Chapter 3: Common Injuries and Therapy Management for Runners

4 Contact Hours

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Learning objectives

- Discuss key biomechanical impairments that contribute to injuries in runners and identify the physical therapist's role in facilitating healing, as well as improving practical function of an injured runner.
- Define gait cycle and discuss the key components of each phase.
- Summarize the fundamental components of objectively and subjectively evaluating a runner, including efficiently using initial intake forms, effectively observing the runner to recognize any abnormalities, and providing suggestions for improvement to avoid future injuries and pain.
- Identify and discuss the importance of footwear considerations, including the types, design and performance of the shoe and how the quality of the shoe and its fit will dictate the foot contact performance of the runner.
- Describe common injuries and common sources of pain or discomfort found in runners; discuss the pathology, symptoms and treatments of each.
- Discuss the treatment principles for physical therapy, including isolating mechanical dysfunctions, strengthening weak muscles, encouraging running efficiency, controlling tissue loading and overuse and training in dynamic stability.

Introduction

Running, as a hobby and as a hard-core competitive sport, has virtually exploded in popularity in the past several decades because its health benefits and also because of its sheer accessibility. According to RunningUSA.org (2015), the sport has experienced a 300 percent growth from 1990 to 2013. In the United States alone, approximately 40 million people run regularly; more than 10 million people run at least 100 days per year. The popularity has spawned entire industries: from the evolution and progress of increasingly functional running shoes and fashion, to themed races, events and activities aimed at an adventurous, health-conscious and active crowd. IBISWorld, a market research firm, values the road-running industry at $1.4 billion.

With the popularity of running increasing, so are the frequency of injuries reported for those involved in the sport - many of these injuries involve the lower extremities; the most commonly injured body part is the knee. This course will familiarize the physical therapy professional with the unique needs, complications and injuries that he or she may encounter when dealing with runners in his or her daily scope of practice.

THE ROLE OF THE PHYSICAL THERAPIST

The general principles of physical therapy treatment apply to the treatment of runners; however, this population requires several special considerations. The goals of physical therapy treatment for an injured runner are to:

- Achieve pain-free movement.
- Resume control, balance, and symmetry of running gait.
- Educate the patient on principles of maintenance and future injury prevention.
- Address patient-centered concerns and goals.

BIOMECHANICS OF RUNNING

When analyzing causing factors of running injuries, it is crucial to break down running gait into its mechanical phases.

Phases of the running gait

1. Weight acceptance/loading response:
   a. Initial contact – Note which portion of the foot the runner makes initial contact with. Generally, runners who contact the ground at the forefoot incur less injuries than those who exhibit a rear-foot or heel first initial contact pattern.
2. Single limb support:
   a. Mid stance – If the runner is a forefoot initial contact runner, the foot will remain in forefoot contact during this phase. If the runner is a heel first contact runner, this phase will consist of transition from the heel to the forefoot with a heel raise observed.
   b. Terminal stance – Mid-phase, generally observed with the heel raised.
   c. Pre-swing – The final phase of single limb support, consisting of the heel raise to toe off.
3. Swing limb advancement:
   a. Initial swing – The limb is no longer weight bearing, and the hip moves from extension towards flexion.
   b. Mid swing-phase of maximum hip flexion and knee flexion.
   c. Terminal swing – Phase prior to reverse swing phase. This phase is where running gait most drastically differs from walking gait, as the swing limb must reverse prior to returning to initial contact.

The functional demands of running locomotion

1. Forward movement – Propulsion of the body forward.
2. Stability.
3. Shock attenuation – This is key for injury prevention.
4. Energy conservation – Use of the most efficient running form is crucial for energy conservation.
5. Single limb support.
6. Foot clearance – Possible through sufficient hip flexion.
7. Maintenance of a stable trunk and head for vision and balance.

EVALUATION OF THE RUNNER

The patient should be informed prior to their evaluation to bring their running shoes and any personal medical equipment they have been running in (orthotics, braces, etc.). The patient should wear or bring running shorts, socks, and a T-shirt or tank top for their evaluation and expect to run on the treadmill as part of their evaluation if their injury allows them to.

As with any other orthopedic patient, initial evaluation of the running patient begins with an intake questionnaire. A pain scale, body chart, current complaint, and complete current and past medical history should be included. An additional form unique to runners should be included as well in order to collect pertinent information regarding the running injury.

Initial intake form running questions

1. **Current running shoe type** – Motion control, neutral, minimal, maximal, and trail are common categories of running shoe.
2. **Running shoe mileage** – Average miles put on a shoe before it is retired. There is no hard and fast value for how many miles should be put on a shoe. A runner with faulty running form may put high impact and strain on a shoe and be required to retire the shoe far earlier than a runner with a soft running stride.
3. **Warm-up habits** – Does the patient warm up? Are they stretching before or after exercise? Is the stretching static or dynamic?
4. **Running surfaces** – Approximately how many miles per week does the patient spend on the street, track, treadmill, or a trail? If they are running on the street, follow-up questions during evaluation may include: Are they always running on the same side of the street? Do they run the same route consistently? If they run on a trail, is the trail comprised of dirt, gravel, bark mulch, and are there roots, large rocks, or other obstacles?
5. **Training mileage** – What does an average month of running look like? Are they currently training for a race? Are they in a training cycle where they are steadily building up mileage, or is their running more sporadic? Are they including speed work or track workouts?
6. **Cross training** – Does the runner participate in other forms of training or exercise?
7. **Lifestyle and activities of daily living (ADLs)** – What demands are placed on their body in their job, home life, chores, etc.?

Subjective examination: Similar to a general orthopedic evaluation, a subjective examination will consist of follow-up questions on information on the intake form. The therapist should seek to gain understanding of the source of the current problem, the duration and chronicity of the injury, and contributing factors. The therapist should rule out red flags for appropriateness of the patient for safe physical therapy treatment. This includes screening for the presence of the following:

1. Change in bowel or bladder control.
2. Pattern of pain intensity – Is the pain positional or activity related, or is it incessant?
3. Is the patient experiencing light-headedness or loss of consciousness at any point?

It should be noted that questions regarding night pain have been controversial as a red flag due to the finding that night pain has been associated with osteoarthritis and mechanical low back pain in individuals with non-red-flag-associated illness. Clinicians should keep in mind that the finding of night pain should be considered as one component of a more complete clinical picture when ruling out serious pathology.

Objective examination: Initial evaluation should consist of observation of the patient running on a treadmill if the patient is capable of running with the injury. This portion of the evaluation should be video recorded, if possible for review with the patient for educational purposes and so that they may observe themselves running. Video recording also presents the opportunity to slow the motion digitally to allow the physical therapist to note the intricacies of the gait cycle.

During running gait observation, therapists should allow the patient to select a comfortable pace on the treadmill. The treadmill placement should allow the therapist to view the runner from all vantage points: posteriorly, anteriorly, and laterally from the left and right. This allows for observation of sagittal and coronal mechanics. Transverse plane mechanics may be deduced from these planes as well.

Additionally, therapists should measure the cadence of the runner. They may count the number of strides per minute, which is most easily counted in foot strikes on one limb side and multiplied by two. Some evidence suggests that 180 foot strikes per minute is the most physiologically efficient rate of running. This value has not definitively shown to decrease injury rate; however, increasing a slow stride rate by 10 percent can reduce center of mass vertical excursion, braking impulse, and mechanical energy absorbed at the knee, as well as decrease peak hip adduction angle and peak hip adduction and internal rotation moments during running.

Gait observation can reveal pertinent information about the cause of chronic running injuries due to faulty running mechanics. More often than not, the site of injury or pain is due to a functional impairment either above or below the painful area. These dysfunctions may be classified in planes of movement.

Sagittal plane dysfunctions: Often the most revealing plane of gait abnormality leading to injury. At this vantage point, the physical therapist can determine foot strike pattern and other important parameters.

1. **Foot inclination** – The angle created by the sole of the shoe and the surface of the treadmill at initial contact creates this measure. Excessive dorsiflexion leads to a high value of foot inclination and is associated with increased ground reaction forces in the lower limb, particularly the knee, which is associated with injury.
2. **Knee hyperextension** – The knee may snap into hyperextension during stance phase, placing excessive force on the knee joint and foot.
3. **Hip extension** – Reduced hip extension in late stance can be associated with hip and low back pain during running; however, the exact value of hip extension required varies depending on the speed of the runner. A slower jog will generally produce a shorter stride and thus require less hip extension, whereas a faster run will require more hip extension. Hip extension is often a value that gives more clinical knowledge when combined with observation of the lumbar spine and the lower limb.
4. **Anterior pelvic tilt/increased lumbar lordosis** – The runner may exhibit a sway back posture during running, or anterior pelvic rotation, inducing an increase in lumbar lordosis. It has been suggested that approximately 10 degrees of anterior pelvic tilt and 7 degrees of forward trunk lean with resulting decrease in lumbar extension results in decreased forces at the patellofemoral joint without increased strain on the ankle.
5. **Vertical displacement of center of mass** – This is a measure of how much height or bounce the runner demonstrates with each stride. This is most easily observed at the head. Ideally this value will be minimal, as increased vertical displacement is associated with injury mechanics and is not energetically efficient.

