

Running Injuries to the Knee

Stan L. James, MD

Abstract

Approximately one third of serious runners will incur an injury in a given year, and approximately one third of the injuries will involve the knee. Biomechanical studies on running reveal the tremendous cyclic forces to which the knee is subjected. There are several etiologic factors involved, including training errors, anatomic and biomechanical variations, and differences in shoes and running surfaces. Training errors, particularly rapid transitions in training, are responsible for two thirds of injuries. Knee injuries in runners must be approached with a thorough review of the training program and a complete examination of the lower extremity. Several conditions can cause anterior knee pain commonly involving the extensor mechanism, and these must be differentiated. Most knee injuries can be resolved with conservative treatment, but occasionally surgery is indicated. After a layoff due to injury or surgery, appropriate rehabilitation, including a graduated return to running, is essential to avoid reinjury.

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Distance running is a significant part of the basic fitness program of many people. However, "serious" distance runners (defined as those who run more than 25 miles per week) face an injury rate of approximately 30% each year.

In their 1985 study, McKenzie et al¹ reported that the incidence of knee injuries in runners had increased from 18% in studies performed a few years earlier to 50%. They believed that the improved construction of running shoes probably played some role in reducing the number of leg and foot injuries, but had not been quite as effective in protecting the knee. In a review of the epidemiologic literature in regard to running injuries, van Mechelen² found that most running injuries occur in the lower extremity, preponderantly in the knee. In another review of data on running biomechanics, James

and Jones³ also found that the knee is the most common site of running injuries.

Biomechanics of Running Injuries

Leadbetter's "rule of too's" (i.e., athletes court disaster when they exercise *too* often, *too* hard, and *too* soon and *too* much after injury and attempt remediation *too* little and *too* late)⁴ often applies to runner's injuries, most of which are attributable to training errors. The body is a tremendously adaptable mechanism, but it requires time to accommodate to new stress levels, which in the case of the knee can be significant. In a study in 1978, James et al⁵ reported that training errors accounted for two thirds of runners' injuries and that one third of the injuries affected the knee.

Lysholm and Wiklander⁶ studied variables in runners' injuries and found that a training fault was the cause in 72% of the cases. Such training errors involve a sudden change in the frequency, duration, and/or intensity of training. The most common error is suddenly increasing mileage or trying to maintain too high a training mileage.

Scott and Winter⁷ calculated the patellar tendon force to be around 4.7 to 6.9 times body weight. They also found patellofemoral joint compressive forces to be 7.0 to 11.1 times body weight in a jogger and two middle-distance runners. Peak loads were associated with the mid-support and push-off phases of running, when muscle activity is maximal. This type of biomechanical information is consistent with high knee loads and greater frequency of injury.

Dr. James is Courtesy Professor, Department of Exercise and Movement Science, University of Oregon, Eugene, and is in private practice with Orthopedic & Fracture Clinic of Eugene.

Reprint requests: Dr. James, Orthopedic & Fracture Clinic of Eugene, 1200 Hilyard, Suite 600, Eugene, OR 97401.

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Andriacchi et al⁸ have reported that the maximum knee-flexion moment with running is more than five times the moment that normally occurs during level walking. That large increase in knee-flexion moment during the support phase of running must be balanced primarily by the quadriceps mechanism, which generates significant forces in the patellofemoral joint. They also noted a large adduction moment of the hip and the knee, which stresses the iliotibial band (ITB) and possibly contributes to a very common knee injury, ITB friction syndrome.

History

Because approximately two thirds^{4,5} of runners' injuries are related to training errors, such as sudden changes in duration, frequency, or intensity of training, the single most important aspect of the history is an analysis of the runner's training program for errors. The examiner must be able to "speak the language" of runners. Noakes's *Lore of Running*⁶ is perhaps the most comprehensive resource now available; it covers all aspects of running, including information on training as well as physiologic and medical considerations.

The runner's history must include the current complaints, past running injuries, running experience, training patterns (duration, frequency and intensity), and running terrain. Is cross-training used? What type and how often? Has there been a sudden increase in mileage? An increase in miles run per week of 10% is about the maximum that can be tolerated safely. It must be kept in mind that many complaints are secondary to compensation for a previous injury that may not, at the time of evaluation, be the most prominent problem. It is important to know where and when the pain occurs in the run. For

example, is it worse running uphill or downhill? Does it vary with the intensity of the run? Does the pain occur during the swing phase or the support phase?

