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A Review of Common Overuse Injuries in Runners and a Proposed Training Program for Prevention

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A Review of Common Overuse Injuries in Runners and a Proposed Training Program for Prevention

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Dedication

This paper is dedicated to all of my clients, past and future, who deserve a pain-free running experience.

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A Review of Common Overuse Injuries in Runners and a Proposed Training Program for Prevention

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The University of Texas at Austin, 2014

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This report examines three common overuse injuries in recreational runners: patellofemoral pain syndrome, iliotibial band syndrome and plantar fasciitis. The anatomy of the knee, hip and foot is presented and discussed as it relates to each condition before exploring the mechanism of injury. A review of the literature for each injury includes various risk factors such as muscle weakness, muscle tightness and specific biomechanical factors potentially leading to injury. Recommendations for standard physical therapy exercises are included at the end of each chapter should injury occur. Finally, a preventative routine, developed with guidance from the practitioners at Sports Performance International is presented at the end of the report, taking into consideration the risk factors for overuse injury outlined previously, intended to reduce the likelihood of time being taken off due to pain or swelling.

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Chapter 1: Introduction

There is no question that recreational running in America has become an industry. Over a decade ago, 35.9 million Americans ran as a recreational activity. One third of those were running at least 100 days per year (38). 2013 saw an all-time high for number of United States marathon (541,000) and half-marathon finishers (2 million). The half-marathon surpassed the marathon in terms of growth rate in 2003, with a 12.5% annual growth, and has maintained a 10% rate per year in the decade since. Over 1,100 different half-marathon and marathon races (each) were held in 2013. Total participation in race distances ranging from 5k to marathon topped 8.6 million female finishers and 6.8 million male finishers (32). These statistics do not provide a completely accurate image of the number of runners in the country because it does not account for participants racing in multiple events, nor does it account for runners who participate in the sport without registering for any events.

A combination of the repetitive action of running and lack of contact in the sport leads most injuries to be chronic and resultant of overuse. James et al. (1978) found in a review of 180 patients complaining of 232 conditions, 65% of those injuries occurred among distance runners, 9% in sprint and middle distance and 24% in joggers. Of 107 males, 178 injuries were self-reported and of 73 females, 116 injuries were self-reported, indicating some participants experience multiple injuries annually. The average recreational runner has a

37-56% incidence of being hurt in the course of a year's training (39). Using a different cohort, Paterno et al. (2013) found one third to 50% of running injuries are chronic overuse injuries related to "constant levels of physiologic stress without sufficient recovery time". According to Dr. Ted Spears of Sports Performance International located in Austin, Texas, the most common overuse injuries include: Peripatellar pain, iliotibial band syndrome, plantar fasciitis and other injuries of the arch/foot, medial tibia stress syndrome (MTSS), and calf tightness. Most of the time, the fix for a chronic overuse injury is simple: take a break. Runners are notorious for being hesitant to take time off of their training regime, even if it means a reduction in pain.

There is little evidence in the literature regarding existing or developing preventative or reduction programs. This paper will examine three of the most common injuries in beginner and intermediate-level runners: patellofemoral pain syndrome (PFPS), iliotibial band syndrome (ITBS) and plantar fasciitis. The anatomy of the injury, risk factors for occurrence as found in the literature, and treatment of the injury should it occur will be discussed. Finally, at the end of the discussion of the three injuries, a comprehensive preventative exercise routine for runners, as recommended by the clinicians at Sports Performance International, will be presented for athletes to implement during their training.

Chapter 2: The Knee

The knee joint is the largest and most complex joint in the body. It is composed of a detailed structure of bone, muscle and connective tissue. The bones involved are the femur superiorly, the tibia inferiorly and the patella serving to improve flexion efficiency and protect the tibiofemoral joint (41). The tibia and femur articulate in a synovial, modified hinge joint that allows for flexion, extension and some rotation of the leg. The femur and patella also form a synovial joint that is, like the tibiofemoral joint, diarthrotic and moves in a gliding fashion. The patella is stabilized by several structures of the upper leg; the iliotibial band (ITB) and vastus lateralis (VL) stabilize the joint laterally while the vastus medialis (VMO) and adductor magnus stabilize the knee medially (14).The medial and lateral retinaculum, which attaches the VMO and VL to the patella respectively, as well as the bony architecture of the trochlea govern the movement of the patella over the joint (42). In a healthy knee, the VL pulls the patella up and out while the VMO pulls the patella up and in resulting in a net upward pull of the patella in extension. Patellar stability throughout the movement of the knee joint is critical for pain-free function. This stability is provided by static and dynamic restraints (7).

