Overuse Injury and Running: A Biomechanical and Functional Movement Approach

A Case Report

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The final copy of this case report has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline
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Abstract
The purpose of this case report is to describe how exercises designed to promote neuromuscular control and strength of the hip musculature in conjunction with other physical therapy interventions were used to treat a runner with bilateral medial tibial pain. The evaluation and treatment of a patient with a 3-month history of bilateral shin pain are described as an example of when proximal control could be affecting distal components of the kinetic chain. This case report demonstrates that a patient was able to return to participation in running competition without pain following a hip stabilization exercise program.
Introduction

Americans are flocking to endurance sports. Running, having relatively no equipment cost minus a pair of shoes, has become the recreational sport of choice for the average American. There is a local five kilometer (5k) race every weekend, but more importantly there is an increasing allure to finish longer distances such as a half (13.1 miles) or full marathon (26.2 miles). Running USA (2011) reported 49,408,000(+12.6% 2009-10) runners that run/jog at least once a year, 27,664,000(+8.2% 2009-10) run/jog 50+ days/yr, and 18,383,000(+11.5% 2009-10) run/jog 100+ days/yr. In addition to a national growth in the number of recreational runners, there is an increase in running related injuries with a reported 19-79% of runners being injured annually (van Gent, et al. 2007). Van Gent et al. (2007) reports that the main factors contributing to running related injuries in the lower extremity are previous injury and an increase total weekly mileage. Other factors include changes in running intensity and running equipment (Magrum & Wilder, 2010). The runner’s body systems cannot adapt appropriately or quick enough to the new stresses being placed on them. Consequently, injury arises. The following paper will discuss running gait, common running injuries assessment techniques, and interventions of the runner.

Purpose

Recreational running has experienced a vast influx of participants over the past few years. This could be attributed to a number of factors including the accessibility of the sport, affordability, and an increase in the number of races and types of races. A large percentage of the population is participating in running events nationwide, and research shows that a large majority of the runners will incur at least one injury annually, if not more (van Ghent et al.). The case report demonstrates the importance of regional interdependence when evaluating a patient presenting
with a running related overuse injury. More specifically the case report illustrates the use of hip stabilization exercises in a runner with bilateral shin pain while running. Treating the patient’s cause rather than the symptoms of the injury is becoming more widely researched.

**Literature Review**

**Recent trends in Running**

Both the marathon and half marathon distances have seen increases in finishers. In 2010 sold out and record fields were reported. There is a recorded 255% increase in the number of marathon finishers from 1980 to 2010 as well as a 30% increase in the number of marathon races held in the U.S. from 1985 to 2010 (Running USA, 2011). Most of participating individuals are not professionals, but they are recreational runners lacking training knowledge. Almost half, 46%, of marathon finishers were masters runners, 40+ years, in 2010. Masters running category begins at 40 because that is the age when studies observe the first decline in endurance peak performance (Lepers et al. 2010; Sultana et al. 2008; Tanaka & Seals 2008).

While there is a dramatic increase in recreational runners seeking to complete these races of 26.2 miles, there is also a documented increase in injuries affecting runners. Injuries that were once predominately seen in upper echelon marathon runners are now common in recreational runners (Fields, 2011). Also, as runners age most continue to train the same way as when they were younger despite age related changes in the muscle tendon units (McKean et al., 2006).

**Running Gait**

The term gait refers to the locomotion of the human body (Levangie & Norkin, 2011). A complex combination of joint motions and muscle actions are required to produce these movements of the body. In order to understand abnormal gait patterns to assess running injury,
one must have knowledge and understanding of the normal gait pattern. The human gait has been dissected and studied in depth. The gait cycle is the time interval or sequence of motions occurring between two consecutive initial contacts of the same foot (Magee, 2008). The gait cycle can be broken down into two main phases: a stance phase and a swing phase. The stance phase accounts for 40% of the running gait cycle, and the swing phase accounts for the remaining 60% (Magee, 2008).

**Stance phase**

Functionally, stance phase serves to absorb forces and propel the body forward (Dugan & Bhat, 2005). The stance phase can be broken down into smaller sub phases consisting of a progression from initial contact, to midstance, and then to toe off (Magee, 2008). The entire kinetic chain must be taken into consideration when looking at each phase of the gait cycle. During the stance phase the foot acts as a shock absorber and a support structure so that the lower limb can bear the weight of the body and then advance it forward. The foot is slightly supinated at the subtalar joint as the heel makes contact with the ground (Dugan & Bhat, 2005). As the forefoot approaches the ground the tibialis anterior contracts concentrically to stabilize the ankle. The plantar flexors including the soleus and gastrocnemius contract eccentrically to control forward tibial progression and stabilize the ankle (Dugan & Bhat, 2005).