Previous injuries and their treatment should be investigated because there is a tendency toward reinjury to a given area. An anecdotal example involves a marathon runner with a history of recurrent Achilles problems. As he was telling me his history, he casually mentioned that every time his weekly mileage got over 80 miles, he seemed to get injured. At the time of evaluation, he was running 110 miles per week. It was only when I specifically pointed out what he had just said that he began to relate mileage to injury.

Finally, it is important to identify the make and style of running shoe worn and whether a shoe change or wearing a particular type of shoe can be related to an injury. If orthotic devices have ever been used, it is helpful to know whether they had any positive or negative effect on symptoms.

Physical Examination

The physical examination must include a thorough assessment of the entire lower extremity, from pelvis to toes. It is not uncommon for the cause of knee pain in runners to be either distal or proximal to the knee itself (Fig. 1). One cannot emphasize enough the importance of not simply concentrating on the major complaint at the knee without a thorough examination of the entire lower extremity. It must be borne in mind that gross abnormalities are not always present on examination, nor should they be expected.

The lower-extremity examination should include evaluation of alignment in the frontal and transverse planes during stance and walking and/or running. The level of the

iliac wings will give some idea of whether there is a leg-length discrepancy. Extremity length should be measured from the anterior superior iliac spine to the medial malleolus. Patellar dynamics should be assessed with the patient walking to detect patellar malalignment or transverse-plane rotational abnormalities. The presence of "squinting patellae" (patellae that incline somewhat to the midline when the feet are parallel) suggests rotational malalignment. Ankle dorsiflexion should be assessed with the knee extended and flexed. At least 10 degrees of dorsiflexion is required during the support phase of running; compensatory foot pronation is necessary when there is a tight gastrocnemius group. The overall alignment and configuration of both feet should be noted with the patient both standing and walking. Muscular imbalance can often be grossly detected with muscle testing against resistance.

Heel-leg alignment and heel-forefoot alignment should be evaluated. With the subtalar joint in neutral position, forefoot supination or pronation is sought. Subtalar joint motion normally should allow approximately 8 degrees of eversion and 25 degrees of inversion (i.e., a ratio of about 1:3). A disruption in this ratio is often associated with compensatory pronation of the foot secondary to tibia vara, tightness of the gastrocnemius muscles with limited ankle dorsiflexion, heel varus, or forefoot supination. Compensatory pronation becomes necessary for the foot to assume a plantigrade position during the support phase; to achieve this, the tibia is held internally rotated for a longer-than-normal period of time, which, it has been speculated, creates rotational mistiming at the knee.³ Inspection of the runner's shoes for wear patterns and distortion of the heel

