: lightweight shoe used for speed work or racing
Minimal support: form fitting or minimal materials, mimics barefoot running

- **Would you recommend any diagnostic testing to confirm the diagnosis?**

Medial tibial stress syndrome is a clinical diagnosis. The use of diagnostic imaging is typically used to exclude other pathology. In this case, bilateral tibia and fibula x-rays were obtained and read as normal. If x-rays are negative and the clinical suspicion remains high for a stress fracture, a bone scan MRI could be considered. Various stages of tibial stress injuries can be identified on MRI ranging from periosteal inflammation seen in medial tibial stress syndrome to cortical fracture [14].

- **What is treatment and prevention?**

Treatment for this condition starts with the basic principles for any acute musculoskeletal injury including relative rest, ice, and nonsteroidal anti-inflammatories. The

decision to discontinue running versus reduce training intensity depends on the severity of symptoms. If pain is worsening, then it would be advisable to stop running due to the risk of progression to a stress fracture [13]. The most important treatment is relative rest from running. The evidence for more specific treatments in the literature is weak and limited to a possible benefit from custom insoles and reduced training [15]. Supportive treatments used for medial tibial stress syndrome include topical or oral anti-inflammatories, ice massage, modalities such as ultrasound, or compression socks, although these are not backed by high-quality randomized trials [11–13]. Once the acute pain is controlled, the focus then shifts to preventing injury recurrence. The most common factor would be error in training and so a review of the pre-injury running program is recommended [1,3]. Once running in resumed, a gradual return to run program would be recommended. Training on hard surfaces such as concrete or track should be avoided initially [16,17]. Common biomechanical deficits include tight heel cords and pre-tibial muscle weakness [11–13]. A focused flexibility and strengthening program is therefore recommended for these muscle groups. Again, orthotics may be helpful in reducing overpronation if present and help to prevent future injury [13,15].

CASE 2: ANTERIOR-MEDIAL KNEE PAIN

Initial Presentation and History

A 35-year-old male recreational runner presents with 3 weeks of right medial knee pain. He denies prior knee injuries. He has been training for a half marathon and was increasing his training frequency and intensity. The pain started a few days after a 10-mile run on a cambered road. The pain is described as an ache. This is exacerbated if he is sitting too long or when he first goes to stand. Ascending or descending stairs, deep knee squatting, and running also aggravate the pain. The pain is up to 4/10 and he has cut back on his running to every other day now, with mild relief. He has also tried a stationary bike at high resistance and this makes the pain worse. He has no numbness, tingling, or weakness, swelling, locking, or buckling.

Physical Examination

Physical examination showed the patient to have a non-antalgic gait, with a neutral arch type. He had normal strength, sensation, and reflexes in the lower limbs. Knee exam showed no effusion or redness. Range of motion was normal. He has no joint line tenderness. He was noted to have medial peripateller tenderness. No apprehension or crepitus was noted on patellar glide. There was no pain or laxity on varus or valgus stress test. Anterior and posterior drawer tests were negative. McMurray's was negative medially and laterally. Dynamic valgus instability was noted on right single knee squat. Ober's test showed asymmetric right iliotibial band tightness.

- **What is your differential diagnosis?**

A broad differential diagnosis for runners with knee pain would include patellofemoral pain syndrome, chondromalacia patella, patellar tendinitis, iliotibial band syndrome, osteoarthritis, meniscal tear, pes anserine bursitis, collateral ligament injury, or proximal tibia or fibula stress fracture. In this case, the pain is medial and so several of the above diagnoses can be excluded.

Chondromalacia patella refers to softening of the cartilage behind the patella [13]. This presents with many of the same features as patellofemoral pain syndrome. Symptoms include pain around or behind the patella. These conditions have been used interchangeably with "uunner's knee" in the past. However, not all cases of patellofemoral knee pain are associated with chondromalacia [13].

Differentiating these conditions can be readily performed on a clinical basis with a careful history and physical exam. Focal tenderness over the joint line would indicate possible arthritis or meniscal pathology. Collateral ligament tenderness or laxity versus pes anserine bursa tenderness would also help to localize the problem. Tenderness over the proximal tibia would raise the concern for a stress injury to the bone. When in doubt, MRI can be utilized to confirm the clinical suspicion.