At the knee the quadriceps femoris contracts eccentrically to prevent knee buckling and to absorb impact of landing (Magee, 2008; Levangie & Norkin, 2010; & Nicola & Jewison, 2012). Working our way up the kinetic chain, the gluteus maximus and hamstrings contract eccentrically (Magee, 2008). The hip adductors are contracting in late stance phase to provide stability (Levangie & Norkin, 2010; Dugan & Bhat, 2005). All muscles are functioning to either provide support for the skeletal system or generate energy to propel the body forward.
Midstance is the transition from initial contact to push off. The body moves over the foot, and the ankle reaches maximum dorsiflexion of 20 degrees (Dugan & Bhat, 2005). Dorsiflexion happens in conjunction with internal rotation of the tibia. As the tibia rotates internally, the subtalar joint falls into pronation as described in the mitered hinge model (Nordin & Frankel, 2001). Pronation at the subtalar joint allows for more shock absorption by conforming the foot more to the contour of the running surface (Nordin & Frankel, 2001). Eccentric contraction of the tibialis posterior, gastrocnemius, and soleus provide the control for pronation (Dugan & Bhat, 2005).

At this point the lower extremity has absorbed the shock from the ground and is ready to propel itself forward. Intrinsic muscles of the foot contract to add rigidity (Nordin & Frankel, 2001). The foot subtalar position moves into a supinated position to provide a more rigid lever for push off (Nicola & Jewison, 2012). Plantar flexion of the ankle occurs as the contractions of the gastrocnemius and soleus shift from eccentric to concentric, pushing the heel off the ground. Contraction of the knee and hip extensors help propel the body forward during toe off. Earlier the hamstrings were contracting eccentrically to stabilize the lower extremity for absorption of impact forces, now they have converted into an active hip extensor (Dugan & Bhat, 2005). Toe off signals the end of the stance phase of the gait cycle.

**Swing phase**

Just before swing phase, the body is in a period where neither foot comes in contact with the running surface. This period is referred to as the float period (Levangie & Norkin, 2010). Looking first at the ankle, the tibialis anterior contracts to dorsiflex the foot so that it can clear the ground. At the hip, the iliopsoas and rectus femoris concentrically contract to pull limb “swinging” through the air (Dugan & Bhat, 2005). Swing phase exhibits the greatest amount of
knee flexion, 80-130 degrees. To facilitate this degree of flexion, the short head of the biceps femoris contracts concentrically from about 40% to 58% of initial swing (Levangie & Norkin, 2010). At this point, the opposite limb is also off the ground, marking the second float phase. As a result of forward momentum the knee begins to extend, and the hamstrings eccentrically contract to control this movement (Levangie & Norkin, 2010; Dugan & Bhat, 2005). As the foot approaches the ground, the gastrocnemius and soleus contract to prepare for weight bearing (Dugan & Bhat, 2005).

**Ground Reaction Forces**

As the foot hits the ground in stance phase the body is met with a force. This force applied to the body is defined as the ground reaction force (GRF). Three components on their respective axes contribute to the GRF, a horizontal, an anterior-posterior, and a medial-lateral component (Ethan et al., 2010). The vertical ground reaction force reaches the highest magnitude of the three forces. Vertical ground reaction force has two main peaks an impact peak and a midstance peak. Impact peak occurs at approximately 12% of the gait cycle just after heel contact with the ground. The second and greatest vertical peak is the midstance peak. At midstance peak the forces on the body are approximately 2.5 times the runner’s body weight (Derrick, 2004). Forces can vary depending on the runner’s contact style, cadence, and slope of the running surface (Dicharry, 2010). Recent research experimenting with gait analysis and gait retraining is aimed at reducing GRF for the purpose of preventing running overuse injury (Noehren et al., 2010; Crowell et al., 2010). This research will be discussed further later.