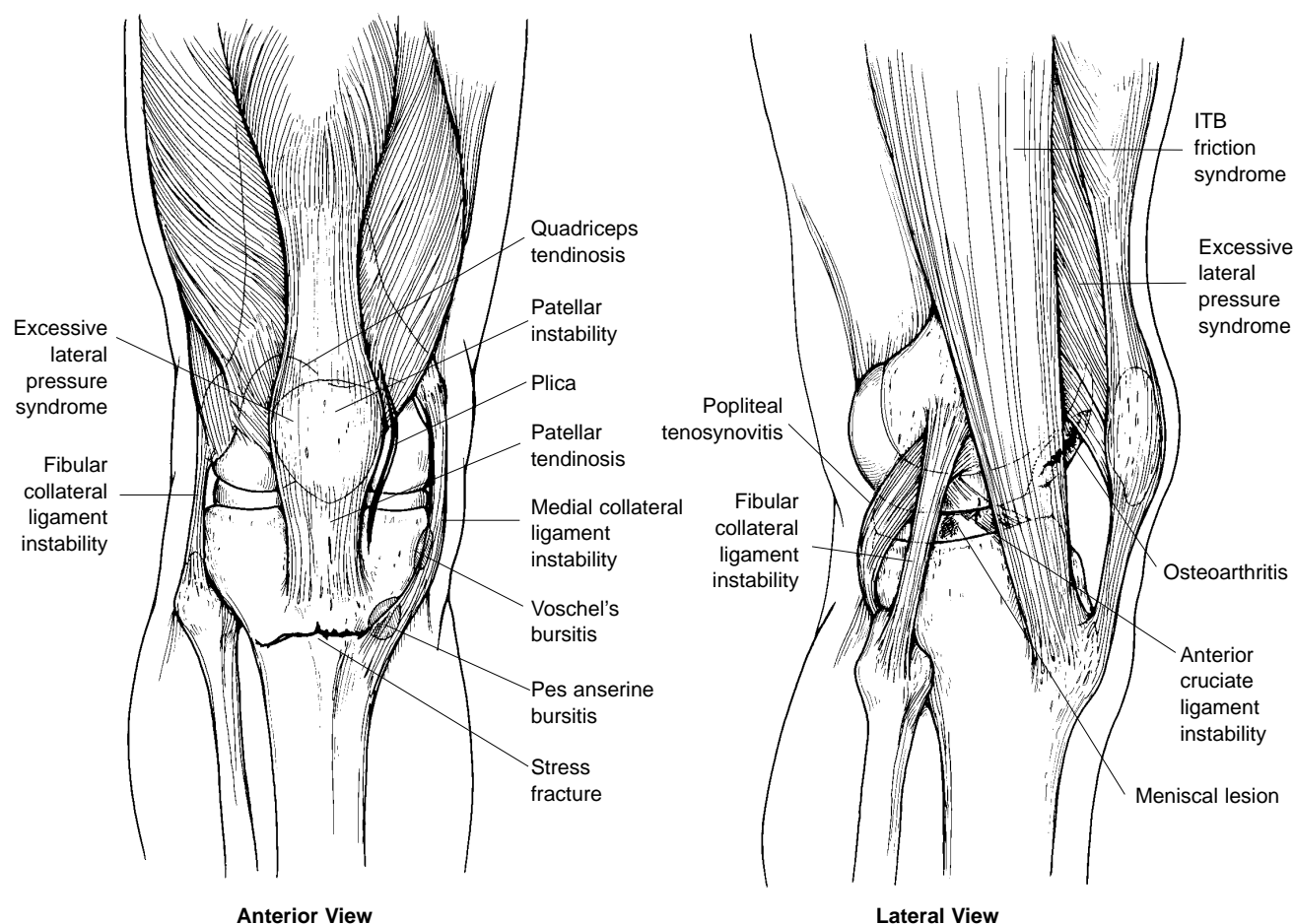


Fig. 1 Sites in the knee affected by conditions commonly seen in the runner.

counter may give a clue to the cause of lower-extremity malalignment.

It is not uncommon for runners with knee pain to have several anatomic variations. A classic example of such a combination occurs in the "miserable malalignment" group,⁵ who usually are seen with the complaint of knee pain associated with running. Examination reveals femoral-neck anteversion with a greater range of internal hip rotation than external hip rotation, genu varum, squinting patellae, excessive Q angle, tibia vara, functional equinus with tight gastrocnemius muscle groups, and often compensatory pronation of the feet.

Finally, a thorough knee examination must be carried out. Since many of the problems dealing with the knee in runners involve anterior knee pain, the extensor mechanism must be examined in detail, as described by Fulkerson.¹⁰ Patellar position, tracking, stability, and crepitus and areas of tenderness about the patella should be noted.

Radiographic Examination

Radiographic examination of the knee includes at least four views: a weight-bearing anteroposterior view, a lateral view in 45 degrees of

flexion, a tangential view of the patella, and a notch view in either the weight-bearing or the non-weight-bearing position. Such a study is not required for an obvious tendinopathy or other soft-tissue condition, but if a degenerative condition, patellofemoral malalignment, or a bone abnormality or injury is suspected, a complete examination is certainly warranted.

Anterior Knee Pain

Approximately one third of runners' injuries fall into the category of knee pain (Table 1). In the 1970s, at the

Table 1
Causes of Knee Pain in Runners

| |
|-------------------------------------|
| Anterior knee pain |
| Excessive lateral pressure syndrome |
| Patellar instability |
| Quadriceps or patellar tendinopathy |
| Pathologic plica |
| Other conditions |
| Meniscal lesions |
| Bursitis |
| Stress fracture |
| Osteoarthritis |
| ITB friction syndrome |
| Popliteal tenosynovitis |
| Ligamentous instability |

peak of the running boom, the term “runner’s knee” was prevalent in the lay literature. This term seems synonymous with chondromalacia in the professional literature. However, neither term accurately defines the range of problems associated with anterior knee pain. Several conditions may cause anterior knee pain and must be specifically diagnosed before any attempt at treatment can be considered.