Patellofemoral Pain Syndrome

Our second patient was diagnosed with patellofemoral knee pain. This condition is typically related to maltracking of the patella. This accounts for 20% of all running injuries and is more common in women than men, especially high school girls [13,18,19]. The pain is usually dull or achy with stiffness in the anterior knee or retropatellar region. The pain occurs during or after running. Other activities such as ascending or descending stairs, squatting, kneeling, or prolonged sitting

with knee flexed also cause pain [13,18,19]. Predisposing factors can include weak gluteus medius, tight hamstrings, tight iliotibial band, or running on uneven surfaces such as cambered roads [18–20]. Hyperpronation, leg length discrepancy, or increased training intensity can also contribute [18–20]. Lateral patellar tilt, increased Q-angle, shallow patellar groove, or history of prior trauma to the patella are other factors to consider [18–20].

- **Would you recommend any diagnostic testing to confirm the diagnosis?**

Patellofemoral pain syndrome is a clinical diagnosis. Knee x-rays with a sunrise view can be helpful though in evaluating underlying anatomical predispositions to pain, such as lateral patellar tilt or a shallow femoral groove. An MRI would be helpful only to exclude other pathology.

- **What is treatment and prevention?**

Acute treatment for this condition is similar to that for medial tibial stress syndrome, including relative rest, ice, and anti-inflammatories. Short-term but not long-term benefit has been noted with naproxen use and intra-articular injections of glycosaminoglycan polysulphate [21]. In chronic cases, a cortisone injection could be considered, but this would be expected to provide only temporary relief. Bracing options, such as a patellar stabilizer brace can help as well. Once the pain has improved, running can gradually be restarted. Again the treatment should not stop here. The clinician must address the underlying predisposing factors [22–24]. Open and closed kinetic chain exercises including quadriceps strengthening have been shown to reduce pain in this condition [25]. A resistive brace and acupuncture have also shown some pain reduction in smaller studies [26]. In addition to assessing the training program, one must look at the running shoes and arch type. Both pes planus and pes cavus arch types have been associated with knee pain in runners [18,27]. Also, running shoe age may play a role [18]. Shock absorption capacity is reduced at 250 miles in a running shoe. It is generally advised that running shoes be replaced every 400 to 500 miles [5,28–30]. There is limited evidence to suggest decreased pain and improved function with orthotics and patellar taping methods [26,31]. Offending biomechanical factors such as tight iliotibial bands, hamstrings, and weak quadriceps and gluteal muscles need to be addressed through an active rehabilitation program [22–24]. The rehabilitation needs to be specific, as full arc leg extension or cycling at high resistance can exacerbate this condition clinically.

CASE 3: LATERAL KNEE PAIN

Initial Presentation and History

A 30-year-old female recreational runner presents with right lateral knee pain rated at 1/10. She reports the pain in her right knee began approximately 3 weeks ago after running on trails that were muddy and sloppy. She has not run for the last 2 weeks due to her pain. She describes the pain as dull and achy in nature. She was running approximately 30 to 35 miles per week while training for a half-marathon. She also does spin classes 2 to 3 times per week and has no history of previous running injuries. She has been running for less than 3 years. She is currently running in trail running shoes.

Physical Examination

Physical examination revealed a subtle Trendelenburg gait pattern, with an otherwise normal lower extremity neurovascular exam. Calcaneal valgus was noted. There was some functional weakness in the patient's right hip internal and external rotators and abductor muscles on single knee squat. Flexibility assessment revealed tightness in the bilateral soleus, right hamstrings, hip adductors, and rectus femoris. On palpation there was tenderness laterally over the distal iliotibial band. Special tests revealed positive Ober's and Noble's tests on right. Running biomechanical gait analysis evaluation revealed increased foot inclination angle and knee extension at initial contact and increased right hip adduction and internal rotation leading to increased right knee valgus at midstance.

- **What is your differential diagnosis?**

There are many different causes of lateral knee pain. It is important to identify the specific pain generator and

their symptoms before diagnosing a specific knee injury. Common causes of lateral knee pain include iliotibial band friction syndrome, lateral meniscus tear, lateral collateral ligament tear or sprain, and insertional hamstring tendinopathy.