**Foot and Ankle Mechanics**

Foot and ankle mechanics are described to some degree above as a component of the running gait. However, further explanation and in depth analysis of foot and ankle mechanics is
required because of the injury implications that faulty ankle foot mechanics can perpetuate onto the runner. Significant research has been conducted concerning the effects of the ankle foot on the biomechanics of running. The pronation/supination motions of the ankle foot complex have been regarded as being of major importance during the running gait. In the closed chain environment during running, pronation is a combined motion of calcaneal eversion, plantar flexion, and adduction of the head of the talus. Supination is described as calcaneal inversion, dorsiflexion, and abduction of the head of the talus (Levangie & Norkin, 2011). In normal running mechanics, the ankle/foot complex transitions from a supinated position at initial contact, to a pronated position at midstance, and back to a rigid supinated position for push off.

Individuals who exhibit an inability to dynamically control the pronation/supination transitions of the foot through the running gait cycle may have increased risk for LLOI. This associated risk perpetuates from an increase in torque placed on the lower extremity and increased tibial internal rotation (McClay, I. & Manal, K., 1997; Messier et al., 1991; Messier et al., 1988). The muscles responsible for controlling internal rotation at the ankle, knee and hip are the posterior tibialis and soleus, hamstring, and hip external rotators respectively. Theoretically, excessive or prolonged pronation would place increased stress on the aforementioned muscles, tendons, and bony attachments leading to soft tissue overuse injuries. One prospective study correlated significantly increased pronation in runners experiencing exercise-related lower leg pain compared to runners experiencing no lower leg symptoms (Willems et al., 2006).

**Pelvic and Spine Involvement**

In addition to the lower limb movements during the gait cycle, running also incorporates complex motions of the pelvis and spine (Schache et al., 2002). These areas can be overlooked
when assessing the runner, but the pelvis and spine can sometimes be a contributor to a
dysfunctional movement pattern. Franz et al. (2009) looked at 73 recreational runners suggests
that running with an increased stride length can cause a compensatory reaction by the pelvis to
anteriorly tilt. The researchers go on to suggest that possibly increasing length of the hip flexors
could normalize the pelvic orientation and equalize the tissue demands of running. Guten (1981)
proposed that the great amount of hip extension required for running combined with strong
lumbar muscles anteriorly tilts the pelvis resulting in an increased anterior pelvic tilt that
increases the lordotic curve. An excessive lordotic curve has been shown to increase interdiscal
pressure, narrow the intervertebral foramen, compress the posterior vertebral bodies and facet
joints, as well as stretch the anterior longitudinal ligament (Levangie & Norkin, 2010).

The core musculature is intimately involved in running motion. These muscles have two
main functions: 1) maintain stability of the kinetic chain and 2) generate and transfer energy for
distal mobility (Kibler et al., 2006; Fredericson & Moore, 2005). A strong core is essential to
proper running biomechanics and peak performance. The core is the base of movement for the
running motion, and most of the prime movers for running have attachment on the pelvis
including the hamstrings, quadriceps, and iliopsoas. Also the muscles for frontal plane
stabilization attach onto the pelvis, spine, and ribcage (Levangie & Norkin, 2010). The core
muscles include multifidi, paraspinals, quadratus lumborum, rectus abdominis, transverse
abdominis, external oblique, internal oblique, diaphragm, gluteals, and the pelvic floor
musculature (Kibler et al., 2006; Fredericson & Moore, 2005). This makes 29 muscles in all that
working in conjunction to provide stabilization and transference of force during running motion
(Fredericson & Moore, 2005).
Running is a sagittal plane movement, and the body needs to remain erect and in that sagittal plane for optimum functionality of movement (Arellano & Kram, 2011). The transverse abdominis and the multifidi form the major stabilization components of the abdominal hoop (Fredericson & Moore, 2005). This hoop of muscle keeps the lumbar spine stiff and helps provide support for the lower extremities during running (Lundin et al., 1993; Miller & Bird, 1976; Nashner, 1979). Hodges & Richardson evaluated motor control of the transverse abdominis, and they noted that in healthy individuals the transverse abdominis contracts right before limb movement. This finding suggests that the transverse abdominis does play a role in the running motion. Evidence shows that the quadratus lumborum (QL) mainly contracts isometrically as a frontal plane stabilizer to discourage excessive frontal plane motion (Kibler et al., 2006; Akuthota & Nadler, 2004). The gluteus medius and maximus activity has been shown to stabilize the lower extremity (Aukuthota & Nadler, 2004).

Overall, like components of the lower extremity, there is a complex combination of complementary segments that aid in running performance. In a study by Khamis & Yizar, (2007) induced hyper pronation using a wedge to promote calcaneal eversion resulted in increased internal rotation of the tibia and anterior pelvic tilt. Thus, evidence shows that changes at the foot and ankle region can have effects that travel up the kinetic chain to more proximal segments. Hence, it is important when evaluating the runner to use a functional whole body approach versus a regional approach.