Excessive Lateral Pressure Syndrome

Excessive lateral pressure syndrome¹¹ is characterized by diffuse anterior knee pain, but usually the runner will indicate the patella as being the major site of discomfort. Clinical examination of patellar tracking may not reveal anything particularly remarkable, but palpation over the lateral retinaculum often reveals tenderness. There may be tightness of the lateral retinaculum, which can be identified when the lateral border of the patella cannot be brought to the horizontal plane on examination. This is determined by stabilizing the medial patella with the fingers of both

hands while using the thumbs to pull up on the lateral patella and then observing the degree of mobility present. If the condition has persisted, there may be crepitus and tenderness along the lateral patellar border, which is indicative of possible degenerative changes in the lateral-facet articular cartilage.

An axial view of the patella, such as the Merchant view (taken with the knee flexed 45 degrees and the x-ray beam projected caudad at a 30-degree angle from the femoral plane), will normally show the patella concentrically positioned in the sulcus without tilt or subluxation. Tilt is suspected when the medial facet is lifted away from the medial trochlear condyle. Since this technique is not particularly sensitive for tilt, there are some instances in which carefully performed computed tomography should be performed, with special emphasis on patellofemoral joint alignment,¹⁰ particularly when the diagnosis is not clearly confirmed and surgery is contemplated.

Once the diagnosis of excessive lateral pressure syndrome has been made, a conservative treatment program should be initiated (discussed later in the “Treatment” section). If 6 months of conservative treatment does not result in reduction of symptoms and the diagnosis is clinically and radiographically confirmed, surgery may be considered.

An arthroscopic or open lateral retinacular release is thought to be effective for treatment of patellar tilt, particularly when there is minimal or no articular involvement of the patella. A lateral retinacular release when there is no evidence of patellar tilt stands much less chance of being successful. Although arthroscopic lateral release may seem relatively benign, it is important to stress that a rehabilitation period of 8 to 12 weeks may be necessary before the patient can return to running.

Patellar Instability

Patellar instability is a condition associated with anterior knee pain in runners. A dislocated patella in a runner is rare, but subtle subluxation and maltracking are frequent. Even minor patellar subluxation or lateral maltracking can alter the normal distribution of patellofemoral joint-compression forces, creating pain with or without actual articular cartilage damage. Usually the pain is insidious and gradual in onset; however, some dramatic alteration in the runner’s program, such as incorporating hill workouts, may trigger pain. Symptoms of giving way may be present, but anterior knee pain is the most common complaint.

Physical examination to determine patellar position, tracking, and stability should be done along with appropriate radiographic evaluation. It is important to observe patellar tracking with active knee extension and flexion. Lateral placement of the patella or lateral displacement at termination of extension, termed the J sign, suggests maltracking. The knee is positioned in 30 degrees of flexion, lateral pressure is applied to the patella, and the presence of lateral displacement is noted. Normally, the patella should remain secure in the sulcus. A positive instability test, particularly when associated with apprehension, denotes instability. A Q angle of more than 20 degrees indicates a tendency for the quadriceps to displace the patella laterally. In cases of patellar instability and maltracking, the diagnosis can usually be made on the basis of the history and clinical examination. Confirmation is by x-ray examination. Determination of the congruence angle on a Merchant view of the patella may reveal patellar subluxation. A lateral radiograph with the knee in 30 degrees of flexion will suggest whether there is patella alta, which is often present with

instability. The normal ratio of patellar length to patellar-tendon length should be no more than 1:1.2.

Most of the more subtle forms of maltracking and subluxation can be managed with quadriceps rehabilitation, placing emphasis on closed-chain exercises. A program directed by a knowledgeable physical therapist or the physician should be faithfully pursued for at least 3 months before surgical treatment is even considered. Most runners will become symptom-free and can return to training after such a rehabilitation program, but continuation of rehabilitation exercises for an indefinite period may be necessary even after there has been a return to training.

For the small group of patients for whom surgical intervention is considered, arthroscopic lateral retinacular release followed by patellar chondroplasty is the option selected most often. A lateral release is compatible with a return to running and is preferable to more extensive procedures. As in the case of patients who have had this procedure for lateral tilt, 8 to 12 weeks of rehabilitation is required before a return to running. Distally, medial tibial-tubercle placement or anteromedialization of the tibial tubercle, as described by Fulkerson,¹⁰ may be indicated. Proximally, medial retinacular reefing can be carried out, but this must be done judiciously so as to avoid creating a tight medial retinaculum and patellar tilt or rotation. In runners, extensive proximal and distal realignment of the extensor mechanism has unpredictable results in terms of the ability to return to serious running. The simpler the procedure, such as a lateral release, the more likely are the prospects for a return to training. In large part, the result will be determined by the extent of patellofemoral joint degenerative changes or chondral damage from repeated

episodes of subluxation or maltracking.