Patellofemoral Pain Syndrome Description and Risk Factors

Of the overuse injuries incurred through running, the knee is the most common site of injury. Taunton et al. (2002) found patellofemoral pain syndrome

(PFPS) makes up 25% of the injuries of the knee. PFPS is classified by anterior knee pain, caused by abnormal motion of the patella in the trochlear groove. The pain is often exacerbated by activities of running, squatting, jumping or walking down stairs (during full flexion of the knee). Patients can also experience catching or locking at the knee joint, stiffness and swelling, as well as buckling sensations (14). The three main mechanisms for PFPS injury are acute trauma to the knee, overuse (as common in runners) and abnormal patellar tracking. Each of these situations increases strain on the peripatellar soft tissue and patellofemoral joint stress, or both (42).

Muscle Weakness

Muscle weakness commonly leads to injury as force that should be absorbed by the muscle has to be transferred to a surrounding structure. In the case of PFPS, weakness of the quadriceps, due to their role in knee extension, is often explored. More specifically imbalances between VMO and VL. VMO weakness has been shown to cause lateral shift and tilt of patella during last 30 degrees of extension (33, 43, 44).

Additionally, altered VMO/VL response time is considered a risk factor for PFPS (41, 5). Cowan et al (2002) found that within the control group, VMO and VL EMG activity occurred at the same time but for the PFPS subjects, VL EMG appeared before VMO. This delayed activation of the VMO may contribute to lateral tracking of the patella and the pain manifesting itself on the anterior knee. (5).

Muscle Tightness

Hamstring tightness may cause quadriceps to have to work harder, as well as keeping the knee joint in flexion (41). Additionally, tightness in the rectus femoris may prevent full inferior excursion of the patella. Tight iliotibial band tissue may force the patella into lateral tracking. Tight gastrocnemius or soleus muscles may restrict talocrural dorsiflexion which leads to subtalar prontation and causes increased knee flexion (increasing compression of patella on femur) (14). It is common to find weak gluteus medius and tight tensae fascia latae with overactive or shortened ITB in PFPS patients. *Insert comments from SPI here.*

Quadriceps (Q) Angle

The Quadriceps (Q) angle is formed by the intersection of a line extending from anterior superior iliac spine on the pelvis through the midpoint of the patella, and another line from the tibial tubercle through the midpoint of patella. This line represents the line of pull of the quadriceps and patellar tendons. An increased or decreased Q angle creates an increase in peak patellofemoral pressure. An increased Q angle is associated with patellofemoral contact pressure and patellar dislocation whereas a decreased Q angle may not shift the patella medially but increases the medial tibiofemoral contact pressure through varus orienation of the knee (23). Because of these potential increases in pressure it has been suggested that a deviated Q angle could cause PFPS as it is often discussed as a potential risk factor for developing PFPS. It's agreed that the patella tends to track more laterally as the angle increases but little relationships between Q angles and patient complaints exist.

Q angle is not a significant predictor because of a failure to demonstrate consistent correlation between abnormal Q angles and anterior knee pain. One consideration for this is that Q angle is a static measure, whereas movement at the knee joint is dynamic in nature. Q angle can vary significantly with the degree of foot pronation/supination, especially when compared to the measurements taken in the supine/non-weight bearing position. Reliability of Q angle measurements is to be questioned (7).

Stride Length

There are multiple factors to consider when examining the biomechanics of a runner. Perhaps one of the easiest to modify for a positive effect is step length. Authors for article 6 found that a 10% decrease in step length resulted in 34% decrease in negative tibiofemoral joint stress per step on the treadmill (42). Wilson et al (2014) found a longer step length resulted in 9.2% increase in peak patellofemoral joint stress for both control and PFPS groups. A reduced step length decreased the PFJS by 16.3%.

Treatment of PFPS

Non-operative treatment of PFPS is successful in 75-84% of cases (6). Decreased activity resolves 30% of anterior knee pain after 4 weeks (17). Even changing the modality from running to cycling can reduce PFPS by 2-3times. In a review of different approaches to strength training, no significant difference was found in quadriceps strengthening modality.

A traditional physical therapy approach to rehabilitation would focus first on controlling pain, swelling and inflammation before treatment is initiated. Patients are encouraged to avoid activities that have been identified as causing an increase in patellofemoral compression (jumping, stair climbing, squatting and prolonged sitting with knee flexion) (7).

The first treatments to be incorporated are controlled ROM exercises with decreased loading. Exercises are prescribed with goals of neuromuscular control, timing, balance and proprioception. While there is little documentation that isolation of the VMO is possible through exercise (7), it is still a target muscle of knee extension exercises during rehabilitation.

