What We Talk About
When We Talk About Running

B.J. Lehecka

“Of course it was painful... but pain seems to be a precondition for this kind of sport. If pain weren't involved, who in the world would ever go to the trouble of taking part in sports like the triathlon or the marathon, which demand such an investment of time and energy? It's precisely because of the pain, precisely because we want to overcome that pain, that we can get the feeling, through this process, of really being alive.” — Haruki Murakami, What I Talk About When I Talk About Running

Running Injuries

“Up to 70% of runners sustain overuse injuries during any 1-year period.”¹ Running-related injury is widely agreed upon as the following: "Running-related musculoskeletal pain in the lower limbs that causes a restriction on or stoppage of running (distance, speed, duration, or training) for at least 7 days or 3 consecutive scheduled training sessions, or that requires the runner to consult a physician or other health professional."²

“The causes of all overuse running injuries could be classified as training errors, and thus, all overuse running injuries should be preventable.”³

In a 12-month retrospective study of 446 men and women top-level Finnish athletes representing three endurance sports (cross-country skiing, swimming, long-distance running), athletes with less than 2 rest days per week during the training season had 5.2-fold risk for an overuse injury.⁴

The vast majority of running injuries are a result of overuse. Patellofemoral knee pain, meniscal pathology, shin splints or lower leg pain, Achilles tendinopathy, iliotibial band tendinopathy, plantar fasciitis, metatarsal stress fractures, and tibial stress fractures are among the most common running-related overuse injuries.⁵,⁶

Multiple authors have suggested a maximal increase of weekly mileage of no more than 10% to reduce the risk of injury.⁷,⁸ However, a study of a graded training program adhering to this 10% rule was tested in a randomized controlled trial and results showed that such adherence had no significant decrease in the number of running-related injuries compared to a faster training program (8-week versus 13-week training program for a 4-mile race).⁹ Moreover, a study of the effect of a 4-week preconditioning walking and hopping program on running-related injuries among novice runners revealed no decrease in injury

rates (the incidence was 15.2% and 16.8% in the treatment and control groups, respectively, over a 9-week training period). A review of literature reveals that injury rates are higher in runners with higher weekly mileage. One study of recreational runners reported the risk of running-related injury to be 1 injury per 100 hours of running exposure. Another reported a 20% chance of sustaining an injury among novice runners during an 8-week training program.

<table>
<thead>
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<tr>
<td>Restricted hip or ankle ROM</td>
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<tr>
<td>Increased Q-angle</td>
<td>Patellofemoral pain &amp; stress fractures</td>
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<td>DF ROM deficit &amp; greater PF ROM</td>
<td>Plantar fasciitis</td>
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<td>Low &amp; high arches</td>
<td>Shin splints &amp; knee pain; medial- &amp; lateral-sided injuries respectively</td>
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<td>Peak hip adduction &amp; IR during running</td>
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Summary

- Runners experience a high rate of overuse injuries, mostly at the knee, ankle, and foot.
- Runners with higher weekly mileage and fewer rest days experience higher rates of injury.
- A slow, graded increase of mileage during training is suggested; however, studies exist showing no decrease in injury rates using such a program or participating in preconditioning walking/hopping.
- Runners with hip or ankle strength deficits, limited hip or ankle mobility, abnormal arches, or increased peak hip adduction and internal rotation have an increased risk for running injury.

Proposals

- Runners should be advised in a graded progression of mileage with the inclusion of multiple rest days. See below for examples of such graded progressions for return to running, a 5K, and a half-marathon.
- A conditioning program targeting specific musculature and potential modification of running patterns are likely needed to prevent running-related injuries.
- Runners should undergo assessment of their hip and ankle mobility, hip and ankle strength, arch height, and running mechanics to determine appropriate interventions to reduce the risk of injury.

BEGINNING WALK/RUN PROGRAM (perform 3 times per week)

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<tr>
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<td>Week 8</td>
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3-WEEK 5K TRAINING PLAN FOR BEGINNER/INTERMEDIATE RUNNERS

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12-WEEK HALF MARATHON TRAINING PLAN FOR BEGINNER/INTERMEDIATE RUNNERS

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<td>Rest</td>
<td>Rest</td>
<td>Race</td>
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In one study, isometric strength measurements of the hip abductors and external rotators were taken in female runners. Trunk endurance was also assessed via a side-plank. Gait analysis was subsequently performed as the participants ran. Most notably, isometric strength was not related to kinematics, but side-plank endurance was associated with increased peak hip internal rotation.22

Striking Patterns

“Running can be most injurious at the moment the foot collides with the ground. This collision can occur in three ways: a rearfoot strike, a midfoot strike, and a forefoot strike. Sprinters often forefoot strike, but 75-80% of contemporary shod endurance runners rearfoot strike... Barefoot runners who forefoot strike generate smaller collision forces than shod rearfoot strikers. This difference results from a more plantarflexed foot at landing and more ankle compliance during impact.”23