A tear in the lateral horn of the meniscus results in localized pain at the lateral tibiofemoral joint line of the knee. Pain tends to be sharp in nature with weight-bearing activities involving rotation of the knee. In advanced cases, the knee may give out or lock up preventing straightening. McMurray's test is often positive for pain or audible pop. [32]

A tear or sprain in the lateral collateral ligament also presents as sharp or dull and achy in nature with localized pain over the ligament or lateral joint line. This is typically related to an acute rather than chronic type of injury. Pain is often reproduced with weight-bearing activities on the knee, particularly those placing a varus stress on the knee. Giving out of the knee may occur if there is subsequent quadriceps weakness.

A lateral hamstring tear or strain or tendinopathy will present as dull and achy pain in the posterior thigh or the outside of the knee. There may have been an audible pop at time of injury. Pain is reproduced with resisted knee flexion and eccentric activities to the knee flexors such as running (during the swing phase) or squatting. Pain or stiffness may be increased by prolonged sitting [33].

Iliotibial Band Syndrome

Patient 3 presents with a classic case of iliotibial band syndrome, which is the most common cause of lateral knee pain in runners [34–36]. Tenforde and colleagues reported a lifetime prevalence of 7% in female and 5% in male high school runners [37]. Other researchers report incidence values for iliotibial band syndrome between 12% and 22% of all running injuries [34,38]. Iliotibial band syndrome occurs when the iliotibial band glides over the lateral femoral condyle repetitively, causing a friction syndrome [39]. The iliotibial band is a thick band of fascia and a continuation of the tensor fascia lata and gluteal muscles and attaches to the fibular head, Gerdy's tubercle, lateral tibia, patella, and retinaculum [36,40–42]. The iliotibial band tends to get pinched or subjected to friction at about 30 degrees of knee flexion just after initial contact [40]. More recent studies suggest that the innervated soft tissue is compressed between the iliotibial band and the femur creating pain in the lateral knee [43].

Iliotibial band syndrome presents as an achy or burning sensation on the outside of the knee during or after running [40]. The symptoms tend to get worse with longer runs and better with shorter, faster runs. Runners with iliotibial band syndrome get stiff after long periods of sitting and experience discomfort with ascending or descending stairs [40]. Snapping may be felt at the lateral knee as the iliotibial band attaches to the fibular head, Gerdy's tubercle, or patella and lateral retinaculum [38].

Iliotibial band syndrome tends to occur more often in runners that make initial contact with their heels. It is more common in runners that make initial contact with a more supinated foot or have significant varus alignment at the knee [44,45]. This results in increased frontal plane motions at the hip including adduction and internal rotation. This is related to weakness in the hip abductor and external rotator muscles of the hip [44,46,47]. Other possible causes include a rapid increase in training mileage or intensity greater than 10% over a 1 or more week period, downhill running to lengthen the stride, and running on cambered roads or the same direction on an indoor track for a long period of time [48–50]. Additional potential causes of iliotibial band syndrome are genu varus alignment, rectus femoris tightness, and leg length discrepancy [40,51,52]. It has also been suggested that wearing shoes with too much stability or an orthotic device with too much medial posting may lead to onset of symptoms consistent with iliotibial band syndrome [44].

- **Would you recommend any diagnostic testing to confirm the diagnosis?**

Imaging is not necessary to diagnose iliotibial band syndrome. X-rays were performed in this case to evaluate for other causes of pain and revealed increased lateral tilting of the right patella. MRI findings in patients with iliotibial band syndrome often show thickening of the iliotibial band [53]. An MRI was not performed on this patient.

- **What is treatment and prevention?**

In acute situations, treatment consists of cessation of running and implementation of relative rest, ice, and

anti-inflammatory medications. Cross-training activities such as swimming, cycling, and elliptical training may be performed if pain-free. A cortisone injection may be useful in extremely inflammatory conditions [54].

Subacute and chronic cases involve treatment designed to stretch the muscular areas surrounding the knee, including the tensor fascia lata, gluteus maximus, rectus femoris, iliopsoas, and hamstrings. Soft tissue mobilization and modalities including ultrasound may be helpful in managing inflammation, although randomized controlled trials have failed to confirm this [40–43,55]. Manual therapy techniques are beneficial for improving mobility of bony structures such as the fibular head and subtalar joint that may contribute to faulty biomechanics. Aggressive hip abductor, external rotator, and extensor muscle strengthening is implemented in open chain positions then progressing to closed chain activities such as squatting or lunging. Proprioceptive and neuromuscular education exercises are utilized to initiate proper recruitment of hip abductor and external rotator muscles and facilitate proper timing [40–43]. In situations where running can be performed without pain, it is allowed on a limited basis ever other day. Progression of distance and time should be increased by 3 to 5 minutes or 0.5 miles per day of running [54,56].