Quadriceps and Patellar Tendinopathy

Quadriceps tendinosis and patellar-tendon (ligament) tendinosis, often referred to as "jumper's knee,"¹² are frequently encountered in runners. The latter, by far the more common, involves the tendon insertion on the distal pole of the patella. Excessive stress at the ligament insertion on the patella results in microruptures and perhaps local areas of deep tendon degeneration or tendinosis. The microtears lead to structural deterioration with partial tissue failure and, in some instances, can lead to complete rupture of the tendon.² Tendinosis at the tendon insertion distally on the tibial tubercle is a far less common running injury.

Quadriceps tendinosis is associated with pain at the insertion site of the quadriceps tendon, which is usually more lateral than medial, on the proximal pole of the patella. Patellar tendinosis pain is felt at the distal pole of the patella. The runner will usually indicate one or the other area as the site of maximum discomfort. He or she may also describe localized swelling when the symptoms are acute, but generally the complaint is largely of pain at the involved site, particularly with bent-knee activities. Typically, pain comes on gradually during the course of a run. Initially the symptoms may not stop the runner from training; with time, however, the pain becomes more persistent and may eventually lead to cessation of the sport.

In cases of quadriceps tendinosis, physical examination reveals tenderness directly over the insertion site of the quadriceps tendon, which is commonly located proximal and lateral on the patella. There may be associated crepitus, particularly if

there is a prominent lateral epicondylar ridge or perhaps even an osteophyte from some degenerative patellofemoral joint changes, similar to that noted with maltracking of the patella. Squatting places increased tension on the tendon and is often painful.

The tenderness associated with patellar tendinosis is best palpated with the patient's knee in full extension and the quadriceps relaxed. Pressure is applied to the proximal pole of the patella to tilt the distal pole up, so that the patellar tendon insertion may be easily palpated. Occasionally, swelling or induration of the soft tissues is also noted. There may be an increased Q angle. The Q angle may be observed to change dramatically during the support phase of gait, during which pronation or supination of the foot results in alteration of tibial rotation. This dynamic effect on lower-extremity alignment may aggravate or cause the problem by placing eccentric traction on the patellar tendon.

The radiographic findings are often normal, although the distal pole of the patella may have an elongated or fragmented tip. Occasionally, ectopic bone or calcific deposits are noted in the tendon. Ultrasonography and magnetic resonance (MR) imaging may delineate a lesion within the substance of the tendon. These studies are usually reserved for cases in which conservative treatment for at least 3 months has failed and surgery is contemplated. Ultrasonography is quite specific and less expensive than MR imaging.

Both patellar and quadriceps tendinosis can usually be resolved conservatively with the use of the treatment protocol that will be discussed later. Curwin and Stanish¹³ have described an eccentric rehabilitation program for tendinosis with a success rate approaching 90%. However, their results were less suc-

cessful with patellar tendinosis, with only 30% of patients experiencing relief.

In the event of intractable pain that fails to respond to 3 to 6 months of conservative treatment, surgical exploration of the proximal portion of the patellar tendon and excision of any abnormal tissue may be considered. If the tendinous lesion is quite large, reattachment of the tendon to freshened bone may be necessary. Fortunately, in most patients the area of involvement is relatively small, and the defect can be closed by imbrication. The surgical technique for quadriceps tendinosis is similar. If an osteophyte or prominent epicondylar ridge is present, it can be removed to decompress the involved area.

Pathologic Plica

Another condition that causes anterior knee pain in runners is painful plica. Most commonly, a medial parapatellar plica becomes fibrotic and rubs or snaps over the medial femoral condyle with knee motion. Occasionally, a retained suprapatellar plica may become symptomatic as well. Pain usually comes on gradually with distance running; however, it can be acute and associated with a sudden change in training routine, such as more intense, shorter-interval workouts. Snapping and buckling may be noted. The patient may also report that sitting is painful. Pain may be diffuse, but often the runner can localize it to the medial retinacular area or the suprapatellar area.

A common physical finding is localized tenderness over the femoral condyle adjacent to the medial border of the patella. Often a palpable snap and sometimes crepitus are noted over a tender and palpable medial fibrotic cord. If the suprapatellar plica is involved, there may be tenderness and sometimes crepitus on compression of the

patella and quadriceps tendon. Acute knee flexion may elicit suprapatellar pain. An effusion is not usual; if present, other intra-articular conditions should be considered. There is a tendency to overdiagnose this condition, but it is also important to remember that a truly pathologic plica may mimic many other conditions in the joint.