Transverse plane dysfunctions:

1. **Thoracic rotation** – Either in excess or limitation. The thoracic spine should rotate over the contralateral advancing limb during running gait in various amounts depending on the speed of the runner. A faster speed will yield a smaller rotation, whereas a slower jog will yield slightly more rotation. The presence of true scoliosis in the thoracic spine can affect running gait as well.

2. **Pelvic rotation** – Approximately 15 degrees during swing limb advancement or toe off.
3. **Femoral rotation** – Most easily observed by analyzing the relationship between the pelvis and the patella during stance phase. This motion should be limited, with excessive femoral rotation associated with hip and knee pain.
4. **Tibial rotation** – Most easily observed by analyzing the relationship between the patella and the foot. This also should be limited with excessive motion here associated with knee and ankle pain.

Frontal plane dysfunctions: This includes views of both the anterior and posterior aspects of the runner.

1. **Stride width** – From the posterior view, the right and left foot should not overlap each other in their ground contact location, as this pattern is associated with medial tibial stress syndrome. Likewise, there should not be more than 2-4 inches of distance in ground contact location lending to an overly wide stride width.
2. **Calcaneal eversion** – Generally associated with over-pronation of the foot in stance phase, and seen in conjunction with knee valgus and hip adduction. This is commonly associated with poor hip and lower limb strength.
3. **Knee valgus** – Often seen with hip adduction during stance phase and highly correlated with knee injury.
4. **Hip adduction** – Often seen with knee valgus and upward pelvic tilt during stance phase.
5. **Pelvic tilt** – Contributes to hip adduction and correlated with injury. This is often associated with weak core, hip abductor and hip rotator muscles.
6. **Spine lateral flexion** – There should be very little lateral flexion of the spine; however, in the presence of pelvic tilt with associated hip and core weakness as discussed above, lateral flexion may be observed similar to a Trendelenburg sign as seen in walking gait. This occurs particularly in patients reporting back pain while running.

Physical examination of the runner: The observation of the runner on the treadmill and review of video footage, if available, will assist the therapist in directing the physical examination process. Faulty running mechanics indicate areas of restriction and muscular weakness, and the physical therapist can systematically test the areas in question.

1. **Standing examination**.
   a. Posture – Analyze standing posture and bony alignment. Note asymmetry in bony landmarks such as navicular height, knee joint angle, iliac crest, anterior superior iliac spine (ASIS), posterior superior iliac spine (PSIS) and clavicles.
   b. Spine range of motion – Flexion, extension, side bending, and rotation.
   c. Functional squat – Observe the patient squat to the ground, note depth of the squat, ability to keep the feet flat on the floor, pelvic angle, and spine position. This can be observed as a double leg squat and single leg squat on each limb. During single leg squat, therapists should observe the patient's depth of the squat, control of the knee angle, and ability to balance.
   d. Dynamic abilities – Therapists should observe the patient walking on the toes and then heels for approximately 10-20 feet. Additionally, they should observe the patient's ability to perform single leg heel raise for at least 10 repetitions on each limb. During the heel raises, PTs should observe calcaneal position, specifically looking for calcaneal eversion, as this can indicate decreased ankle strength and stability which may contribute to running issues. Therapists should have the patient perform single leg step-ups on an 8-inch step up both anterior and laterally; this will also give information about lower extremity strength and dynamic control.
   e. Stork test for pelvic mobility – The patient stands with their back to the therapist. Palpate the posterior superior iliac spine (PSIS) and the spinous process exactly horizontal to it, placing one thumb on the PSIS and the other thumb on the spinous process opposite. Have the patient lift one knee up as high as it will go. If the sacroiliac (SI) joint is functional then the posterior-superior iliac spine will move down under its original position, rotating at the ilia. A dysfunctional SI joint will not rotate at the ilia.
   f. Asymmetrical lunge test (wall test) – A test for ankle dorsiflexion in standing position. The weight-bearing lunge is performed in a standing position with the heel in contact with the ground, the knee in line with the second toe, and the great toe 10 cm away from the wall. PTs should have the patient contact the wall using two fingers from each hand for balance. Have the patient lunge forward, directing their knee toward the wall until their knee touches the wall. If the patient is unable to reach the wall move the foot forward incrementally 1 cm. until they can touch the knee to the wall. If they can reach at 10 cm, then the foot is progressed away from the wall 1 cm at a time, repeating the lunge until they are unable to touch the wall with their knee without lifting the heel from the ground. Repeat on both sides.10 Normative values for this test are 10-12 centimeters from the wall to the great toe. Inability to reach the wall at 10 cm indicates restriction in ankle dorsiflexion which is associated with lower extremity injury in athletes.

Asymmetrical lunge test (wall test)

   g. Single limb jump – Observe height of jump, symmetry of each limb during the jump, and control during the loading and landing portion of the jump. Observe whether the patient is able to land softly.
   h. Foot position.
      i. Static navicular height – Measure the distance between the floor and the navicular bone on each foot.
      ii. Dynamic navicular height – Measure the distance between the floor and the navicular bone with the patient seated, and then have the patient stand and re-measure, looking for a difference between seated and standing position. In a laboratory setting, this is measured using three-dimensional video testing during walking and running.
      iii. Evidence – While these measurements are good to note when forming a broad clinical picture, they do not predict injury rate in runners. Furthermore, research shows that

static foot alignment testing is not predictive of foot alignment during walking or running, though dynamic assessment of navicular mobility may be an effective tool to examine how the force demands of gait and structure and neuromuscular control affect foot function in walking and running.

   i. Arch type – There are three basic arch types: normal, high, and low.

2. **Seated examination**.
   a. Seated posture – Observe pelvic rotation, and general symmetry and alignment.
   b. Lower extremity strength test – Quadriceps, hamstrings, hip internal, and external rotation.
   c. Range of motion of the hip – Internal and external rotation.
   d. Foot examination – If foot pain is present a subtalar drawer test, and forefoot splay test are beneficial.
3. **Supine examination**.
   a. Limb length measured from the ASIS to the medial malleolus.
   b. Hip range of motion – Flexion, adduction, abduction, and bent knee internal and external rotation.
   c. Knee range of motion – If knee pain is a complaint.
   d. Knee stability tests: Lochman's test for the Anterior cruciate ligament (ACL), Valgus test for the Medialcolateral ligament (MCL), Varus test for the lateralcolateral ligament (LCL).
   e. Straight leg raise – Assist ascent and descent, analyze hamstring length.
   f. Active straight leg raise – The patient will raise one limb approximately 45 degrees independently. Analyze core and pelvic stability on both ascent and descent.
   g. Ankle dorsiflexion and plantarflexion.
   h. Foot examination.
      i. ROM: Metatarsalphalangeal extenstion – 70 degrees.
      ii. Stability testing of the talocrural and subtalar joint.
      iii. First ray mobility of the foot.
4. **Side-lying examination.**
   a. Hip abduction and adduction strength-hip abduction strength is highly correlated to knee valgus which is a contributing factor to injuries such as Iliotibial band friction syndrome.
   b. Ober's test for iliotibial band restriction.
   c. Hip extension range of motion.
5. **Prone examination.**
   a. Passive intervertebral mobility testing.
   b. Gluteal and hamstring strength.

FOOTWEAR CONSIDERATIONS

Assessment of running footwear is vital to the outcome of therapy, as poorly fitting or improperly selected footwear can negate the effects of rehabilitation once the runner resumes running. Running footwear has become a hotly debated topic with the onset of polarizing philosophies regarding lightweight or minimalistic shoes, maximalist shoes, and everything in between. Christopher McDougall's 2009 best-selling book Born to Run brought this topic to popular culture and led consumers to purchase minimalist shoes or even to begin running barefoot.