Acute Phase of PFPS Rehabilitation

- Straight leg raises into abduction with thigh externally rotated
- Low-resistance knee extension, externally rotated (50-20 degrees). Resistance increases from 0 to 5 pounds
- Hip adduction in side-lying position on involved side.
- Step downs (paying close attention to form and action of the femur)
- Squats on a slant board
- Unilateral stance with hip extension, slight knee flexion and hip and trunk rotation. Use softer surfaces for greater challenge.

Stretches

- Quadriceps
- Hip flexors
- Hamstrings
- Gastrocnemius

After the patient can successfully perform the exercises listed previously with no pain or discomfort, treatment moves into the functional phase. The aim now is to address tissue overload problems and functional biomechanical defecits (7). In order to accomplish this, the patient will gradually increase joint-loading activities up to 25-30 pounds. The goals of this phase include attaining full pain-free range of motion, restore normal joint function, improve targeted muscle strength and neuromuscular control.

Functional Phase of PFPS Rehabilitation

- Lateral step ups and downs
- Single leg heel raises
- Partial to full squats with heavier resistance
- Seated leg press
- Front and side lunge (working up to resisted)
- Jumping and landing exercises
- Fitter-board exercises
- Resisted walking in all four planes
- Balance activities
- Obstacle jumping

Patients will be released back to their sport if they can regain normal gait pattern, ascend and descend stairs, and full range of motion and can perform a one-legged squat for 15-20 repetitions (7). The key thing is also the presence of pain-free motion.

Chapter 3: The Hip

The hip is another pivotal yet complex joint for runners. A ball and socket joint structure provides good range of motion in all three planes. It is comprised of the head of the femur and the acetabulum of the pelvis. Supporting structures include ligaments and the musculature of the glutes. Strong ligaments and a deep socket help limit the range of motion of the femur, providing stability through the hip (23).

The hip joint is surrounded by 21 powerful muscles that act to accelerate, decelerate and stabilize the joint (7). The iliotibial band is a sheet of connective tissue originating on the iliac crest of the hip and inserting at Gerdy's tubercle (tibia) and the fibular head. It runs down the lateral thigh and knee, passing over the lateral femoral epicondyle. Its function is to act as a lateral hip stabilizer, resisting hip adduction proximally (15). It also functions to flex and extend the knee (7). During standing, it maintains knee and hip extension, providing thigh muscles the opportunity to rest. During running or walking, it helps maintain flexion of the hip and is a major support of the knee during squatting from full extension until 30 degrees of flexion. Beyond 30 degrees it becomes a weak knee flexor and external rotator of tibia. This connective tissue has been known to cause problems more inferiorly at the knee joint.

Iliotibial Band Syndrome Description and Risk Factors

Iliotibial Band Syndrome (ITBS) is classified as an overuse injury. The friction of the IT band as it slides over the lateral femoral condyle is the cause of pain and inflammation in the lateral knee (7). While this is the most commonly reported knee condition in runners, it is not unique to their sport, and can also present in pain at the hip. Activities that involve repetitive knee flexion and extension (circuit training, jumping sports, skiing, cycling) are also at risk for developing this condition. For diagnosis, patients typically describe a pain with repetitive motions of the knee, particularly climbing or descending stairs. The pain is lateral to the knee, diffuse and hard to localize. Strain rate is a major factor in the development of ITB syndrome (15).

The impingement zone occurs at approximately 30 degrees of knee flexion during foot-strike and early stance phase: the ITB passes over and posterior to the lateral femoral epicondyle. During this period, eccentric contraction of the tensor fascia lata and gluteus maximus occur to decelerate the leg during running and this exerts great tension through the ITB (8,20,27).

Weak Muscles

Grau et al. (1993) found no difference between hip ab/adductor strength in healthy or ITBS injured runners. Several studies have found a decreased hip adduction moment in runners with ITBS at touchdown (10, 13). The gluteus medius and tensor fascia latae are primary hip abductors and should work eccentrically to control the amount of hip adduction present during running. This change in adduction leads to internal rotation of the thigh at mid-stance, causing increased tension on the ITB at the knee (7). Studies have shown the injured leg of a runner before rehab to have weaker hip abductors (glute medius and tensor fascia latae) than the uninjured side (20). These muscles control frontal plane movement of the hip during stance phase (60% of the gait cycle) through eccentric loading. ITBS symptoms in these participants improved with a successful increase in hip abductor strength (7).