**Common Musculoskeletal Running Injuries**

With the increased popularity of recreational running and the subsequent increase in running related injuries, it is necessary to look at these factors that may predispose or self-impose the runner to an increased risk of injury. However, this can be difficult since running
injury risk is multifactorial, and there does not appear to be a consensus among researchers pertaining to all identified risk factors. With that said, much research has been conducted on running injuries and there are some commonalities that should be addressed. A prospective study based on plantar pressure measurements during barefoot running to determine intrinsic risk factors for lower leg overuse injuries (LLOI) found that a more laterally directed force distribution during initial contact phase, a more laterally directed force displacement in the forefoot contact phase, and a higher force and loading underneath the lateral border of the foot to be potential gait related intrinsic risk factors for development of LLOI (Hesar et al., 2009). This suggests that a runner landing in a more supinated position has a greater potential risk for developing a LLOI. It is pertinent to note that Hesar et al. looked at barefoot runners vs. shod runners because shoes could be an extrinsic factor influencing gait pattern abnormalities.

Among the reported affected sites of musculoskeletal running injury are knee (25%), lower leg (20%), foot (16%), ankle (15%), upper leg (10%), hip and pelvis (7%), and lower back (7%) (Fields, 2011; Chang, 2012; van Middlekoop, 2008). Recent reports state that the number one knee problem in runners is Iliotibial Band Syndrome (ITBS) (McKean, 2006). This is possibly due to the higher number of recreational runners competing in competitive events. Older reports show that patellofemoral pain syndrome (PFS) is the most common knee injury (Fields, 2011). PFS involves abnormal tracking of the patella on the femur usually on the lateral aspect (Levangie & Norkin, 2010). Contributing factors to PFS include vastus medialis weakness, hip abduction weakness, and cavus feet have been linked to PFS (Fields, 2011). Souza & Powers (2009) performed a cross sectional study demonstrating that females suffering from PFS exhibited decreased hip muscle performance in 8/10 hip strength measurements. Faulty hip stability perpetuates into malalignment of the patellofemoral joint which manifests
itself as pain in the runner. In addition, evidence shows that there are biomechanical influences contributing to PFS. In a prospective study of 143 recreational runners, Thijs et al., (2008) found a significantly higher vertical peak force underneath the second metatarsal, a shortened time to the vertical peak force at the lateral heel, and a significantly higher vertical peak force at the lateral heel and the third metatarsal in the subjects who developed patellofemoral pain (Thijs et al., 2008). This suggests that the runners have a dysfunctional movement pattern leading them to incur increased shock with initial contact during the running gait.

Another common injury, medial tibial stress syndrome, Commonly referred to as “shin splints”, presents with pain along the posterior medial border of the tibia during activity and with palpation along this border over a length of at least 5cm. This occurs because the stresses placed on the tibia cause a bony resorption that outpaces tibial cortex formation (Moen et al., 2009). Microtrauma occurs at the locations of the periosteum, muscle attachment sites, and cortical bone. If abnormal stresses continue to be compounded on the cortical bone of the tibia, a stress fracture can take place (McCormick et al., 2012). Some individuals are more susceptible to overuse injury, and having the ability to identify predisposition to injury is beneficial to for the runner and for the treating physical therapist. Verrelst and colleagues (2013) measured isokinetic hip strength of the abductors, adductors, internal rotators and external rotators of 96 female physical education students. Then a cox regression analysis was used to correlate potential risk factors for the development of exertional medial tibial pain. The researchers identified hip abductor weakness as a significant predictor for exertional medial tibial pain. Another prospective study that measured female kinematics in the frontal and transverse plane during a single leg drop jump concluded that increased ROM in the transverse plane of the hip and thorax during landing and push off are significant predictors of exertional medial tibial pain.
in women (Verrelst et al., 2014). Therefore, a runner’s concentric hip abductor strength and
dynamic hip stability specifically in the transverse plane should be screened clinically as a
predictor of potential exertional medial tibial pain.