CASE 4: HEEL PAIN

Initial Presentation and History

A 44-year-old female recreational runner presents with the complaint of posterior right heel pain rated at 5/10. She reports that the pain in her right heel began approximately 6 weeks ago during a run. She describes the pain as achy but sharp with sudden movements. She was running approximately 20 to 30 miles per week on an asphalt surface prior to her injury. The pain was relieved with ice and massage to right heel. She cut a hole in the back of her shoe to prevent rubbing along the posterior heel. She runs in a minimally supportive free form running shoe.

Physical Examination

Physical examination revealed a normal gait pattern, with a normal lower extremity neurovascular exam. Range of motion of right ankle was within normal limits. Functional strength deficits were identified on right ankle eversion and plantarflexion. Observation revealed callus formation on bilateral big toes, bilateral squinting patella, thickening of right Achilles tendon, and increased subtalar joint eversion with squatting. Palpation identified hypomobility of right talocrual joint with anterior, posterior, and lateral glides, and tenderness along the right medial calcaneal tubercle and medial Achilles tendon.

- **What is your differential diagnosis?**

In order to make the correct diagnosis of posterior heel pain in a runner, one must formulate a broad differential diagnosis. Potential etiologies would include Achilles tendinitis, heel spur, plantar fasciitis, calcaneal fracture, and calf strain.

A heel spur creates a localized achy or sharp pain on the medial, posterior, or plantar surface of the calcaneus. Symptoms tend to be aggravated with weight-bearing activities on the heel, prolonged standing, and inappropriate footwear.

Plantar fasciitis is an inflammatory or degenerative condition causing pain in the medial heel and arch of the foot particularly after periods of inactivity or first steps in the morning. Pain improves with activity then worsens by the end of the day. Tightness of the calf muscles is related to the development of pain along with other factors [57].

A calcaneal fracture is rare without presence of trauma to the foot and ankle. The calcaneus is not a common place for a stress fracture in runners. Pain would be localized in the heel and sharp in nature. Diagnosis would be confirmed by radiographs or MRI revealing the fracture.

A strain of the gastroc-soleus complex would produce pain on weight-bearing and activities that plantarflex the ankle such as descending stairs, raising up on the toes, and pointing the toes downward. Tightness would be noted in the calf muscles with pain reproduced with resisted plantarflexion.

Achilles Tendinitis

Our final patient was diagnosed with Achilles tendinitis, which accounts for approximately 10% of running injuries [48,58]. Achilles tendinitis tends to occur in middle-aged runners. It is more common approximately 2 to 6 cm proximal to its attachment on the calcaneus [48,58].

Achilles tendinitis presents as an achy or sharp sensation on the posterior lower leg and heel during or after running. The symptoms tend to get worse with runs on uneven surfaces such as grass, trails, and cambered roads.

Table 2. Key Elements in Performing a Running Injury History and Examination

History
Pain at rest or only with activity
Recent changes in training frequency or intensity
Primary running surface
Type of running shoe and frequency of replacement
Prior running injuries and treatment
Physical Examination
Gait assessment
Assess for leg length discrepancy
Evaluation of arch type
Examine running shoes for wear pattern
Screen for common flexibility deficits
Thomas test for hip flexors
Ober's for iliotibial band
Popliteal angle for hamstrings
Ankle dorsiflexion for heel cords
Screen for common function weakness
Single knee squat for hip abductor weakness
Runner's pose or plank for core stability

Runners with Achilles tendinitis report morning stiffness and tightness in their calf muscles. Pain may be reproduced by plantarflexion of the ankle, descending stairs, or raising up on the toes and lowering slowly. There may be visible swelling or thickening of the Achilles tendon in chronic cases [48,58].

Runners with Achilles tendinitis have tightness or weakness in their hamstring muscles. Upon biomechanical analysis they demonstrate late stage pronation and excessive forefoot abduction during the midstance phase of the running gait cycle. They also tend to overstride at initial contact [58]. Other possible causes include a rapid increase in training mileage or intensity greater than 10% over a 1- or more week period, a leg length discrepancy, or running on uneven surfaces [54].