Training Stimuli

The most common factor reported in the literature as contributing to the development of ITBS is a sudden increase in exercise intensity (mileage/hill training/speed work) (2, 9, 25, 26, 35, 37). Other possible causes due to their ability to increase tension in the ITB include downhill running, old shoes, always running on the same side of a sloped surface, leg length discrepancies, excessive pronation, tight ITB and weakness of glute medius (3, 9, 10, 21, 27, 35). These factors alter hip and knee angles to contribute extra strain to the tissue.

Treatment of ITBS

Since the primary cause of ITBS is generally overuse or overtraining, backing off of the training stimulus is usually the first recommendation to the patient. New running shoes, strengthening of the hip abductors and stretching of the ITB are also conservative recommendations for treatment.

Although the pain manifests itself around the knee, the hip structures are typically targeted for treatment of this syndrome. Goals of the acute phase for the hip include protection of the injury site (in this case, the knee), restoration of pain-free range of motion (knee extension to flexion) in the entire kinetic chain, decreasing pain, slowing muscle atrophy and maintenance of general fitness. This protocol typically begins with a reduction in weight-bearing exercises, including removing running from the training routine.

Fredericson et al. (2007) found that with a 6-week standardized rehab program focused on strengthening the abductors and stretching the ITB, with a discontinuation of activity, was successful in increasing abductor torque in the injured leg and 22 out of 24 athletes returned to running after 6 weeks. More involved treatment includes ultrasound and deep transverse friction massage.

Chapter 4: The Foot

As the only parts of the body to touch the ground during running, the feet play an immensely important role in the health of a runner's body. Simply considering the anatomy of the foot demonstrates its intricacy. Each foot has 26 bones, for a total of 52 bones in the feet; 25% of the 206 bones in the human body. These bones plus more than 100 ligaments, tendons and muscles combine to form the 33 joints of each foot. These structures are divided into regions based on the bone structure as well as the role each region plays in gait; rearfoot, midfoot and forefoot. Comprised of the calcaneus, talus and related soft tissue structures, the rearfoot forms the talocrural and subtalar joints. The midfoot contains the cuneiform, navicular and cuboid bones along with their soft tissue structures. Finally, the forefoot is the remaining structures of the metatarsals and phalanges.

These joints allow motion in several planes at once which helps for adaptation to sloping and uneven terrain, as well as force transmission (7). For the majority of runners (RFS), the subtalar joint first moves into supination to allow for a rigid, locked position. It moves into pronation in order to assist the ankle and knee with impact shock absorption and to adapt to ground reaction forces. Finally, as the body crosses over the foot, the subtalar joint moves back toward supination to increase the rigidity of the joint for a sturdy push off. The function of the midfoot is to provide the keystones for the three arches of the foot; lateral (cuboid), medial (navicular) and transverse (cuneiforms). Much like the subtalar joint, these joints also move from rigid to unlocked during various phases of the gait cycle.

The midfoot can directly affect the functioning of the forefoot via the cuneiforms, determining the mobility of the phalanges. The shape or rigidity of the cuneiforms can contribute to this determination. At the end of any of the stance phases (RF, MF or FF), the metatarsal and phalangeal joints are extended fully. This extension creates the tautness of the plantar fascia, as well as the elevation and rigidity of the longitudinal arch (7, 24).

The plantar fascia is an accessory structure of the foot. This band of multilayered, fibrous tissue originates at the medial aspect of the calcaneus, runs inferior to the bones of the foot and splits into five different bands as it inserts on the proximal phalanges. From heel strike to toe-off the plantar fascia serves to distribute the shock throughout the foot, and flattens as it does so (moving through dorsiflexion to plantar flexion).

Plantar Fasciitis Description and Risk Factors

Inflammation of this tissue, or plantar fasciitis (PF), is the most common cause of rearfoot pain in runners (31). PF manifests itself through pain in the heel in weight-bearing circumstances, particularly first thing in the morning. There is additional pain with overpressure into great toe extension and palpation of the plantar aspect of the heel (7).

Biomechanical Considerations

Most of the research suggests biomechanical causes for plantar fasciitis. Riddle et al. (2003) revealed limited dorsiflexion on the affected side among 50 patients. Ankle dorsiflexion of 6-10 degrees had an odds ratio (of having PF) of 2.9 whereas patients with 0 degrees or less had an odds ratio of 23.3.

A second biomechanical contribution is excessive pronation and supination. (18,19) The presence of either of these events in the gait cycle is suggestive of something awry in the initial phase of heel strike, and having excess force transmitted to the surrounding tissue or fascia.