There is increasing evidence that anatomical factors contribute to development of stress
fractures. Bennell et al., (1996) showed that smaller calf muscle girth and less lower limb
muscle mass correlates with incidence of stress fractures in female runners. The proposed
reasoning for this correlation can be explained by looking at the movement occurring during the
running gait cycle. At initial contact, the part of stance phase responsible for shock absorption,
the posterior compartment muscles eccentrically contract to absorb some of the ground reaction
force. A smaller muscle girth could translate into a decrease in the ability for the muscle to
absorb those forces. Therefore, the resulting forces are translated into the tibia. Other
anatomical considerations contributing to stress fractures include low bone mineral density, leg
length discrepancy, and Q angle greater than 15 degrees (Magness et al., 2011; McCormick et
al., 2012). Extrinsic factors that can increase incidence of stress fracture include an increase in
weekly mileage, running shoes older than 6 months, and training on hilly terrain (Brunet et al.;
Gardner et al., 1988; Koplan et al., 1982; Macera et al., 1989; Marti et al., 1988). More recent
evidence on biomechanical correlations with incidence of stress fracture in runners reveals that
excessive hip adduction and rear-foot eversion can be a contributing factor to tibial stress
fractures (Pohl et al., 2008).

Furthermore, asymmetrical differences from side to side as well as strength and
flexibility asymmetries may have implications for increased injury risk in runners. Plisky et al.
(2006) demonstrated that high school basketball players with asymmetrical right/left differences
in dynamic postural control detected using the Star Excursion Balance Test were 2.5 times as
likely to sustain a lower extremity injury. In addition, asymmetrical movement pattern differences in professional football players using the Functional Movement Screen (FMS) have been identified to be at higher risk for serious injury (Kiesel et al. 2007). Although these studies do not include distance runners, one can appreciate the role asymmetry plays in injury prediction. Brumitt et al. (2013) demonstrated that female division III athletes including cross country runners with side-to-side asymmetry between single leg hop distances >10% had a 4-fold increase for a foot or ankle injury. More prospective studies including one using a sample population of endurance runners need to be conducted in order to draw more definitive conclusions on the role of asymmetry in LLOI.

Assessment

There is no professional standardized running evaluation used by all clinicians. A study of 153 (82 men and 71 women) recreational runners by Lun et al., (2004) concluded that static lower limb alignment measures do not correlate to running injury with the exception of runner’s with patellofemoral pain syndrome. Over the years, the evaluation of runners as well as other patients/clients has involved region specific measurements, assessment, and treatments. Focusing on one area might achieve short-term relief, however, a compensation or movement of the problem up the kinetic chain might result. The kinetic chain, its segmental integrations, and connections have been discussed earlier. Knowledge of the kinetic chain should lead us to theorize that a regional specific approach is not the most effective in treating musculoskeletal running related injuries and a more functional biomechanical approach should be taken (Cook, 2010).

Magrum et al., (2010), describes the evaluation of the injured runner to include a biomechanical assessment composed of a standing, sitting supine, side lying, and prone position.
In sitting, leg length and patellar position and tracking are assessed. In supine, leg lengths, lower extremity alignment, patellar tracking, and flexibility are assessed. This is accomplished by assessing femoral and tibial torsion, measuring the Q angle, assessing patellar glide, performing knee ROM testing, performing knee stability testing, performing the Thomas test, and assessing hamstring length. Side-lying can be used to test hip abductor strength and assess the length of the ITB. Lastly, with the patient in prone the clinician can observe the soles of the feet, examine the ankle and foot mobility, assess subtalar motion, measure quadriceps flexibility, and assess first ray mobility. Following the posture and segmental alignment examination, the clinician then checks specific sites by inspection, bone palpation, soft tissue palpation, strength testing, range of motion testing, neurologic examination, specialized testing, and examination of related areas. Magrum et al., (2010), then suggests the usage of functional tests. Cook, (2010), proposes using a group of functional tests following subjective history, observation, and neurologic screening. Thus, the clinician can pinpoint areas of dysfunctional movement prior to the specific tests to better direct the evaluation.