This topic is controversial for many reasons. Long-standing marketing trends, influence of famous athletes, media, and varying beliefs among coaches and healthcare professionals all contribute to the input in consumer habits. Anecdotal evidence suggests that, ultimately, the physical therapist may make footwear recommendations based on sound biomechanics, and the patient may or may not choose to follow through because a running shoe is a consumer choice, not a medical equipment device. As consumers, runners tend to purchase shoes based upon the look and feel of the shoe, sometimes with little regard or education about the mechanics of the shoe and the appropriateness of the shoe for their individual running ability. The physical therapist may observe that the patient has purchased a particular shoe because they were told by a coach, friend, or salesperson that the shoe may perform certain aspects of the work of running for them.

Running shoe types: There are three essential running shoe mechanics categories: neutral, motion control, and cushion. There is no conclusive data on how best to match a runner to a type of shoe, though the design of the shoe can influence the gait of the runner. Evidence demonstrates that in particular, midsole stiffness and shape can change running mechanics. Evidence also suggests that incorrect footwear choices can exacerbate or cause lower extremity dysfunction, while ideal footwear can assist in preventing injury due to decreased stress on injured tissue. Furthermore, it has been demonstrated that the style of shoe can dictate the foot contact performance of the runner. A study by Lieberman et. al. demonstrated that 80 percent of African runners who ran barefoot ran with a forefoot contact style.

In the past, wet-foot tests for footprint type and dynamic foot measurements have been used to determine which running shoe category to place a patient into. Richards et. al. determined that while these clinical tests offer a way to classify the foot, these methods are not effective as a means of prescribing footwear. Research shows that although the footwear industry has made advancements in the quality of construction of shoes, focus on midsole production, and production of various shoe types (cushion, neutral, and motion control), these changes do not correspond to a decrease in injury rate in runners. By and large, this research suggests that although most running shoe companies have created shoes with elevated and cushioned heels and pronation control midsoles, these changes have not reduced injuries in runners. When analyzing foot type, new evidence further suggests that foot pronation is not associated with injury risk to newer runners. Thus, placing overly pronated feet into motion control shoes is rendered unnecessary.

There is evidence that this type of shoe is actually more harmful to the runner[2]. Cushioned running shoes are built with a 2:1 ratio wherein the rear foot is twice as high as the forefoot. The 2:1 ratio that heel cushioned, motion-control shoes also causes an increase of load on the forefoot, which translates to increase muscle activation of the quadriceps over the gluteus maximus muscle. It can result in gait changes as well. This is because the cushioned build can dictate foot contact style of the wearer, often promoting heel-first contact, which alters muscle activation in the lower extremity. Specifically, the heel-first strike causes increased muscle loading of the quadriceps muscle which can lead to increased joint torque at the knee, while forefoot contact style encourages muscle load at the gastrocnemius. This cushioned build of shoe also places the ankle joint in plantarflexion during stance phase, which is a position of poor proprioception.

It is not only cushioned and motion-control shoes that cause changes to a runner's gait, but any shoe worn while running. Kinematic studies show that when a runner's gait was examined in a barefoot and shoe-wearing condition, there were significant changes. Namely, cadence increased while stride length decreased during barefoot condition. Runners are more likely to demonstrate a forefoot contact style while barefoot and show improved physiological running economy as well. Wearing a shoe resulted in increased joint torque of 36 percent in knee flexion at the patella, 38 percent knee varus, and 54 percent hip internal rotation.

Width of the shoe is extremely important in decreasing forces placed through the foot and into the lower extremity. If the shoe is narrower than the foot, squeezing the foot into the shoe results in decreased base of support, and limited splay of the foot at the metatarsals, which then limits the reactivity of the foot. The best way to determine if the shoe is too narrow for the patient is to remove the inside sole of the shoe and have the patient stand on it. If the foot splays over the sole pad and is wider than the print, this indicates that the shoe is too narrow. This is a helpful tool for patients to utilize when shopping for shoes as well.

Another way that shoe wear affects the runner is in design of the midsole of the shoe. Midsole stiffness of the running shoe has been shown to be highly impactful on proprioception of the foot. Increased cushioning of the shoe results in the runner contacting the ground with increased limb stiffness and can lead to instability resulting from decreased proprioceptive feedback from the foot. The effect of increasing midsole cushioning on proprioception was further studied and found to have a marked impact on both oxygen consumption of the runner and functional patterns of the lower leg. A softer midsole has also been found to result in greater vertical impact forces while running.

While popular belief is that a highly cushioned shoe will provide elastic properties that will compress and then rebound, contributing to performance of the run, this has been found to be mechanically incorrect. When compared to a running shoe, the muscular and tendinous tissues of the body store energy and recover ten times more. This is because the physical properties of the shoe, commonly made of ethyl vinyl acetate (EVA) or polyurethane, absorb energy from the runner, but do not return it. The energy recovered from the cushioned shoe is found to be statistically quite small.

When considering motion control of the foot and the body in shoes, or even the addition of orthotics, it is important to recognize what role these external devices truly have on the structure and function of the body. Shoe construction has not been found to improve static structure, range of motion, or force vectors. What the shoes and orthotics actually do is cause compensatory changes which result in altered proprioceptive feedback through the shoe interface, as discussed above in the principles of stiffness and cushioning of the shoe.

While there is a great deal of evidence of how a running shoe can negatively affect a runner, therefore suggesting what not to wear, there is a paucity of literature supporting what a runner should wear. Furthermore, there is little evidence to direct a physical therapist in assigning a particular runner to a shoe. Thus, it is important to make recommendations based on sound clinical judgement and information gathered during the evaluation regarding the patient's strength, flexibility, dynamic control, and proprioceptive capabilities in conjunction with running style.

When recommending footwear for runners, therapists should consider the following:

1. **Fit of the shoe**: Remove the shoe insert from the shoe and have the patient stand on it. If their foot spills over the sides, the shoe is not wide enough. There should also be half of an inch distance from the great toe to the front of the shoe. It is recommended that shoes be tried on in late afternoon, as this is a common time of day for feet to be slightly swollen.
2. **Running surface type**: Where is the patient commonly running? Many well-made street running shoes can be worn on flat and basic dirt or light gravel paths if the runner exhibits good proprioceptive capabilities. A trail running shoe should be considered for running on highly uneven terrain such as trails with larger rocks and tree roots.
3. **Distances the runner is intending to run**: Is the patient a novice or well trained? The novice runner may have weaker intrinsic foot and lower extremity muscles and benefit from a stiffer midsole, whereas the well-trained runner may be strong enough for a more minimal shoe. This will be discussed in greater detail later.
4. **Price of the running shoe**: Evidence suggests that more expensive running shoes do not result in fewer injuries, and in fact, may be associated with more injuries and a lower rating overall by consumers.

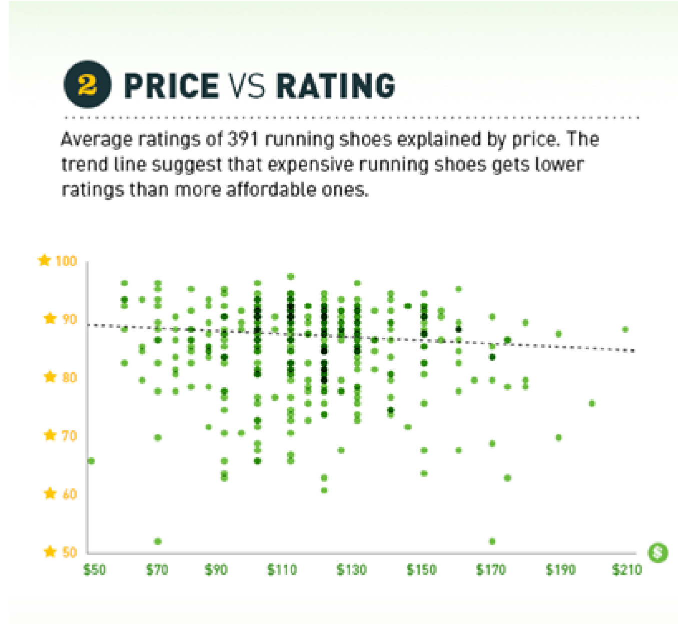

Image via RunRepeat

5. **Shoe durability**: Most manufacturers recommend buying new shoes between 300-500 miles. The midsole of most shoes loses 60 percent of its cushion capabilities after 400-500 miles.
6. **Weight of the shoe**: The heavier the shoe, the less physiologically economical it becomes for the runner. Specifically, for every 3.5 oz added to a foot, the energy cost for the runner increases by 1 percent.