“Habitually shod runners can gain more shock absorption by changing the striking pattern to a forefoot strike when running with shoes and barefoot conditions. Habitually shod runners may be subject to injuries more easily when they run barefoot while maintaining their heel strike pattern. Higher muscle activity in the gastrocnemius was observed when running with a forefoot strike, which may imply a greater training load on the muscle and a tendency for injury.”24

“Barefoot and barefoot inspired footwear were associated with significant reductions in patellofemoral contact force and pressure... and significant increases in Achilles tendon force compared to conventional shoes.”25 Forefoot runners have higher mean plantarflexion strength than rearfoot runners.26

“While minimal data exist that definitely support barefoot running, there are data lending support to the argument that runners should use a forefoot strike pattern in lieu of a heel strike pattern to reduce ground reaction forces, ground contact time, and step length.”27

Summary

• Most shod (shoe) runners have adopted a rearfoot strike pattern, while barefoot or minimalist runners are more likely to demonstrate a forefoot strike pattern.
• Rearfoot striking is likely to lead to more stress at the knee and hip than midfoot or forefoot striking, while the latter is likely to lead to more stress at the Achilles tendon despite smaller collision forces.

Proposal

• Patients attempting to transition to barefoot or minimalist running and the accompanying forefoot strike pattern to reduce impact forces (specifically those at the knee and hip) should be instructed in an ankle and foot strengthening program prior to adaptation.

# Foot & Ankle Strengthening Exercises

**Domino:** Sitting with the feet flat on the ground, lift the metatarsal knuckles and glide the toes towards the heel, creating a “dome” with the foot. Do not curl or hammer the toes, but rather keep them long and flat. If isolating these muscles proves difficult, use the hands to gently shape the foot to the correct position first, then let go and try to maintain the shape. This exercise is intended to strengthen the intrinsic foot muscles and support the arch.

**Progression:**
- Sitting, maintaining dome for 10-30 seconds.
- Standing, maintaining dome for 10-30 seconds.
- Unilateral stance, maintaining dome for 10-30 seconds.
- Unilateral stance, maintaining dome for 5 seconds followed by a small hop and landing with the dome maintained.
- Unilateral stance, maintaining dome for 5 seconds followed by a larger hop and landing with the dome maintained.
- Bilateral maintenance of doming while hopping side-to-side and forward/backwards to opposite extremity.

**Eccentric Heel Drops:** From an upright body position and standing with all body weight on the forefoot, and the ankle joint in plantar flexion lifted by the contralateral leg, the calf muscle is loaded eccentrically by having the patient lower the heel slowly with the knee straight. The exercise is also performed with the knee slightly flexed. Three sets of 15 repetitions twice per day have been recommended for both exercises in patients with Achilles tendinopathy. A “do-as-tolerated” frequency has also been described as similarly effective.

**Unilateral Balance:** Patient standing on one extremity first with eyes open, arms spread, and on stable ground. Advancement of the exercise involves modification of one of the aforementioned factors (i.e. blinding of the patient, arms crossed over the chest, or stance on a labile surface with or without external perturbations). Performance on this common, versatile exercise has been correlated with ankle strength in all directions.

**Running Retraining**

After gait retraining in one study of 10 runners with patellofemoral pain, hip internal rotation decreased by 23%, hip adduction decreased by 23%, and pelvic drop decreased by 24%. Moreover, pain during 30-minute runs was reduced by 86%, and loading rates were decreased by 20%. The participants were instructed to “contract their gluteal muscles and attempt to run with their knee pointing straight ahead, while maintaining a level pelvis.”

In a similar study, 10 female runners with patellofemoral pain completed 8 sessions of mirror and verbal feedback concerning lower extremity alignment during treadmill running. Retraining was effective in reducing peaks of hip adduction, pelvic drop, and hip abduction moment during running. Most mechanics were maintained at 1 and 3 months post retraining in the absence of continued feedback, and subjects reported significant improvements in pain and function. The participants were instructed...

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to “run with [their] knees apart with [their] kneecaps pointing straight ahead” and to “squeeze [their] buttocks.”

In another study of 10 runners with relatively high peak positive tibial acceleration, eight 15-30-minute retraining sessions significantly reduced tibial acceleration (by nearly 50%), vertical force loading rates (by approximately 30%), and vertical force impact peak (by 20%). These reductions were maintained at the one-month follow-up and hypothesized to reduce the risk of stress fractures. The participants were instructed to “run softer” and “make their footfalls quieter.”

In a single-subject study of a female runner with IT band syndrome, nine 15-30-minute running retraining sessions appeared to improve running time (by 12.5%), reduce pain while running (by 50%), and improve the subject’s LEFS score (by 10%). The subject was instructed to “keep the knee pointing forward, reduce the arm swing, and keep the foot pointing forward.”