Despite location in the evaluation, functional tests can be used to identify deficits or compensations. The following tests have been shown to be useful when evaluating the injured runner: dynamic pronation/supination, navicular drop, single leg squat, bilateral squat, step-down test, star excursion balance test, (SEBT) multi-segmental rotation, multi-segmental extension, multi-segmental flexion, cervical patterns, shoulder patterns, and swing test (Magrum et al., 2010; Cook, 2010; Geraci & Brown, 2005). In addition, an overall gait assessment of the runner is essential because then the clinician can observe how the runner’s posture, joint motion, arm swing, and leg swing function while running. (Magrum et al., 2010) These are aspects of the evaluation that may not appear in a static assessment alone.
In addition, a shoe wear assessment is also considered when assessing the injured runner (Yamashita, 2005). The theory behind running shoes is to place all runners in a normal subtalar neutral position. Therefore, to determine the appropriate running shoe for an individual, the clinician evaluates the runner’s plantar shape and subtalar motion both weight bearing and non-weight bearing. However, there is not clear evidence stating whether or not this subtalar neutral position is actually ideal for optimum running function and prevention of injury (Nester, 2009). Furthermore, a recent study conducted by Knapik et al., (2010), found that assigning running shoes based on static weight bearing plantar shape versus assigning all subjects a stability shoe had no significant influence on the risk of injury in marine corps basic training corps recruits. In addition, more research on barefoot running is being conducted and the benefits of a forefoot running strike (Jones et al., 2012; Griffiths, 2012; Lieberman, 2012). The modern day running shoe has evolved to allow the runner to bypass natural progression and the body’s built in systems for proprioception and shock absorption (Cook, 2010; Griffiths, 2012) On the other hand, there is evidence that demonstrates how footwear alters the biomechanics while running (Cheung, 2008). Overall, in regards to shoe wear prescription, more research needs to be conducted to determine the best approach. In addition, as the running shoe market evolves the clinician needs to stay informed on the types of shoes available and how they affect the runner.

Treatment & Prevention

Previous treatment for runners has taken a more region and pain specific approach. For example, if the iliotibial band is causing pain, then the treatment prescription combines some form of stretching of the ITB, therapeutic ultrasound to the ITB, ice, NSAIDS, cortisone injection, and friction massage (van der Worp, 2012). However, none of these methods are proven to be very effective for long-term prevention of ITB. In addition, research does not
strongly support any one specific treatment method for ITBS (van der Worp, 2012). During the acute phase of injury, the application of RICE is appropriate for most running injuries. The lack of long term prevention success of the region specific approach could be due to the fact that the biomechanical dysfunction responsible for the injury has not been addressed or resolved.

Treatment should not begin by attacking the overused/stressed site; instead look to address biomechanical abnormalities elsewhere along the kinetic chain (Geraci & Brown, 2005).

The clinician’s results from the functional movement tests should point him/her in the direction of a muscle imbalance. For example, the single leg squat might suggest the runner has a muscle imbalance stemming from weak hip abductors (Cook, 2010). The treatment would then consist of eccentric exercises to increase strength and endurance to the hip abductors (Geraci & Brown, 2005). Running involves repeated eccentric contractions of the hip abductors. Thus, eccentric closed chain exercises are most effective in rehabilitating a running muscle imbalance. Earl & Hoch (2011) performed a case series that observed significant improvements in pain, functional ability, lateral core endurance, hip abduction, and hip external rotation strength in females with PFPS after an 8-week rehabilitation program focusing on strengthening and improving neuromuscular control of the hip and core musculature.

The core is the base of all movement. Many strength & conditioning specialists and medical professionals have indicated the importance of a strong core for efficient movement. Therefore, many running rehabilitation treatment plans contain a core strengthening exercise component. Sato & Mokha, (2009), found that core strength significantly improved recreational and competitive runners 5000 meter run times and increases scores on the SEBT albeit not statistically significant increases.
In addition, runners experiencing chronic injuries have been shown to benefit from gait retraining (Noehren et al., 2010; Crowell et al., 2010). Crowell et al., (2010), used real time visual feedback to retrain gait in recreational runners who primarily heel strike at initial contact. Their results indicate that this method can be used to effectively reduce lower extremity impact loading. Hence, this could be an option for preventing chronic injuries. Another study used real time visual feedback in runners with PFPS and found reduced hip adduction, contralateral pelvic drop, pain, and Lower Extremity Functional Index (LEFI) (Noehren et al., 2010).

Case Description

Patient History

This case involves a 16 year-old female high school track/cross country runner. The patient presented to physical therapy with bilateral shin pain of approximately 3 months duration. At this time of pain development the patient was participating in track season. The patient ran recreationally prior to joining the track team. The patient’s bilateral shin pain presents after 2-3 days of consecutive running without a rest day; pain is experienced throughout the day even after cessation of running. Factors contributing to an increase in symptoms include running on cement surfaces and running long distances with the latter being the largest contributor. The patient runs in a year old pair of shoes with an over the counter orthotic that provides medial support. The patient’s goal for physical therapy is to be able to run pain free. The patient has no significant past medical history, social history, or medications. The evaluator did not mention the patient’s menstrual status.