Minimalist shoes are shoes that are lightweight and tend to have a minimal drop from the heel to toe of the shoe. Due to the lack of cushioned heel and overall weight of the shoe, evidence suggests that they are associated with fewer running injuries. While the minimal shoe is suited for most runners, not every patient can simply buy a pair of minimal running shoes, lace them up, and start running in them right away, as these shoes require the body to have strength and flexibility in order to avoid gait changes that may result in injury. Certain adaptations in the body need to be made prior to running in the shoe in order for it to be effective. This includes mobility in the Achilles tendon, as the minimal heel drop allows for greater range of motion at the ankle. The absence of the elevated heel of a cushioned shoe also requires more motion of the forefoot, as the shoe does not propel the runner forward through a rocking motion. Less cushioning and support overall in the minimal shoe requires the runner to have strong intrinsic foot muscles as well as ankle stabilizers in order to support the forces placed through the limb while running.

There are three criteria that a patient should meet prior to running barefoot or in minimal shoe:

1. Achilles tendon and plantar fascia mobility.
2. Single leg balance ability: The patient should be able to balance at least thirty seconds.
3. Ability to isolate the flexor hallucis brevis while standing (toes up, big toe down).

Evidence suggests that for the average recreational running population, consisting of runners who are steadily training and who participate in a long-distance run every now and then, the overall yearly incidence rate for running injuries varies between 37 and 56 percent. This statistic will vary for sub-populations of runners such as youth athletes and elite runners. With race participation steadily on the rise, physical therapists can expect to see a growing population of injured runners turning up in the clinic.

Training error induced injury

While runners often look to external forces, such as shoes or running surfaces for blame when they become injured, it is often the runners themselves that are at fault. The leading cause of injury to runners is training errors. Mileage per week and month, intensity of running workouts, running surface, and consistency are all factors leading into training induced injury. When evaluating a runner's training habits, it is important for therapists to discuss their overall training plan, or lack thereof, and cycle pattern.

A healthy training program will be fairly consistent, not erratic. It may include a pyramid or build-up of mileage, especially if they are training for a longer-distance race. These training plans tend to include weekly training runs of various lengths, and long runs on weekends. The long run should account for approximately 30 percent of the weekly mileage total. Long runs will often increase gradually by one to two miles per week, peaking approximately three to four weeks prior to the race before tapering down to allow the body to acclimate and then rest. This training program is common in half- and full-marathon racing as well as ultra-running distances.

Cross training is also important in a healthy running program. Maintenance of overall strength in muscles that are both directly and indirectly involved in running is important. Including balance and stability drills and training is also important. Effective cross training includes things such as weight lifting, swimming, yoga, Pilates, and participating in other sports.

Varying of running surfaces and intensity of runs is also important. Varying the pace and effort of particular runs is beneficial in improving aerobic capacity, and in preparing the body for greater challenges. Rest days each week are vital to preventing overuse injuries. This may involve limiting physical activity all together, or participating in an active rest day, which may involve yoga, Pilates, stretching, or swimming. Physical therapists should ask the patient questions about nutritional habits, and to refer them to a nutritionist if necessary.

General causes of running injuries are:

1. Poor motor control – Lack of coordination or timing in running gait.
2. Mechanical compensations or substitution patterns – Often due to weakened muscles or tight connective tissue, or improper footwear.
3. Delayed onset muscle soreness (DOMS) – Usually within 24 to 48 hours of a hard run and can be accompanied by inflammation.

Tibialis posterior tendinopathy

The tibialis posterior tendon courses posterior to the medial malleolus and inserts into the navicular tuberosity and the middle section of the plantar aspect of the tarsus. It assists in supporting the medial longitudinal arch of the foot as a primary dynamic stabilizer of the arch. Irritation and dysfunction of the tibialis posterior tendon is common and can result in acquired flat foot deformity in adults. Patients may subjectively report medial foot pain and limited function of the affected foot.

Pathology of the tibialis posterior tendon may be that of tendonitis (more acute inflammation and irritation) or tendinosis, wherein the tendon degenerates and over time becomes fibrotic, losing its tensile capabilities and resulting in flattening of the arch.

Symptoms of posterior tibialis tendinopathy include:

1. Pain and swelling posterior to the medial malleolus and medial aspect of the arch.
2. Limited ability to walk and run.
3. Decreased balance on the affected limb.
4. Report of the foot aching when walking.
5. Decreased arch height and change in foot shape.

Objective observations during initial examination include:

1. Single leg heel raise: Considered the most commonly utilized functional test, patients with tibialis posterior dysfunction are unable to perform an unsupported single limb heel raise on the affected side. It is expected that an asymptomatic foot can perform a single limb heel raise eight to ten times.
2. Observation of loss of medial longitudinal arch in standing: Observation of the patient in standing position from behind will reveal diminished medial arch on the symptomatic side compared to the non-symptomatic side. Collapse of the arch may also result in the "too many toes sign" wherein more than two toes are observed along the lateral edge of the foot from behind.

Evidence supports physical therapy management as conservative management for posterior tibial tendinopathy. Nielsen et al. reported that for sixty-four patients treated with physical therapy modalities; medications such as nonsteroidal anti-inflammatory drugs (NSAIDs); oral or local infiltration of corticosteroid; and orthotics or bracing such as a foot orthoses, an arch and ankle brace, a low-articulating ankle-foot orthosis (LAFO) or similar AFO, or shoe modifications. The authors reported an 87 percent success rate defined as not requiring further surgical treatment. Similar studies have shown beneficial results from an exercise program. Success with high repetition exercises, plantarflexion activities, and a high-repetition home exercise program that included gastroc-soleus tendon stretching has been documented. The exercises consisted of strengthening the posterior tibial, peroneals, anterior tibial, and gastroc-soleus muscles and included isokinetic exercises, exercise band, heel rises (double and single support), and toe walking.

Plantar fasciitis

Plantar fasciitis is caused by repeated micro-trauma to the fascia at its origin on the calcaneus. The hallmark indication of plantar fasciitis is patient report of heel pain during weight-bearing activity and first step pain in the morning. Heel pain is most commonly reported at the medial, lateral and lower aspect of the calcaneal region. It is thought that plantar fasciitis is most commonly caused by training error, training on hard surfaces such as paved roads, and improper footwear. Structural and biomechanical factors associated with plantar fasciitis include obesity, poor plantar flexor strength, reduced plantar flexor flexibility, and excessive foot pronation.

Treatment techniques should aim to reduce pain and inflammation, reduce stress to the tissue, and restore muscular strength and flexibility. In a randomized clinical trial, iontophoresis with dexamethasone administered twice weekly for six weeks in conjunction with other physical therapy modalities such as ice was shown to provide more immediate reduction in symptoms than modalities alone in reduction of plantar fasciitis pain and inflammation. Another randomized clinical trial found that trigger point manual therapy combined with a self-stretching program resulted in greater improvement in physical function and reduction in pain in patients with plantar fasciitis when compared to patients who did not receive manual trigger point therapy.

Stretches included:

1. Standing wall lunge calf muscle stretch: (A) Soleus muscle: both the front and the back knees are bent while keeping the back heel on the floor until a feeling of stretch in the calf is felt. (B) Gastrocnemius muscle: similar set up as for soleus, however keep the knee of the back leg straight.

2. Plantar fascia-specific self-stretching in sitting: If sitting patient places the affected foot over the opposite thigh, then places the fingers over the base of the toes, and pulls the toes up towards the shin.

Manual trigger point release was performed to trigger points in the gastrocnemius muscle. Pressure was applied to the trigger point and held until release was felt. This process was repeated with ninety-second holds for three repetitions. Patients also received a neuromuscular manual technique of strokes along taught bands in the gastrocnemius from the calcaneus to the knee. Other manual treatment methods for plantar fasciitis may include instrument-assisted soft tissue mobilization to the gastrocnemius – Graston, Guasha, and Astym techniques according to the individual therapists training and comfort level with instruments.

In addition to the stretches described above, exercise prescription may consist of:

- Intrinsic foot strengthening – Squeeze a toe separator, compressing inward, hold for five seconds. Repeat ten times. May repeat three times daily.
- Abductor hallucis strengthening – Use a thick rubber band wrapped around the toes to create resistance for abduction of great toe. Repeat ten times or perform longer holds.
- Towel scrunch – Sit with feet over a towel, placed on a hard surface. Scrunch the towel using the toes and feet. Hold five seconds, repeat ten times.
- Eccentric Achilles lengthening: Two feet up, one foot down on a block – Standing on a step with heels extended over the edge, use both legs to raise up onto the ball of the foot, then switch to standing on one leg and slowly lower down for a count of five.