- **Would you recommend any further diagnostic testing to confirm the diagnosis?**

MRI can be used to confirm the diagnosis or exclude other pathology. In this case, a right ankle MRI revealed Achilles tendinosis, Achilles paratendinitis, and thickening of the Achilles tendon bursa. Of note, Achilles tendinitis represents the acute or inflammatory stage of tendon injury. As this condition becomes chronic, the pathology becomes more consistent with tendinosis or tendon degeneration and disorganization, rather than inflammation.

- **What is treatment and prevention?**

In acute Achilles tendinitis situations, it is best to limit running and implement cross-training activities such as cycling and elliptical trainer. If running is allowed, avoiding uneven surfaces and cambered roads is recommended. Overall, evidence-based treatments are used less than half of the time in treating this condition [59]. Taping procedures and heel lifts can provide some healing by decreasing stress to the Achilles tendon. In subacute and chronic stages, one must first regain the flexibility and strength of the gastroc-soleus complex and hamstring muscles [60]. It is important to obtain appropriate footwear to decrease loading on the Achilles tendon in midstance. In this case report, the minimally supportive shoes were not considered appropriate to continue, at least in the short term for this patient. Proprioceptive exercises have been shown to be beneficial to strengthen the muscles of the foot and ankle and improve neurological feedback to the Achilles tendon [60]. Eccentric strengthening has been shown to break up scarred, fibrotic tissue around the Achilles tendon leading to chronic symptoms [61]. Deep soft tissue massage is also helpful along with modalities such as ultrasound and iontophoresis. Cortisone injections are typically avoided around the Achilles tendon, although in cases with associated bursitis, a retrocalcaneal bursa injection can be considered. In situations where running can be performed without pain, it is allowed on a limited basis ever other day.

SUMMARY

The above cases demonstrate a practical approach to the diagnosis, treatment, and prevention of common running injuries. **Table 2** outlines the key elements of the history and physical exam to include when evaluating an injured runner. Due to the nature of most running injuries being related to repetitive stress, it is important to try to identify underlying predisposing risk factors, which may have contributed to the injury. Most injuries

will improve with activity modification or relative rest, but if the underlying risk factors are not addressed, there will remain a risk of future injury. Further research is needed, particularly in regards to appropriate footwear selection for running injury prevention. Nonetheless, underlying training errors, strength, and flexibility deficits should be identified and addressed for the optimal treatment and prevention of running injuries.

Corresponding author: Ryan C. Enke, MD, 324 Roxbury Rd, Rockford, IL 61107, ryane@rockfordortho.com.

Financial disclosures: None.

Author contributions: conception and design, RCE; analysis and interpretation of data, RCE, JEG; drafting of article, RCE; critical revision of the article, RCE, JEG; collection and assembly of data, RCE, JEG.