Summary

- Running retraining has been shown to significantly decrease pain and improve function in runners with patellofemoral pain and IT band syndrome.
- Retraining has also been shown to significantly decrease hip internal rotation, hip adduction, pelvic drop, vertical force loading rates, vertical force impact peak, and tibial acceleration. All of these changes can be argued to reduce the risk of running injury.
- The following instructions have evidence to support their use during running retraining:
  - “Contract the gluteal muscles” or “squeeze the buttocks.”
  - “Attempt to run with the knees/kneecaps/feet pointing straight ahead.”
  - “Run with the knees apart.”
  - “Run softer” and “make the footfalls quieter.”

Proposals

- Clinicians treating runners should observe their running gait over multiple sessions and provide the aforementioned cues regularly to reduce the risk of recurrent injury. Cues about cadence should not be neglected, and these details will be specifically described in the pages ahead.
- Considering participants in the running retraining studies were shown visual feedback of their kinematics in addition to being provided instructions for retraining, clinicians should strongly consider using video recording to provide runners with additional feedback and monitor for specific deviations.

The Ubersense app (www.ubersense.com) allows free video recording of running gait with the ability to slow the motion to 1/8th of the recorded speed, measure joint angles, zoom, record voice-over commentary, and subsequently send the video to the runner.

Resistance & Interval Training

Resistance training has been shown to improve performance among recreational endurance runners. Six or more weeks of sport-specific, explosive resistance training or heavy weight resistance training have shown to improve running economy by up to 8% and performance by 2.9% in 3 km and 5

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km runs (equating to about 37 seconds for a 21-minute 5K runner). One study demonstrated significantly improved 5-km running times with the addition of 9 weeks of explosive-type strength training to runners’ normal aerobic training regime. Moreover, interval training has been associated with lower risks of running-related injuries. The benefits of strength training are theorized to be a result of improved neuromuscular characteristics, improved running economy, or improved anaerobic capacity.

Several types of resistance training are available for the 5K runner to improve performance. Traditional resistance training (lunges, squats, leg press, etc.) is a beneficial option. It has been shown to improve performance in both trained and untrained runners. Time to exhaustion at 80% VO2max and time to exhaustion at 100% of VO2max were improved in both types of individuals following 10 weeks of leg resistance training 3 to 5 times per week. Given the average 5K run time (somewhere between 15 and 35 minutes), time to exhaustion at 80% VO2max may be of most interest; however, bursts of energy at full oxygen consumption are also used near the finish of 5K races.

Interval training – training at speeds higher than race pace for shorter distances – has also been shown to increase performance. One study by Gunnarsson et al found an improvement in 5K times by 48 seconds after seven weeks of replacing normal training with interval routines. This improvement was especially surprising given about a 50% decrease in training volume among participants during the intervention period. Other studies show similar results. For example, even in well-trained individuals, one study found that replacing several normal training runs with 30-second maximal running bouts for a four-week period improved performance, despite a 64% reduction in training volume. Yet another study demonstrated that the integration of 30-second sprints and high-intensity aerobic training (4 minutes with a heart rate of 90-100% of maximal heart rate, repeated four times for 6-9 weeks) improved running performance despite a 25% reduction in training volume.

Interval speed training can be implemented into a 5K runner’s training program in an infinite number of ways. One suggested method is the 10-20-30 routine studied by Gunnarsson et al. This method begins with a 3/4 mile warm-up of low-intensity running followed by three or four 5-minute running bouts spaced by 2-minute rest periods. Each 5-minute bout consists of five continuous 1-minute running intervals. Each interval is divided into 30, 20, and 10 seconds at an intensity corresponding to <30%, <60%, and 90-100% of the runner’s maximal intensity, respectively. This training session was repeated 3x/week during the first four weeks of the study, and 4x/week during the final three weeks.

Lastly, one study showed that a 6-week core strength training program correlated to a significant improvement in 5K run times (n=20) compared to controls (by 30 seconds; mean post-
training 5K time of 28:42). The training program included the following exercises performed 4 times per week (2-3 sets of 10-15 repetitions each time): (1) abdominal crunch on a stability ball to target abdominal muscles; (2) back extension on a stability ball to target back extensor muscles; (3) opposite 1-arm/1-leg raise to target back/hip extensor muscles; (4) hip raise on a stability ball to target back/hip extensor muscles; and (5) Russian twist on a stability ball to target abdominal muscles.

**Summary**
- Six to 10 weeks of resistance training (explosive resistance training, heavy weight training, or more traditional resistance training of the legs or core) significantly improves running economy and running performance (i.e. a 30-second improvement in 5K times).
- Four to nine weeks of interval training substituted for normal training significantly improves running performance (i.e. a 48-second improvement in 5K times) despite significant reductions in training volume (25-64%).