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Achilles tendinopathy

Achilles tendonitis is a highly common overuse running injury. In its acute stage, the tendon itself may be inflamed. Though it has been suggested that Achilles tendinopathy is a condition of failed healing response to trauma rather than one of inflammation. Overuse in running, often due to poor mechanics, over time may lead to micro tearing or degeneration of the tendon and the tendon itself may develop calcium deposits. The presence of these findings lend to a diagnosis of Achilles tendinosis. The sheath around the tendon may be inflamed, lending to a diagnosis of tenosynovitis. Tendonitis and tenosynovitis commonly occur together and are treated similarly in the scope of physical therapy. The retrocalcaneal bursa, lying between the calcaneus and the Achilles may also become inflamed with friction and compression from the tendon, or an improperly fitted shoe.

Subjectively, the patient will report pain in the distal Achilles tendon and posterior aspect of the heel. Pain is exacerbated with running or other physical activity and alleviated by rest. A runner may note that pain is worst at the beginning of the run, and decreases as the runner warms up. This may be due to loosening of adhesions in the tendon sheath.

Objective findings may include pain with palpation over the Achilles tendon, and a feeling of thickening at the portion of the Achilles tendon just superior to the posterior calcaneus. There may be warmth at palpation of the posterior calcaneus and distal Achilles tendon, and presence of calcification deposits.

Because Achilles tendinopathy is by and large a condition of failed healing, common anti-inflammatory treatments such as non-steroidal anti-inflammatories (NSAIDS), ultrasound, electric stimulation, iontophoresis, and ice commonly fail to reduce pain long term or return the athlete to running. Traditional physical therapy modalities have not produced consistent results in clinical trials.

Physical therapy management should consist of eccentric calf muscle training. In a study by Alfredson et al., subjects with chronic Achilles tendonitis who were unable to run due to pain were placed on a twelve-week exercise program consisting of heavy load eccentric Achilles strengthening. After the twelve-week program, all subjects had returned to running with significant decrease in pain reports and significant increase in objective calf strength. When compared to a group of athletes with the same diagnosis who were treated with traditional conservative methods of rest, nonsteroidal anti-inflammatory drugs, and traditional physical therapy treatments and changes in shoes, the heavy load eccentric exercise group successfully returned to running while the traditional group did not.

An exercise prescription may consist of:

- Eccentric Achilles lengthening: Two feet up, one foot down on a block – As described above in the plantar fasciitis section. Once the patient is able to perform this exercise with no difficulty, PTs should have them hold weights to increase the load to the Achilles. Begin with three lbs. on each side and increase the weight as they are able.
- Uphill walking – The patient may practice walking uphill on the treadmill, begin with a 2 percent grade and increase gradually to 5 percent.
- Treadmill push walk – With the treadmill turned off, have the patient walk, using the gastrocnemius to push hard to create movement on the treadmill belt.
- Jump rope – Begin with a basic two-foot bounce, progress to skip, and then to a one-foot hop. Progress endurance as the patient is able.

Patellofemoral sndrome/patellar tendinosis

Patellofemoral pain (PFP) is defined as anterior or retro-patellar pain in the absence of other pathology. The patient will often report pain to be exacerbated by running, stair climbing, prolonged sitting, squatting, and kneeling.

Improper tracking of the patella due to poor quadriceps strength is one theoretical cause of PFP. Studies examining vastus medialis oblique (VMO) and vastus lateralis activity have found that subjects with PFP tend to have reverse activation of these muscles or latent activity of the VMO when descending stairs. These findings have sparked the theory that VMO timing and overall strength are an important component in treating PFP. Exercises focused on activating and strengthening the (VMO) component of the quadriceps muscle have been found to decrease symptoms in some subjects.

Multi-modal physical therapy treatments involving quadriceps muscle retraining, patellofemoral joint mobilization, patellar taping, and daily home exercises have been found to be beneficial in the treatment of PFP as well. Crossley et al. compared these treatments to a placebo treatment consisting of sham ultrasound, application of non-therapeutic gel, and placebo taping.

It is important to recognize faulty mechanics in runners as a cause of patellofemoral pain (PFP). Too often, clinicians have tunnel vision when treating PFP, focusing on patellar tracking and treating only the patellar joint itself. Research shows that PFP is often due to influence of interaction of joints and movement above and below the patella. Specifically, abnormal motion of the femur and tibia while running may affect the patella, as well as instability in the pelvis and hip, or the ankle and foot. Careful analysis of running gait, as discussed above, and examination of the patient during evaluation will give a more complete picture of factors contributing to PFP.

In female runners, hip abduction and external rotation muscle weakness may contribute to poor lower extremity alignment and mechanics leading to patellofemoral pain. A study conducted by Ireland et.al. found that females with anterior knee pain demonstrated 26 percent less hip abduction strength and 36 percent less hip external rotation strength when compared to age matched asymptomatic controls.

Furthermore, hip abduction strength and fatigability has been found to be a contributing factor in both males and females with PFP. In a study by Dierks et al., runners with PFP were compared with matched peers who were asymptomatic. Subjects were analyzed for hip strength and kinematics and arch structure and knee kinematics. Hip strength was measured before and after a long run, and subjects with PFP were found to have significantly less hip strength under both conditions. Arch type was not found to be significantly different between symptomatic and asymptomatic subjects.

Exercise prescription may consist of:
- **Anterior step downs** – Step down from a step, leading with the affected limb. Repeat ten times.
- **Clamshell** – With the patient in side-lying position, keep ankles together and lift the top limb up.
- **Decline hop squats** – Standing on a solid step with feet hip width apart, jump down facing forward, and land in a 45-degree squat. The emphasis of this exercises is to a) practice landing softly. Cue the patient to land quietly, using auditory feedback, b) practice landing with the knees in alignment with the hips, avoiding valgus or varus torsion upon landing, and c) practice the final squat without allowing the knees to thrust beyond the toes to activate the gluteal muscles and quadriceps for improved control. Repeat 10 times.
- **Standing resisted flutter kicks** – Tie a therapy band around the end of the ankle on the affected side and anchor to a solid object. Quickly thrust the leg in the desired direction, creating a quick flutter. This should be performed in all four directions for strengthening in the anterior, posterior, abduction, and adduction planes. Repeat twenty times in each direction. Emphasis stability in the presence of quick movement and endurance of the stabilizing muscles.
- **Back lunge** – Begin with feet parallel, and lunge by stepping backward with the unaffected leg, bending both knees. Emphasize knee alignment, avoiding varus or valgus torsion, and mindful of not allowing the knee to flex anterior to the toes. Repeat ten times.
- **Step up forward** – Forward step up on a step, leading with the affected limb. Have the patient rise up onto the affected and lower back down with the same limb. Repeat ten times.
- **Forward jump squats** – Begin standing with the feet hip width apart and jump up onto the block, landing on top of the block with the same alignment. Emphasize knee position and alignment, and landing softly, as was done in the decline squat hops.
- **Lunge hops** – From a double knee bent lunge, spring up and switch legs, landing into a lunge on the opposite side. Emphasize landing softly, and use running arm swing to assist in propelling upward, mimicking the arm swing that is used during running form.

Iliotibial band friction syndrome

Iliotibial band friction syndrome (ITBFS) is the second leading cause of knee pain in runners and the most common cause of lateral knee pain.59 It is caused by repetitive friction of the iliotibial band sliding over the lateral femoral epicondyle. Subjectively the patient may report lateral knee pain, lateral distal thigh pain, or greater trochanter pain. Training errors associated with ITBFS include excessive running in the same direction on a track, increase in weekly mileage and downhill running. Objective findings include weakness in the hip abductors and pelvic instability.

Hip abductor weakness is a contributing factor to ITBFS. Evidence shows that long-distance runners with ITBFS have significantly weaker hip abductor strength on the affected limb when compared to the unaffected limb, and that bilateral hip abduction strength is significantly weaker than non-injured distance runners. It is suggested that when the hip abductor and lateral gluteal muscles do not fire appropriately and timely during the limb stance phase of the running cycle, there is limited ability to stabilize the pelvis and eccentrically control femoral abduction.

Kinematic studies show that females with ITBFS demonstrate atypical hip and foot mechanics that result in friction causing pain. Specifically, these studies show that females with IT band friction syndrome show greater peak rear-foot invertor moment, peak knee internal rotation angle, and peak hip adduction angle compared to asymptomatic peer subjects. Due to the IT band's attachments at both the distal femur and proximal tibia, it is deduced that these aberrant movements at the hip and knee lead result in the development of ITBFS. A recent kinematic study examining the difference between male and female runners with ITBFS demonstrated that while females with ITBFS show greater hip external rotation while running, males with ITBFS exhibit greater ankle internal rotation.