REFERENCES

1. van Mechelen W. Running injuries. A review of the epidemiological literature. Sports Med 1992;14:320–35.
2. Haskell WL, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007:39:1423–34.
3. Johnston CA, Taunton JE, Lloyd-Smith DR, McKenzie DC. Preventing running injuries. Practical approach for family doctors. Can Fam Physician 2003;49:1101–9.
4. McKenzie DC, Clement DB, Taunton JE. Running shoes, orthotics, and injuries. Sports Med 1985;2:334–47.
5. Cook SD, Brinker MR, Poche M. Running shoes. Their relationship to running injuries. Sports Med 1990;10:1–8.
6. Frey C. Footwear and stress fractures. Clin Sports Med 1997;16:249–57.
7. Cheung RT, Ng GY, Chen BF. Association of footwear with patellofemoral pain syndrome in runners. Sports Med 2006;36:199–205.
8. Kennedy JG, Knowles B, Dolan M, Bohne W. Foot and ankle injuries in the adolescent runner. Curr Opin Pediatr 2005;17:34–42.
9. Richards CE, Magin PJ, Callister R. Is your prescription of distance running shoes evidence-based? Br J Sports Med 2009;43:159–62.
10. Gill GS, Halstead ME, Matava MJ. Chronic exertional compartment syndrome of the leg in athletes: evaluation and management. Phys Sportsmed 2010;38:126–32.
11. Bennett J, Reinking M, Pluemer B, et al. Factors contributing to the development of medial tibial stress syndrome in high school runners. J Orthop Sports Phys Ther 2001; 31:504–10.
12. Moen MH, Tol JL, Weir A, et al. Medial tibial stress syndrome: a critical review. Sports Med 2009;39:523–46.
13. Fredericson M. Common injuries in runners. Diagnosis, rehabilitation and prevention. Sports Med 1996;21:49–72.
14. Bergman AG, Fredericson M. MR imaging of stress reactions, muscle injuries, and other overuse injuries in runners. Magn Reson Imaging Clin N Am 1999;7:151–74.
15. Yeung SS, Yeung EW, Gillespie LD. Interventions for preventing lower limb soft-tissue running injuries. Cochrane Database Syst Rev 2011;(7):CD001256.
16. Pinnington H, Lloyd D, Besier T, Dawson B. Kinematic and electromyography analysis of submaximal differences running on a firm surface compared with soft, dry sand. Eur J Appl Physiol 2005;94:242–53.
17. Kurmandani H, Murakami T, Sasaki H, et al. Effect of muscle activities in the lower leg by different road surfaces. Jap J Clin Sports 2007;15:13.
18. Duffey MJ, Martin DF, Cannon DW, et al. Etiologic factors associated with anterior knee pain in distance runners. Med Sci Sports Exerc 2000;32:1825–32.
19. Dierks T, Manal K, Hamill J, Davis I. Proximal and distal influences on hip and knee kinematics in runners with patellofemoral pain during a prolonged run. J Orthoped Sports Physic Ther 2008;38:448–56.
20. Niemuth P, Johnson R, Myers M, Thieman T. Hip muscle weakness and overuse injuries in recreational runners. Clin J Sport Med 2005;15:14–21.
21. Heintjes E, Berger MY, Bierma-Zeinstra SM, et al. Pharmacotherapy for patellofemoral pain syndrome. Cochrane Database Syst Rev 2004;(3):CD003470.
22. Lowry C, Cleland J, Dyke K. Management of patients with patellofemoral pain syndrome using a multi-modal approach: a case series. J Orthop Sports Phys Ther 2008; 38:691–702.
23. Souza R, Powers C. Differences in hip kinematics, muscle strength, and muscle activation between subjects with and without patellofemoral pain. J Orthop Sports Phys Ther 2009;39:12–9.
24. Wittingham M, Palmer S, Macmillan F. Effects of taping on pain and function in patellofemoral pain syndrome: a randomized controlled trial. J Orthop Sports Phys Ther 2004; 34:504–10.
25. Heintjes E, Berger MY, Bierma-Zeinstra SM, et al. Exercise therapy for patellofemoral pain syndrome. Cochrane Database Syst Rev 2003;(4):CD003472.
26. Bizzini M, Childs JD, Piva SR, Delitto A. Systematic review of the quality of randomized controlled trials for patellofemoral pain syndrome. J Orthop Sports Phys Ther 2003;33:4–20.
27. Williams DS 3rd, McClay IS, Hamill J. Arch structure and injury patterns in runners. Clin Biomech (Bristol, Avon) 2001;16:341–7.
28. Dib MY, Smith J, Bernhardt KA, et al. Effect of environmental temperature in shock absorption properties of running shoes. Clin J Sport Med 2005;15:172–6.
29. Cook SD, Kester MA, Brunet ME. Shock absorption characteristics of running shoes. Am J Sports Med 1985;13:248–53.
30. Taunton JE, Ryan MB, Clement DB, et al. A prospective study of running injuries: the Vancouver Sun Run "In Training" clinics. Br J Sports Med 2003;37:239–44.