The treatment protocol discussed later in this article should be initiated, but active resistive knee exercises, which may irritate the plica, must be avoided. Arthroscopic excision may be necessary in some cases and usually will entail little downtime for the runner. If arthroscopic examination shows that the plica suspected of causing symptoms is not thickened, avascular, and widened (over 12 mm), Ewing¹⁴ suggests that it probably is not the cause of the problem; other causes should always be diligently sought by examining the entire joint.

Other Conditions

Meniscal lesions

Meniscal lesions are quite unusual in younger runners but do become a problem in middle-aged and older runners. The diagnosis of meniscal tears in runners is no different from that in any other athlete with this condition. In runners, particularly middle-aged and older runners, the onset of pain is usually insidious, although there may be an inciting incident, such as a misstep or twist. There may be a history of joint effusion or catching. Locking episodes are less common in the older runner.

Physical signs often include a small effusion, usually joint-line tenderness. In my experience, the McMurray test is positive in about half of patients. Arthrography or MR imaging may be helpful if the diagnosis is uncertain, but fre-

quently the diagnosis can be made on the basis of clinical criteria alone.

This condition readily lends itself to arthroscopic surgery, generally with a relatively short interruption (4 to 6 weeks) in the training program. Even so, an appropriate rehabilitation program must be supervised.

Bursitis

Medial knee pain has been reported to most commonly involve the pes anserine bursa and Voschel's bursa deep to the superficial portion of the medial collateral ligament.^{15,16} Tenderness with Voschel's bursitis is immediately below the joint line deep to the medial collateral ligament. Pes anserine bursitis is more distal, with tenderness and perhaps crepitus over the pes anserine area; in addition, active knee flexion against resistance may cause pain. These two conditions must be differentiated from a medial meniscal lesion, with which there will be tenderness more directly over the joint line. Both usually respond promptly to conservative measures. These conditions are relatively uncommon among runners whom I have treated.

Stress Fracture

Proximal medial tibial stress fractures are also a consideration but not very common in runners. Most tibial stress fractures occur in the middle and distal thirds of the tibia in runners. They are usually associated with localized tenderness on palpation and swelling. A bone scan is the best early diagnostic tool. Once the diagnosis has been made, the treatment is rest until the symptoms abate.

Osteoarthritis

Since running became popular in the 1970s, there has been a significant increase in the number of older

runners. It is not unusual to find very dedicated runners in the sixth and seventh decades of life. With increasing age, the frequency of osteoarthritic conditions increases, although there is no evidence to date in the literature that implicates running as a cause of degenerative changes in a normal knee.¹⁷ Once degenerative changes are established, the running program must be carefully customized and monitored.

A frequent question from runners is whether running will accelerate a known osteoarthritic condition. The answer is yes, it probably does to some extent, depending on the program. This possibility raises a difficult problem for runners. Sometimes it is best to first allow them to try to find a program that their knees will tolerate. If they are unable to do so, it may be easier for them to make the decision to discontinue running rather than being arbitrarily told they must stop. With significant degenerative changes, alternative low-impact aerobic activities are an option; these include cross-country skiing or using ski machines, swimming, doing aerobic water exercises, biking, and race-walking.

Minimal joint debridement with arthroscopic removal of symptomatic osteophytes, degenerative menisci, and loose bodies may help symptomatically, but whether this results in long-term improvement is debatable. Extensive chondroplasty procedures and abrasion chondroplasty procedures are not very effective in allowing a return to running.

Iliotibial Band Friction Syndrome

Iliotibial band friction syndrome⁹ is the most common problem involving the lateral aspect of the knee in runners. It is usually initiated by an extra-long run and is particularly aggravated by running

downhill. The pain is lateral, often starts a mile or two into the run, becomes worse for the duration of the run, and may cease on stopping. Sometimes it occurs only with downhill running and running on the level; participation in other sports is pain free.

The physical findings are tenderness over the distal ITB and the lateral femoral condylar region, with occasional swelling and sometimes crepitus. The lateral condyle may be prominent. The runner frequently has genu varum and/or tibia vara, heel varus, forefoot supination, and compensatory pronation. Examination of the running shoes often shows excessive lateral heel wear. This combination of subtle lower-extremity malalignments is thought to cause increased friction between the ITB and the lateral femoral condyle due to greater tension on the lateral structures. It is also thought that hip abductor weakness with early muscle fatigue may cause exaggerated pelvic sag during the support phase and place increasing tension on the ITB. This enhances friction between the ITB and the lateral femoral condyle, which results in synovitis. Tenderness is typically present about 2 to 3 cm proximal to the joint line and over the lateral femoral condyle and distal portion of the ITB.