Physical therapy management of ITBFS in the acute phase includes activity modification, ice, and use of NSAIDs if recommended by a physician. Once acute inflammation has receded, soft tissue augmentation may be performed. This may include myofascial release of the quadriceps, hamstring, and IT band, or application of instrument assisted soft tissue mobilization such as ASTYM, Graston, or Gua sha tool. Exercises aimed at improving hip abductor strength and improved running mechanics followed by return to running drills may be implemented once the patient can ambulate pain free. Fast paced running and sprint drills may be implemented first, as they are least likely to aggravate the IT band. The therapist should instruct the patient to begin running on flat surfaces and to run only every other day initially, building frequency and intensity gradually.

Exercise prescription may consist of:
- Band walks: lateral and monster walks
    - Lateral walks: Using a band tied around the ankles, walk sideways, keeping knees slightly bent and trunk upright. Angle of knee bend may be altered for differential activation of the gluteal muscles. Walk twenty feet to the right and then to the left. Repeat three times.
    - Monster walks: With the band tied around the ankles, bring the leg forward, then swing out laterally and place the foot on the ground. This is also called cowboy walk, and resembles a dance by the Brady Bunch. Walk forward twenty feet, repeat three times.
- Bridges on ball – Lying face up with feet planted on a medium-sized therapy ball, engage the core muscles by gentle drawing the ribs towards each other. Then press heels into the ball and lift the hips a few inches off the ground, pause, then set them back down. Repeat ten times.

- Lateral planks with progression – Patients should begin lying down with one side of the elbow on the ground, stacked directly under the shoulder, and body in a straight line. Engage the core muscles by gently drawing the ribcage in, and press the hips up toward the ceiling. If the full side plank cannot be held, the patient may press up with the knees bent. Once the patient can hold the side plank on each side for one minute, progress to plank with abduction. In the side plank position, lift the top leg, then lower it back down with control. Repeat ten times on each side.
- Warrior III – Stand with arms overhead. Engage the core muscles and lift one leg behind while flexing the trunk forward, keeping the arms stretched past the ears until the body is perpendicular to the ground. Hold five seconds, then slowly return to the starting position.

Hamstring tendinopathy

Also referred to as high hamstring tendinopathy, this impairment is due to overuse in runners. Biomechanically, it is commonly found proximally near the muscle tendon junction and laterally at the biceps femoris. Theoretically, it is caused in runners by rapid active knee extension, and thus, is found more commonly in faster runners. Less common than the previous injuries discussed in this course, this impairment is characterized by the subjective report of deep buttock or posterior thigh pain.

Physical exam will reveal pain with hamstring contraction, though MRI or CT imaging may be required for diagnosis. In some chronic cases, calcification occurs in the tendon. Differential diagnosis includes adverse neural tension, so clinicians should perform an active slump test to rule out sciatic nerve or lumbar spine involvement.

Suggested factors leading to this type of hamstring strain are:

1. Absent or inadequate warm-up: Certain animal studies found that muscles are capable of more stretch at warmer temperatures.
2. Fatigue: Evidence shows that high hamstring strains tend to occur late in training and competitive environments. This may be due to altered coordination or mechanics with fatigue. An animal study demonstrated that fatigued rabbit muscles had decreased ability to absorb energy before reaching the amount of stretch that causes injury.
3. Inadequate training levels and lower levels of fitness: Abrupt increases in training intensity or volume can contribute to injury.
4. Eccentric hamstring capabilities: Poor ability to handle eccentric contractions in the running phase.

Physical therapy management should include soft tissue mobilization, eccentric hamstring strengthening, and core stability training. A study examining the differences between a physical therapy program consisting of passive hamstring stretching, resistive exercise, and icing versus a program of progressive agility, trunk-stabilizing exercises, and icing found that the latter program was more beneficial. Athletes in the agility and trunk stability exercises returned to activity approximately two weeks sooner than the passive hamstring stretching and resistive group. Furthermore, re-injury rate in the passive stretching group was significantly greater at one year follow up. Eccentric exercise prescription is supported in the literature for hamstring tendinopathy as well.

The efficacy of eccentric exercise and core stability was further analyzed in conjunction with trigger-point dry needling. In a case study, injured runner patients were found to experience decreased pain, tenderness, and increased function over the span of eight to nine visits conducted over eight to ten weeks. The authors speculate that the trigger-point dry needling facilitated joint motion and, specifically, reduced pain in the hamstring.

In some instances, patients with proximal hamstring tendinopathy do not respond to conservative physical therapy management. MRI imaging may be used to identify peritendinous edema and exact location of tendinopathy and percutaneous corticosteroid injection may be performed. A study by Zisson and colleagues found that 50 percent of patients experienced improvement in symptoms lasting longer than one month after percutaneous corticosteroid was injected. Physical therapy is still important in this instance to correct mechanics and strengthen weak musculature to ensure that injury does not recur.

Exercise prescription may consist of:

- Non-resistive prone hamstring curl flutters (acute phase) – Lying face down, bend the knee and draw the heel up towards the buttocks, alternating sides in a quick flutter motion. This motion should be performed in a pain-free range, and the emphasis is on speed of movement.
- Single leg deadlifts (tippy bird) – Begin standing on one leg with the knee straight but not locked, holding a long dowel, or light-weight mop or broom behind the back. Engage the core muscles, and bend forward at the hips, keeping the dowel in contact with the spine, and keeping the standing leg straight. Bend forward to 90 degrees, then return back to standing position. Repeat ten times on each side.
- Legs straight bridge – Keep the legs extended long. Engage the gluteal muscles and abdominals, and lift the hips up towards the ceiling. This will be a small bridge, with hips lifting 1-2 inches.
- Back lunge – Begin with feet parallel, and lunge by stepping backward with the unaffected leg, bending both knees. Emphasize knee alignment, avoiding varus or valgus torsion, and mindful of not allowing the knee to flex anterior to the toes. Repeat ten times.

Sacroiliac joint dysfunction

Sacroiliac (SI) joint dysfunction is known to be caused by disruption in the load transference process through the pelvis. This is particularly true in runners. Ultrasound imaging studies show that patients with SI joint pain demonstrate delayed onset of abdominis obliquus internus (OI) and multifidus contraction during weight transfer when compared to asymptomatic subjects.

SI joint dysfunction is known to be the cause of low back pain and lower extremity pain due to mechanical changes and to referred pain. The SI joint can refer pain to the lower lumbar region, buttock, groin and medial thigh, posterior thigh, lower abdomen, and foot. In runners, SI joint dysfunction may be caused by poor running mechanics, or may be a primary diagnosis which effects the runner (present prior to beginning running or an injury accumulated in lifestyle activity outside of running). History of prior pain patterns and careful functional screening during initial examination will be necessary in the proper diagnosis of SI joint dysfunction, as discussed in the initial examination section of this course.

Specific training of the transverse abdominis muscles in isolation has been shown to be more effective in the stabilization of the SI joint than generalized abdominal training. Often times in physical therapy transverse abdominis contraction is verbal instructed by the therapist by asking the patient to “draw the abdominal muscles in towards the bellybutton,” or a similar phrase. This has been shown on ultrasound imaging to co-contract multiple abdominal muscles including the obliques in addition to transverse abdominis and multifidi. Researchers found that the ability to contract the transverse abdominis in isolation was more effective at stabilizing the SI joint. This can be cued as “gently draw your abdominals in as if you were being shrink wrapped around your center,” or to “gently draw the ribs in towards each other”. The emphasis being on a 360-degree concentric contraction of the transverse abdominis versus a compressive contraction of all the abdominal muscles. While overall core stability is important, the patient’s ability to contract the transverse abdominis in isolation should preclude generalized core stabilization training in the treatment of SI joint dysfunction.

Exercise prescription may include:

- Transverse abdominis isolation – Lying face up with knees bent and feet planted hip width apart, inhale and relax, then exhale and gently draw the ribcage in towards the center of the abdomen, as if you were being shrink wrapped around the center. Hold for three seconds. Repeat ten times.