Muscle Weakness

In addition to biomechanical factors, as seen in the hip and knee, muscular weakness is a powerful contributor to injuries in unrelated structures. Deficits in balance and strength in the gluteus medius have been linked to PF as well as weakness of the plantar flexors (I18, 19). These muscles load eccentrically through gait and weakness here causes the forces to be transmitted to the fascia. Tightness of the Achilles tendon has been found in 78% of patients (7).

Treatment for Plantar Fasciitis

Once a patient has been diagnosed with PF, there are a variety of techniques for treatment. Almost 90% of patients undergoing a conservative intervention regime had improved symptoms within twelve months (7). The goals of the initial treatment are to decrease pain, inflammation and swelling; protect the healing area from reinjury; re-establish a pain-free ROM; prevent muscle atrophy; increase weight-bearing tolerance; increase neuromuscular control and maintain fitness levels (7). Rehabilitation for PF is “best organized around a common framework for most foot and ankle pathologies” (7). The next phase of treatment is the functional phase and can begin after pain-free weight-bearing without a compensated gait pattern is present. The goals of this phase are to restore normal joint kinematics; attain full range of pain-free motion; improve neuromuscular control of the lower extremity in full-weight bearing posture on level and uneven surfaces; improve or regain lower extremity strength and endurance through integration of local and kinetic chain exercises; and to return to previous levels of function or recreation. To increase ROM, towel stretches, ankle circles, biomechanial ankle platform system (BAPS) exercise and active/ active assist exercises in straight planes. Foot intrinsic exercises would include toe curl exercises with a towel and moving marbles from the floor to a container with the pateint’s toes. Exercises typical in functional phase rehab: concentric exercises with tubing into DF/PF/Ev/Iv. toe flexion/extension. seated marching on floor, unilateral stance on floor, weight shifting, standing bilateral or unilateral heel raises, standing gastroc stretch, wall slide, toe walking, heel walking, supine leg press (7).

A prospective randomized study of 100 patients diagnosed with PF for more than ten months completed a rehab program of non-steroid antiinflammatory drugs, soft shoe inserts and either stretching of the PF by manually applying overpressure to dorsiflexed toes and ankles while seated or achilles and gastrocnemius stretching for three weeks concluded that stretching of the PF was more a more effective treatment than achilles stretching (19).

Chapter 5: Prevention of Overuse Injuries for Runners

Runners, like any athlete, hate to be told that they must take a break from their normal training routine. In order to prevent injuries like patellofemoral pain syndrome, iliotibial band syndrome and plantar fasciitis, care should be taken when designing a running program to help develop the body into an efficient machine that can properly deal with the stress of training.

The first, and perhaps easiest step to prehabilitation and injury avoidance is following an appropriately training routine. A common risk factor for all of the overuse injuries is increasing in intensity too quickly, whether it was distance, speed or incline. It is important for coaches and athletes to recognize how quickly their intensity is ramping up, as well as being sure to include rest days. The gold standard in the running world for metrics on distance is to never increase total weekly mileage by more than ten percent from week to week.

Secondly, any running routine of serious ambition, whether through high mileage or fast paces, should include an appropriate strength and stretching component. Risk factors for all three overuse injuries explored included musculature imbalances at the hip, knee and ankle as well as limited flexibility through those joints as well. Implementing a strength training program, especially for beginner runners (often sedentary and overweight) has the potential to reduce chance for injury.

A strengthening and stretching program that targets the three regions of the lower body mentioned formerly could potentially ameliorate the effects of the repetitive mechanics of running. Gluteal muscles, tensor fascia latae, quadriceps, and plantar flexor were all cited as being potential areas of weakness leading to one or more of the overuse injuries examined in this paper. Dr. Ted Spears of Sports Performance International commented that quadriceps to have an influence over patellar tracking but in the majority of runners he sees in his clinic, it has to do with postural muscles of the hip (glute medius and minimus). Weakness here leads to a mechanically disadvantaged presentation of the lower body during the gait cycle. Adequate strength here before training begins may help reduce the side effects of having weak muscles. It would make sense to take some of the exercises used to strengthen these muscles during the rehabilitation phase and incorporate them into a strengthening workout for the prehabilitation phase. Muscles targeted should include the hips (abductors, external rotators, glutes) and core as well as a total body strength training routine. Additionally, maintenance of adequate dorsiflexion at the ankle joint is recommended to maintain uncompromised biomechanics via gastrocnemius stretching (careful not to overload eccentrically). Finally, it is important to keep in mind that every runner's body, training schedule and threshold is different. These training routines, running and weights must be individualized to the abilities of the athlete. It's the job of coaches to get their athletes away from the “pure running” mindset and into one that includes any training stimuli to prevent injury. More research is certainly needed in order to prove the potential effectiveness of a full body weights routine in injury prevention in runners.

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