Systems Review

The patient’s past medical history is not significant. No red or yellow flags are noted. The patient’s problem presents as musculoskeletal in origin therefore, the patient is appropriate
Clinical Impressions

Initial impressions from the patient’s presentation lead the investigator to propose the primary problem was a running related overuse injury; possibly medial tibial stress syndrome, posterior tibial tendonopathy, and/or medial tibial stress fracture. With this type of injury it is prudent to find the link in the kinetic chain that could be contributing to the primary symptoms. This case is significant because it will demonstrate how the body functions as a unit while running. Dysfunctional movement patterns at one joint can cause potential injury above or below in the kinetic chain. The examination should thoroughly assess the joints involved (cervical spine all the way down to the ankle) and view the runner as a set of joints that need to work in conjunction to provide a functional and efficient movement pattern.

Examination

The patient describes her pain at time of evaluation as a 3 on a numerical pain scale of 0-10 located at the medial distal tibia. During her last long run her pain was a 6/10. The patient describes the pain sensation as a stabbing pain. Right-sided footwear inspection reveals a mid-foot/forefoot wear pattern indicating the patient probably strikes with her mid/forefoot at initial contact. The left-sided shoe revealed a similar midfoot/forefoot wear pattern accompanied with some lateral rear foot wear. The patient demonstrated minimal to moderate palpable tenderness of the distal medial border of the right tibia. The pattern of tenderness correlates to the region of the tibialis posterior.

Strength: see appendix A for Manual Muscle Test
Biomechanical Analysis

Assessed on the treadmill with the patient in her current footwear with her over the counter orthotics. The patient’s biomechanics were thoroughly observed during both walking and running. A common clinical error is to only observe a patient's gait walking. However, gait biomechanics differ between running and walking. Especially when evaluating a patient with regards to a running injury, gait should be analyzed both walking and running.

Walking:
The patient’s pattern was consistent between running and walking, so details are summarized in the running section.

Running:

Ankle: As indicated from examining the patient’s footwear, the running gait analysis confirms the patient is a midfoot striker. The foot appears supinated at initial contact and maintains supination through toe off. Continued supination throughout the stance phase of gait is abnormal. During normal running mechanics the ankle/foot complex supinates at initial contact but transitions to pronation at midstance in order to absorb forces (Nicola & Jewison, 2012). Then supination is achieved once more to form a lever for push off. In the case patient, it is hypothesized that the orthotic is preventing the ankle/foot from performing correct motion during the running gait. The medial wedge of the orthotic holds the patient’s ankle/foot in supination preventing the proper transition to pronation. It has been reported that individuals with high arches who tend to over supinate have a higher incidence of stress fracture (Sullivan et al., 1984; Matheson, et al., 1987). Therefore, a constant supination of the ankle/foot could attribute to a higher degree of ground reaction forces dissipated throughout the lower extremity.

Knee: The patient demonstrates decreased bilateral knee flexion from push off through mid-
swing phase. The patient is negative for an increased valgus angle of the knee.

**Hip:** Decreased bilateral hip extension is noted at terminal stance.

**Pelvic alignment:** Normal frontal plane pelvic alignment and biomechanics are observed throughout the gait cycle with a concordant negative Trendelenburg sign. Follow-up sessions reveal that the medial orthotic wedge resulted in the negative Trendelenburg sign. An underlying hip weakness/faulty neuromuscular recruitment of the hip abductors surfaced after removal of the orthotic.

**Trunk:** Although the patient demonstrates appropriate arm swing, there is decreased thoracic mobility and trunk rotation while running. Patient presents with the proper thoracic kyphosis and lumbar lordosis curves while running.

**Assessment**

The patient’s physical therapy examination data suggests that the patient experiences pain with running long distances due to altered biomechanics at multiple joints. It is difficult to pinpoint an exact cause for the pain whether it is medial tibial stress syndrome or posterior tibial dysfunction. The actual diagnosis is not that important. The most important thing with treatment will be to address the patterns of movement that are dysfunctional resulting in overstressing the body’s system that ultimately manifests as a pain response. The dysfunctional movement pattern could possibly be due to intrinsic factors such as abnormal neuromuscular firing as well as extrinsic factors such as the patient’s orthotics. In addition, the patient’s decreased right ankle strength as assessed by manual muscle test will contribute to an inability to control the ankle throughout the gait cycle. Atypical ankle mechanics have been shown to contribute to lower extremity overuse injuries in runners (Levinger & Gilleard, 2007; Pohl et al., 2008; Messier & Pittala, 1988). Due to the fact that either or both intrinsic or extrinsic factors
could be the cause of the patient’s pain and dysfunction, both will be addressed as impairments. Therefore, therapy interventions will include strengthening of the right ankle joint complex, gait training, continued analysis of running biomechanics, orthotic adjustment, and proprioceptive training/neuromuscular reeducation. Outcomes will be determined by patient’s level of pain with running, manual muscle testing for strength of the ankle and hip, and observed changes in the patient’s running mechanics. Plan of care for therapy will be twice a week for 6 weeks to address the outlined deficits. The patient and her family indicate the main goal is to be able to run pain-free.