- Bird dog – Beginning on hands and knees, engage the core muscles and extend one leg straight behind you, do not allow the pelvis to move. Alternate the extending leg and complete ten repetitions on each leg. Once this has been mastered, lift the opposite arm and opposite leg, continuing to emphasize stabilization of the low back and pelvis.
- Plank with march – Beginning in a full plank position, lift one leg off the ground, keeping it straight. Do not allow the pelvis to rotate or shift. Gently place the lifted foot back on the ground and lift the other leg. Repeat ten times on each side.
- Plank with shoulder tap – Beginning in a full plank position, lift one hand from the ground and place it onto the opposite shoulder, then return it back to the starting position. Repeat using the other arm. Do not allow the pelvis to rotate or shift. Repeat ten times on each side.
- Lunge jumps – Begin in a lunge, with the front knee stacked over the ankle and the back knee directly under the ipsilateral hip. Engage the core and jump up, switching legs in the air and landing in the start position. Repeat ten times on each side.

Stress fractures

While the repeated impact of running has been shown to promote maintenance of healthy bone cell turnover and increase in bone mass, there is a fine line leading to overuse which can cause stress fractures of various bones in the trunk and lower extremities. An epidemiology study of 320 athletes with a bone scan positive for stress fractures consisted of 145 males and 175 females was analyzed over 3.5 years. The most common bone injured was the tibia (49.1 percent), followed by the tarsals (25.3 percent), metatarsals (8.8 percent), femur (7.2 percent), fibula (6.6 percent), pelvis (1.6 percent), sesamoids (0.9 percent), and spine (0.6 percent). Stress fractures were bilateral in 16.6 percent of cases. The average reported time to recovery across all stress fracture injury types was 12.8 weeks.

Tibia stress fracture is a common running injury associated with overuse due to repetitive loading of the lower extremity. Bone geometry of the individual runner has been shown to play a role in tibia stress fractures occurring in male runners. Specifically, male runners with smaller bones in relation to body size were identified as being more susceptible to stress fracture injury. A study analyzing the compressive strain rates of the human tibia during treadmill running and over ground running found that treadmill running led to lower strain rates. Kinematic differences were seen in treadmill running versus over ground running as well. The authors speculate that treadmill runners are at lower risk of tibia stress fracture than ground runners. Physical therapists may consider this information in return-to-running planning for patients with stress fractures.

Stress fractures in the foot are also common among runners. It is suggested that the navicular and fifth metatarsal are at high risk of delayed union if not diagnosed and addressed in a timely fashion. The navicular bone is more at risk for injury due to its extensive outer covering of articular cartilage, lending to limited blood supply. Risk of recurrent fracture is high in foot stress fractures. Most stress fractures of the foot can be managed conservatively with a period of non-weight bearing followed by gradual return to running.

Pelvic stress fractures occur more often in female runners than male runners and are commonly found in the pubic ramus. Patients with pelvic stress fracture commonly report groin pain that persists during activity and improves with rest. While scintigraphy imaging can help to diagnose stress fractures in the pelvis, it is possible to make a diagnosis with confidence if the following are found on evaluation of a long-distance runner with activity-induced groin pain.

1. The runner experiences such significant pain in the groin that they cannot run (self- limiting).
2. Pain reproduced in the groin during single limb stance on the painful side.
3. Pain on deep palpation to the pubic ramus bone itself, but not to overlying tissue.

Sacral stress fractures in running athletes are relatively rare. Clinically, the symptoms of pelvic stress fracture can appear quite similar to sciatica or lumbar disc disease. The patient may report low back and vague buttock pain, sacral pain radiating into the buttock, groin pain, or radiating pain down the leg. Physical examination may reveal localized tenderness over the sacrum or SI joint. CT or bone scintigraphy are required for a definitive diagnosis. It is important to identify the stress fracture as quickly as possible, thus, patient interviewing regarding training volume and intensity habits, or changes in running shoes or running surfaces can help to identify risks for stress fracture prior to beginning the physical examination. Sacral stress fractures tend to require four to six weeks of rest prior to gradual return to running.

Stress fractures may also be associated with poor nutrition habits, including withholding of food leading to anorexia. Low body weight can be associated with hormonal changes leading to amenorrhea and osteoporosis in female runners. Medical history questions regarding the menstrual cycle of a female patient can also help to identify the need for imaging if a stress fracture is suspected.

Femoral stress fractures are the fourth most commonly diagnosed type of stress fracture in athletes. They can be categorized into two types: insufficiency fractures and fatigue fractures. Insufficiency fractures occur due to normal physiologic stresses on a bone that is deficient. This may be secondary to osteoporosis or other bone pathology. Fatigue fractures are due to repetitive impact to a normally structured bone. Fracture sites are most commonly located in the femoral neck and shaft. As with all stress fractures, the incidence is commonly associated with poor training techniques or sudden increase in volume of training. Femoral stress fractures occur more frequently in females than males, and are associated with lower bone mineral density and disruption in menstrual cycles. Dietary factors such as low calcium and vitamin D intake are also associated with femoral stress fractures. Long-term use of bisphosphonates have been found to be a risk factor for developing sub-trochanteric femoral fractures. If a femoral stress fracture is not diagnosed in a timely fashion, it may progress to a complete or displaced fracture that requires surgical intervention.

Physical therapy management for stress fractures may begin after a period of rest based upon fracture location and severity. Joint-specific strengthening and gradual build-up of weight-bearing exercises may be prescribed followed by a return-to-run program. The patient may begin with a forty-minute-per-day walking period until pain free, and then begin short twenty- to thirty-minute jogs, followed by increasing duration or intensity of the run.

Metatarsalgia

Metatarsalgia is a common overuse injury in runners. The patient will commonly report pain and inflammation in the ball of the foot. Specifically, they may report pain at one or many of the metatarsal heads. Onset is usually slow and insidious and is associated with high volume of training, shortened extensor digitorum and the Achilles tendon, weakness in the flexor digitorum, and poorly fitted shoes. The occurrence of metatarsalgia has been related to pronation with hind foot varus and toe-first initial contact most commonly seen in sprinters or fast runners.

Forefoot pain may also be due to Morton's neuroma, which the patient will report as a burning sensation between the second and third metatarsal heads. This affects more women than men, and is presumably associated with footwear choices that force weight forward onto the forefoot, such as high heels or wedged shoes. Morton's neuroma involves the presence of inflammatory tissue called perineural fibrosis. The inflamed nerve is the common digital nerve and its branches. Magnetic resonance imaging (MRI) or ultrasound imaging may be required to make a definitive diagnosis.

Physical therapy management includes educating the patient in proper shoe attire for both running and lifestyle. It is important to remember that certain lifestyle choices that contribute to a runner's symptoms are not directly associated with running, shoe choice outside of running being one of these. Custom orthotics may be administered; however, there is a paucity of evidence that altering the foot position through the use of orthotics effectively reduces pain or alters limb mechanics for more effective gait patterns.

Medical management may include injection of localized anesthetic, sclerosing agents, and steroids. Surgical intervention involve nerve decompression or neurectomy.

Exercise prescription may include:

- Towel scrunch (as seen above) – Sit with feet over a towel, placed on a hard surface. Scrunch the towel using the toes and feet. Hold five seconds, repeat ten times.
- Eccentric Achilles lengthening – Two feet up, one foot down on a block (as seen above). Standing on a step, use both legs to raise up onto the ball of the foot, then switch to standing on one leg and slowly lower down for a count of five.

Mechanical lumbar pain

The body of knowledge regarding low back pain for the general population is growing. While acute low back pain is found to respond to manual therapy and stabilization exercise, chronic low back pain may require additional patient education for improved mechanics and pain neurophysiology education.

An abundance of evidence suggests that people with chronic low back pain exhibit poor transverse abdominis control and coordination. The emphasis is on the timing and coordination and use of the transverse abdominis muscles versus actual weakness of the muscles. It is postulated that individuals with low back pain make altered postural adjustments of the trunk muscles resulting in limited motion of the trunk and decreased arm swing, which may then result in pain.84 Training the transverse abdominis and internal obliquus muscles to turn on prior to limb movements is advantageous in addressing chronic low back pain, as is educating the patient in the importance of utilizing normal arm swing excursion.

Furthermore, kinematic studies reveal that poor trunk and pelvis coordination can be associated with incidences of low back pain specifically in runners. Reduction in relative motion between the pelvis and the trunk has been observed in runners with a history of low back pain. Deficits in coordination during treadmill running, and walking in people who have experienced even one bout of low back pain indicate risk for further injury. This necessitates physical therapists to identify key aspects of mechanical faults in runners with low back pain and to train proper technique following the resolution of pain to decrease the chance for recurrence of low back pain and injury.

Unilateral hip extensor weakness has also been implicated in incidence rate of low back in collegiate female athletes. It has further been proposed that knee joint stiffness may lead to poor ability to absorb ground reaction forces leading to increased shock and subsequent load at the low back.