31. D'hondt NE, Struijs PA, Kerkhoffs GM, et al. Orthotic devices for treating patellofemoral pain syndrome. Cochrane Database Syst Rev 2002;(2):CD002267. Review. Update in: Cochrane Database Syst Rev 2009;(1):CD002267.
32. Heckman T, Barber-Westin S, Noyes F. Meniscus repair and transplantation: indications, techniques, rehabilitation, and clinical outcome. J Orthop Sports Phys Ther 2006; 36:795–814.
33. Heiderscheit B, Sherry M, Silder A, et al. Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. J Orthop Sports Phys Ther 2010; 40:67–81.
34. Linenger JMCC. Is ilotibial band syndrome overlooked? Phys Sports Med 1992;20:98–108.
35. Taunton JE, Ryan MB, Clement DB, et al. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med 2002;36:95–101.
36. Brumitt J. Tips to reduce risk of iliotibail band syndrome. NSCA Perform Train J 2011;10:19–20.
37. Tenforde A, Sayres L, McCurdy M, et al. Overuse Injuries in high school runners: lifetime prevelence and prevention strategies. Phys Med Rehab 2011;3:125–31.
38. Noble CA. Iliotibial band friction syndrome in runners. Am J Sports Med 1980;8:232–4.
39. Evans P. The postural function of the iliotibial tract. Ann R Coll Surg Engl 1979:271–80.
40. Fredricson M, Weir A. Practical management of iliotibial band friction syndrome in runners. Clin J Sports Med 2006;16:261–8.
41. Birnbaum K, Siebert H, Pandorf T, et al. Anatomical and biomechanical investigations of the iliotibial tract. Surg Radiol Anat 2004;26:433–46.
42. Messier SP, Edwards DG, Martin DF, et al. Clinical investigations: implications: etiology of iliotibial band friction syndrome in distance runners. Med Sci Sports Exerc 1995; 27:951–60.
43. Fairclough J, Hayashi K, Toumi H, et al. Functional anatomy of the iliotibial band during flexion and extension of the knee: Implications for understanding iliotibial band syndrome J Anat 2006;208:309–16.
44. Noehren B, Davis I, Hamill J. ABS Clinical Biomechanics Award Winner 2006: Prospective study of the biomechanical factors associated with iliotibial band syndrome. Clin Bio 2007;22:951–6.
45. Ferber R, Noehren B, Hamill J, Davis I. Competitive female runners with a history of iliotibial band syndromedemonstrate atypical hip and knee mechanics. J Orthop Sports Phys Ther 2010;40:52–8.
46. Gose JC, Sweiser P. Iliotibial band tightness. J Orthop Sports Phys Ther 1993;10:399–407.
47. Niemuth P, Johnson R, Myers M, Thieman T. Hip muscle weakness and overuse injuries in recreational runners. Clin J Sports Med 2005;15:14–21.
48. Strakowski J, Jamil T. Management of common running injuries. Phys Med Rehabil Clin N Am 2006;17:537–52.
49. Walter SD, Hart LE, McIntosh JM, et al. The Ontario cohort study on running related injuries. Arch Inter Med 1989;149:2561–4.
50. Marti B, Vader JP, CE M, et al. On the epidemiology of running injuries: the 1984 Bern Grand-Prix study. Am J Sports Med 1988;16:285–94.
51. Barber FA, Sutker AN. Iliotibial band syndrome. Sports Med 1992;14:144–8.
52. Schwellnus MP. Lower limb biomechanics in runners with the iliotibial band friction syndrome. Med Sci Sports Exerc 1993;25:S68.
53. Nishimura G, Yamato M, Tamai K, et al. MR findings in iliotibial band syndrome. Skeletal Radiol 1997; 26:533–7.
54. Fredericson M, Mishra A. Epidemiology and aetiology of marathon running injuries. Sports Med 2007;37:437–9.
55. Brosseau L, Casimiro L, Milne S, et al. Deep transverse friction massage for treating tendinitis. Cochrane Database Syst Rev 2002;(4):CD003528.
56. Logan C. The scoop on running injuries. IDEA Fitness J; 2006:29–31.
57. McPoil C, Martin R, Cornwall M, et al. Heel pain: plantar fascitis. J Orthop Sports Phys Ther 2008;38:A1–A18.
58. Williams B, Zambardino J, Banning V. Transverse plane mechanics at the knee and tibia in runners with and without a history of achilles tendinopathy. J Orthop Sports Phys Ther 2008;38:761–7.
59. Murray IR, Murray SA, MacKenzie K, Coleman S. How evidence based is the management of two common sports injuries in a sports injury clinic? Br J Sports Med 2005;39:912–6.
60. Carcia C, Martin R, Houck J, Wukich D. Achilles pain, stiffness, and muscle power deficits: achilles tendinitis. J Orthop Sports Phys Ther 2010;40:A2–A23.
61. Lorenz D. Eccentric exercise interventions for tendinopathies. Strength and Cond J 2010;32:90–8.

Copyright 2012 by Turner White Communications Inc., Wayne, PA. All rights reserved.