Ober's test may be positive for ITB tightness. However, a better test is performed as follows: With the patient lying on his or her side with the affected knee up, pressure is applied to the lateral femoral condyle. The knee is then moved through a range of motion of about 30 to 45 degrees. This positions the tensed ITB directly over the lateral femoral condyle, which accentuates pain.

In addition to the modalities usually used in the treatment of runners' injuries in general, a corticosteroid injection or phonophoresis (ultra-

sound with topical hydrocortisone) in the area of involvement may help resolve the condition, particularly in the acute phase. Other techniques include stretching the ITB and strengthening the abductor musculature.

Surgery may be indicated in patients with intractable symptoms. Before arthroscopy of the joint is performed, the knee must be carefully inspected, particularly the lateral compartment, to rule out a meniscal lesion or other disorder, such as synovitis or pathologic lateral plica. If no other cause is identified, an open procedure similar to that described by Noble¹⁸ is performed to release the posterior 2 cm of the ITB at the level of the lateral condyle, where it appears to create the most tension over the femoral condyle. This procedure has been effective in my experience and usually allows a return to running within 4 weeks. However, as is the case for many operations used in the treatment of runners' injuries, there are no well-controlled prospective clinical studies that unequivocally show efficacy.

Popliteal Tenosynovitis

Popliteal tenosynovitis also causes lateral knee pain but in my practice is not as frequent as ITB friction syndrome. It involves the popliteal tendon posterolaterally and may vary from a transient condition to one that becomes chronic. The onset is often associated with downhill running.

Examination reveals tenderness directly over the popliteal tendon just posterior to the fibular collateral ligament. It sometimes is difficult to differentiate this condition from ITB friction syndrome or a lateral meniscal lesion. The former can be differentiated because tenderness is located over the ITB at the femoral condyle; in the latter, tenderness is directly over the lateral joint line.

Treatment is conservative and similar to that used for ITB friction syndrome. I have never considered it necessary to operate on a patient with this condition.

Ligamentous Instability

Ligamentous instability of the knee is not a common injury caused by running, even among competitive runners. However, some recreational runners may have ligamentous instability, particularly anterior cruciate ligament deficits, which have been incurred in other sports. If the menisci remain intact, there are no recurrent episodes of instability with swelling and pain, and the activity of running is confined to good surfaces, the knee may function well without difficulty.

Treatment

Most knee injuries in runners can be resolved with the use of conservative methods.¹⁹ Nigg²⁰ suggests that the most effective biomechanical strategies to reduce load and stress on a locomotor system involve the following factors: (1) the movement, such as a change in running style; (2) the surface (i.e., soft versus hard); (3) the shoe (current shoe designs provide variability in cushion effect and motion control of the foot); and (4) the frequency of repetitive movements (e.g., the mileage, pace, or duration of running).

A logical treatment protocol that addresses the elements listed in Table 2 is adaptable for virtually all runner's injuries, including those involving the knee.

Training Program

The training program must first be evaluated and modified as necessary. This will often resolve many of the injuries. Rest is the last bit of advice runners generally want to hear, but at times it is necessary.

Table 2
Treatment Considerations

| |
|---------------------------------------|
| Training program |
| Anatomic and biomechanical variations |
| Shoe modifications |
| Muscle reconditioning and flexibility |
| Orthotic devices |
| Medications and physical therapy |
| Surgery |
| Rehabilitation |

They generally prefer modification of the program by reducing the frequency, intensity, and duration of their running. Running in water (aqua-jogging) is an excellent form of non-weight-bearing cross-training for running during rehabilitation, which allows patients to maintain a high level of aerobic conditioning as well as lower-extremity muscle strength and endurance and joint mobility.

Anatomic and Biomechanical Variations

Thorough assessment of the entire lower extremity is mandatory. As stressed earlier, concentrating on the site of the injury about the knee will often lead the examiner to overlook the etiologic factor actually causing the pain. Thus, it is important to look both distal and proximal to the knee for anatomic or biomechanical variations. It is also important to learn how to evaluate foot function.^{3,5,21}

Shoe Modifications

Shoes generally come in three classifications: motion control, support, and cushion. Most running-shoe manufacturers have shoes fitting these classifications. A motion-control shoe is for someone who needs control of subtalar joint

motion for compensatory pronation. The support shoe is for the individual who does not demand much control. A cushion shoe is for the runner with a rigid-type foot requiring more flexibility and cushioning for shock absorption. Usually an orthotist or shoe-repair shop can modify running shoes for special problems, such as leg-length discrepancies. Changing the hardness of the midsole and heel wedge and using a variable-hardness heel wedge can change foot mechanics by altering pronation or supination, which then influences knee function through the amount of obligatory tibial rotation during pronation. However, heel-wedge and midsole cushioning do little to alter the vertical impact forces during the support phase.