Manual therapy to the spine is indicated in the presence of low back pain. A clinical prediction rule for determining which patients will respond to spinal manipulation has been determined. Investigators found that patients who exhibit four of the five following variables have a 95 percent probability of responding positively to spinal manipulation:

- Symptoms less than thirty-five days.
- Low fear-avoidance beliefs as demonstrated on Oswestry-Disability Index.
- Restriction in the lumbar vertebrae.
- No symptoms distal to the knee.
- Limited hip internal rotation.

These patients may respond to sacroiliac joint manipulation, and manipulation of the lumbar vertebrae by a physical therapist.

Exercise prescription may include:

- Transverse abdominis isolation – Lying face up with knees bent and feet planted hip width apart, inhale and relax, then exhale and gently draw the ribcage in towards the center of the abdomen, as if being shrink wrapped around the center. Hold for three seconds. Repeat ten times.
- Side-lying runner stride – Lying on one side with head supported, engage the core muscles and move the legs in a running motion. Maintain for one minute on each side, build up endurance towards sixteen sets.
- Runner ready – Have the patient begin in a shallow lunge with the opposing arm in a bent running position. Cue core control and pelvic stability by asking them to keep the pelvis as still as possible, and contract the core muscles by gently drawing the rib cage inward. Then rapidly draw the knee up, swinging the upper extremity with full range, as would be done during running. This exercise is used to train transverse abdominis coordination prior to upper and lower extremity running motion. Repeat for one minute on each side, build up endurance towards sixteen sets.

Femoral acetabular impingement

Femoral acetabular impingement (FAI) is a disorder of the hip involving friction between the femoral head and the acetabulum. This occurs as a result of abnormality in either of the bones, usually in the femoral neck, and is provoked with end ranges of hip flexion and adduction. When FAI is present, bony spurs develop around the femoral head or in the acetabulum. Over time, this friction causes tearing and degeneration of the articular cartilage in the anterior aspect of the joint and can result in osteoarthritis. Patients with FAI will report pain or a dull ache in the groin or deep within the hip itself. Pain is aggravated with running, especially on incline.

Examination should include an FAI-specific test. With the patient supine on a table, therapists should use a combined movement of 90 degrees passive hip flexion on the symptomatic side followed by forced adduction and internal rotation. The test is positive if pain is reproduced. Some evidence suggests that healthy individuals without FAI may exhibit a positive response in this particular test. A radiograph may be required for definitive diagnosis.

Running gait examination can also be telling when diagnosing FAI. Studies demonstrate FAI-related kinematic changes of the symptomatic lower limb during dynamic weight-bearing activities. Kennedy et al. found that patients with FAI presented decreased frontal and sagittal hip range of motion and reduced frontal pelvic mobility during level gait at a self-selected normal speed. Austin et al. reported excessive hip adduction and internal rotation with patient-reported hip pain during moderate- to high-intensity eccentric activities in a female patient with FAI.

Physical therapy is recommended as the first line of conservative treatment prior to surgery. Physical therapy management should involve activity modification including rest if the patient is highly aggravated, and education to avoid end ranges of hip flexion and adduction. Manual therapy to the hip to improve hip glide in flexion as well as strengthening of the hip is indicated as well. Specifically, patients with FAI have been identified as exhibiting weakness in the tensor fascia latae (TFL), hip external rotators, hip abductors, and adductors.

If physical therapy has not assisted in reducing pain and symptoms after six weeks of earnest treatment, surgical management may be considered. Arthroscopic procedures are commonly performed, though physical therapy treatment may be warranted post-operatively to aid in return to sport conditioning.

Exercise prescription may include:

- Running against a wall – Stand approximately two feet away from a wall with hands placed onto the wall at shoulder height. Initially, have the patient practice driving the knee up with the core muscles engaged, and gently placing back to the starting position. Repeat ten times on each side to build hip flexor strength and control. Once this is mastered, have the patient alternate with more force in a running stride with hands placed against the wall. Perform for one minute, complete three sets.
- Arrow – Begin in a modified quadruped position with forearms on the floor and elbows placed shoulder width apart. Begin with the working leg out to the side. Lift it up directly behind the body, then cross it behind the opposing hip, creating the shape of an arrowhead. Lift it back up behind the body, then return to starting position. Repeat ten times on each side.

TREATMENT PRINCIPLES

Essential principles in treatment

This does not differ significantly from general orthopedic treatment principles, and patient education remains an integral part of treatment. Treatments should seek to correct impairments in this order:

1. Isolate mechanical dysfunction of running gait by identifying planes of dysfunction, and educate the patient in a preferred running pattern.
2. Strengthen weak muscles. It is important to strengthen the muscles both in isolation and dynamically in the form of running specific drills.
3. Encourage running efficiency with improved economy and symmetry of movement. Address imbalances in muscle length, strength, and motor control.
4. Control tissue loading and overuse, educate the patient in the impact of cumulative dysfunctional movement patterns.
5. Train the patient in dynamic stability and improve muscular power.

During treatment sessions, isolate specific injured tissue, and isolate the injured limb prior to integrating it into more dynamic drills. Postural muscles, such as the calf muscles and spinal extensor muscles, should be strengthened before phasic muscles such as the gluteal muscles and foot muscles. Core muscles should also be trained early on and prior to dynamic strengthening drills, particularly the transverse abdominis.

Treatment should roughly follow a practical progression from static to more dynamic ability. The injured patient may progress from a walking program to a jumping program. The jumping program may consist of jumping rope for various intervals to build stamina and power, or box jump drills where the jumping becomes progressively higher and more intricate. Once a dynamic jumping program has been completed, the patient may begin small intervals of flat surface running, generally one to two miles per day with a day of scheduled rest. Uneven terrain running such as trail running and hill running may begin once the patient can asymptomatically run on flat and paved surfaces.

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COMMON INJURIES AND THERAPY MANAGEMENT FOR RUNNERS

Final Examination Questions

Select the best answer for questions 1 through 10 and mark your answers online at **PT.EliteCME.com**.

1. The goals of physical therapy treatment for an injured runner include:
   a. Achieve pain-free movement.
   b. Resume control, balance, and symmetry of the running gait.
   c. Educate the patient on principles of maintenance and future injury prevention as well as address patient-centered concerns and goals.
   d. All of the above.

2. As with any other orthopedic patient, initial evaluation of the running patient begins with a(n) _________ __________. A pain scale, body chart, current complaint, and complete current and past medical history should be included.
   a. An X-ray.
   b. Lighthearted banter.
   c. Intake questionnaire.
   d. An easy jog.

3. What contributes to hip adduction and is correlated with injury, often associated with a weak core, hip abductor and hip rotator muscle?
   a. Calcaneal eversion.
   b. Spine lateral flexion.
   c. Pelvic tilt.
   d. Knee valgus.

4. The 2009 best-selling book by Christopher McDougall entitled Born to Run encouraged runners to do what?
   a. Seek professional help for the perfect shoe fit.
   b. Change out shoes every month.
   c. Purchase minimalist shoes or even begin to run barefoot.
   d. None of these.

5. A therapist should consider the following issues when recommending footwear for runners:
   a. Fit of the shoe and the running surface type.
   b. Distances the runner is intending to run and the price of the shoe.
   c. Shoe durability and the weight of the shoe.
   d. All of the above.

6. The following is NOT a general cause of running injuries:
   a. Poor motor control, or lack of coordination or timing in the running gait.
   b. Mechanical compensations or substitution patterns.
   c. The time of day when running.
   d. Delayed onset muscle soreness.

7. What common condition is caused by repeated micro-trauma to the fascia at its origin on the calcaneus?
   a. Shin splints.
   b. Tibialis posterior tendinopathy.
   c. Plantar fasciitis.
   d. Achilles tendinopathy.

8. What condition will cause a patient to report pain that is exacerbated by running, stair climbing, prolonged sitting, squatting or kneeling?
   a. Tibialis posterior tendinopathy.
   b. Achilles tendinopathy.
   c. Patellofemoral syndrome/patellar tendinosis.
   d. Shin splints.

9. What type of stress fracture occurs more commonly in female runners than male runners?
   a. Tibia stress fracture.
   b. Pelvic stress fracture.
   c. Navicular and fifth metatarsal fractures.
   d. Femoral stress fractures.

10. The essential principles in treatment for running injuries include what treatments?
    a. Isolating mechanical dysfunctions and strengthening weak muscles.
    b. Encouraging running efficiency and controlling tissue overloading and overuse.
    c. Training the patient in dynamic stability.
    d. All of the above.

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