**Proposals**
- Runners should include resistance training and interval training in their training schedules to significantly improve performance and reduce injury risk. Moreover, it can be hypothesized that a significant decrease in injury rates may occur given the decrease in training volume (one of the highest predictors of running injury) as miles are replaced with interval training.

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### 5K & HALF MARATHON TRAINING PLAN with RESISTANCE (RT) & INTERVAL (IT) TRAINING

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**RT:** progressive resistance training including lunges, squats, heel raises, and planks  
**IT:** the 10-20-30 routine as outlined previously

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Cadence

When step rate was increased to 110% of the preferred, the hip and knee absorbed significantly less mechanical energy; moreover, peak hip adduction and internal rotation moments were found to decrease.\(^\text{45}\) Center of mass vertical excursion, braking impulse, and peak knee flexion angle also significantly decreased.

Increasing step rate to 110% of the preferred reduced peak patellofemoral joint force by 14%.\(^\text{46}\) Peak stance phase knee flexion decreased with increasing step rate and was found to be the most important predictor of the reduction in patellofemoral joint loading. The range of running cadence was 140–211 steps per minute.

Running with an increased step rate (5–10% above preferred) significantly increased gluteus medius and maximus activity during late swing phase.\(^\text{47}\) It was suggested that this may subsequently decrease peak adduction angles during stance phase.

Faster cadence reduced contact time, pressure and force variables in both the heel and metatarsal regions. Increasing cadence did not elevate metatarsal loads; rather, loads to the total foot and all regions were reduced when healthy runners increased their cadence. If a 5% increase in cadence from preferred were maintained over each mile run, the impulse at the heel would be reduced by an estimated 565 body weights*seconds (BW*s) and the metatarsals 140–170 BW*s per mile run despite the increased steps taken. Increasing cadence may benefit overuse injuries associated with elevated plantar loading.\(^\text{48}\)

Time-to-exhaustion was 18.1% and 19.7% longer, respectively, when running in time to motivational and neutral music, compared to no music.\(^\text{49}\) “Running to motivational music with a very prominent and consistent beat matched to the runner’s cadence will likely yield optimal effects.”\(^\text{50}\)

Summary

• When running cadence is increased by 10%, multiple benefits occur: (1) the hip and knee absorb significantly less mechanical energy; (2) peak hip adduction and internal rotation moments decrease; (3) center of mass vertical excursion, braking impulse, and peak knee flexion angle significantly decrease; (4) patellofemoral joint force is reduced by 14%; (5) gluteus medius and maximus activity increases during the late swing phase; and (6) pressure and force variables in the heel and metatarsal regions are reduced.

• Running with music significantly increases time to exhaustion by almost 20% and yields optimal effects when matched to the runner’s cadence.

Proposals

• Runners should attempt to increase their running cadence by 5-10% to optimize their running kinematics and potentially reduce the risk of injury.

• Music should be used while running to maintain optimal cadence while simultaneously improving performance.

The i-Metronome app or similar apps allow the user to tap a button to determine the beats or steps per minute of a song or cadence, respectively. Tailored music may be the ideal way to retrain running cadence and improve performance (www.running-physio.com/music/):

<table>
<thead>
<tr>
<th>BPM</th>
<th>ARTIST &amp; SONG</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>Pharrell Williams “Happy”</td>
</tr>
<tr>
<td>164</td>
<td>Switchfoot “Hello Hurricane”</td>
</tr>
<tr>
<td>169</td>
<td>The Script “Hall of Fame”</td>
</tr>
<tr>
<td>172</td>
<td>Eminem “Lose Yourself”</td>
</tr>
<tr>
<td>175</td>
<td>Jay-Z “Empire State of Mind”</td>
</tr>
<tr>
<td>180</td>
<td>Angels and Airwaves “Call to Arms”</td>
</tr>
<tr>
<td>180</td>
<td>Katy Perry “Roar”</td>
</tr>
<tr>
<td>185</td>
<td>Coldplay “Hurts Like Heaven”</td>
</tr>
<tr>
<td>185</td>
<td>Sara Bareilles “Brave”</td>
</tr>
</tbody>
</table>

Smartphone apps such as “Adidas Go” are able to sync steps per minute with downloaded music or music from “Spotify.”

A free audio editor and recorder called Audacity can be used to change the tempo of any song to match any desired cadence (http://audacity.sourceforge.net/). After downloading the program, open the desired music file, choose “Change Tempo” from the “Effects” tab, enter the current tempo of the song in beats per minute and the desired tempo, then choose “Export” from the File tab to save your new song.

“There are both physiological and psychological benefits from maintaining positive facial expressions during stress.”

In other words: smile while you run.

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