Muscle Reconditioning and Flexibility

Restoring the muscle strength, endurance, and balance of the entire lower extremity is essential after injury. If runners do not specifically restore muscle strength and endurance to affected muscle groups, deficits will persist even after they return to running. Gentle, sustained stretching is another aspect of conditioning that must not be ignored, since tightness of the hamstring and gastrocsoleus muscle groups is very common among distance runners.

Orthotic Devices

By controlling pronation and supination, orthotic devices are used to alter foot biomechanics. The purpose of an orthotic device in the shoe is to allow the subtalar joint complex to function effectively from the neutral position during the support phase, reducing the amount and duration of compensatory pronation. The special materials used to fabricate the devices provide functional and impact shock absorption.^{9,21,22} These devices are most

useful in the treatment of problems due to subtle patellar maltracking or the ITB friction syndrome.

Medications and Physical Therapy

Reducing pain and inflammation with medications such as non-steroidal anti-inflammatory agents is helpful. Physical therapy modalities are also options. Corticosteroid injection is generally contraindicated in tendons. The most likely indications for steroid injection are ITB friction syndrome, popliteal tenosynovitis, and bursitis, particularly in the acute phase. Administering narcotic analgesics or injecting local anesthetics to allow running cannot be condoned.

Surgery

Most runner's injuries can be managed conservatively, but the program must be adequately supervised so that if conservative means fail, the runner, the coach, and the physician will feel comfortable about considering surgical treatment if indicated.

Surgery is not often required in runners, and the indications for surgery are really no different from those in the general population. Surgery is reserved as almost a last resort, particularly in the elite runner, except in the presence of certain conditions that can be managed effectively with early arthroscopic surgery, such as a documented meniscal lesion or loose body. This does not necessarily mean unusual or unwarranted delay, but rather taking a methodical approach to the problem. In some situations, it is important to point out to the runner that the condition could actually ter-

minate running in spite of well-indicated surgery.

Rehabilitation

If surgery has been deemed necessary, the surgeon must direct the post-operative rehabilitation program with the athlete, the trainer or physical therapist, and the coach. All too often, the results of surgery are negated by too rapid a return to running without adequate and careful rehabilitation. A program that I have found quite satisfactory (Table 3), with modification depending on the individual situation, emphasizes a graduated return to running after a layoff from injury or surgery. The patient should use an easy, comfortable pace (7 to 10 minutes per mile). He or she should also rest one day each week and not be concerned about mileage or aerobic conditioning. The purpose of the program is to condition the injured area. During the course of the graduated buildup, the patient can hold at a given level or even drop back a level if necessary. Aerobic conditioning can be maintained with cross-training activities, such as aqua-jogging, swimming, and biking. General strengthening and flexibility exercises should also be used.

Summary

The knee remains the primary location for lower-extremity injuries in runners, being the site of approximately 30% of all injuries. Anterior knee pain is the most common knee complaint. Although many factors are involved, training errors, particularly rapid transitions in the program and increases in mileage, are the primary cause of injury. A comprehen-

Table 3
Program for Graduated Return to Running

| Week | Activity |
|------|---|
| 1 | Walk 4 to 8 laps (alternate 50 m fast, 50 m normal) |
| 2 | Walk 8 to 12 laps (alternate 100 m fast, 100 m normal) |
| 3 | Jog 10 minutes every other day at an easy pace |
| 4 | Jog 15 minutes every other day |
| 5 | Jog 15 minutes one day, 25 minutes the next |
| 6 | Jog 20 minutes one day, 30 minutes the next |
| 7 | Jog 20 minutes one day, 35 minutes the next |
| 8 | Jog 20 minutes one day, 40 minutes the next |
| 9 | Resume training at an appropriate mileage and intensity |

sive history of the training program, a thorough examination of the entire lower extremity (not just the knee), and a methodical approach to treatment are essential. Most problems can be resolved conservatively, but surgery is occasionally indicated. After an injury or surgery to the knee, the physician must supervise the rehabilitation and the return to running so as to avoid reinjury.

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