**Intervention**

For this patient appropriate interventions included removal of the orthotic in the right shoe, ice bottle massage to decrease inflammation (in the first phase of treatment), myofascial release techniques, stretching to warm up the musculature, therapeutic exercise to address neuromuscular and strength deficits, and treadmill training to improve running mechanics. Removal of the medial posting orthotic in the right shoe allowed the patient’s ankle to move through the normal supination to pronation to supination cycle. This is the normal ankle movement from initial contact to push off during running (Novachek, 1998). It is hypothesized that the orthotic is preventing appropriate right ankle/foot pronation. Pronation of the ankle/foot allows dissipation of ground reaction forces (Levangie & Norkin, 2011).

The patient’s therapy sessions consisted primarily of therapeutic exercise. Exercises designed to enhance hip abductor, hip extensor, knee extensor and knee flexor recruitment were heavily integrated (see Appendix B for complete exercise program). Exercises were progressed as the patient demonstrated increased ability to maintain proper pelvic and lower extremity alignment under various conditions. Recent research shows that hip muscular recruitment
heavily influences the runner’s biomechanics and can contribute to overuse injury (2011). Abnormal hip abductor recruitment alters the biomechanics distally in the kinetic chain. Inability of the hip abductors to stabilize the pelvis causes the contralateral side of the pelvis to drop. An associated medial rotation of the ipsilateral femur occurs creating a valgus moment at the knee (Powers, 2003; Powers et al., 2003). Distally in the kinetic chain the ankle/foot complex experiences greater eccentric loading forces on the ankle plantar flexors and invertors (Nicola & Lewison, 2012).

**Outcome**

With an overuse injury the primary goal of the patient is typically to be able to return to their previous level of activity pain free. This outcome was measured by the patient’s reported level of activity and participation in cross-country practice with a cessation of symptoms. The therapist’s goals for the patient also included increased ankle inversion, eversion, and dorsiflexion strength as assessed by manual muscle test. The therapist observationally assessed the patient’s gait during treatment sessions. This method of gait assessment while not the gold standard is a practical way of analyzing gait in a typical orthopedic clinical setting that does not have access to any motion analysis, high-end force plates and/or other biomechanical technology. Following an initial evaluation, the patient received 5 treatment sessions over the course of 7 weeks. At time of discharge, the patient demonstrated 5/5 muscle strength for all ankle motions, hip abduction, and hip extension. The patient reported being able to run continuously for 8 miles at cross-country practice without reproduction of symptoms.

**Discussion**

Evaluation of the runner is complex and requires a comprehensive evaluation taking into consideration multiple factors including but not limited to mileage changes, running surface,
shoe wear, nutrition, muscle strength, joint range of motion, tissue extensibility, and gait analysis. One of the most important aspects of treating the runner is that the symptomatic area might not be the causative area. The clinician should examine the areas along the kinetic chain that lie above and below the symptomatic region. If the patient with a lower extremity overuse injury demonstrates a hip musculature strength deficit or neuromuscular deficit it is possible that the deficit is a contributing factor to the injury. Exercises to address the deficit should be implemented in conjunction with other treatments deemed necessary. For the case patient it is difficult to discern whether, the implementation of hip exercises was the sole contributor to her success. However, it can be hypothesized that hip exercises did play a role in her recovery, normalized biomechanical running gait, and ability to run pain free.

Conclusion

Running is a complex involved process that combines multiple joint movements and muscular activity. Thus, it is important for the runner to be proficient in all areas to maximize running potential. Many runners use their talent and conditioning to get by with dysfunctional movement patterns pain free. However, just because a movement is pain free does not categorize it as functional. Dysfunctional movement patterns can be attributed to training errors, anatomical factors, and biomechanical factors (Geraci & Brown, 2005). When dealing with an endurance athlete, at any level, it is important to understand all the processes at work in order to progress them in the proper manner. Knowing an effective and comprehensive method to evaluate the injured runner will help the researcher better treat the growing number of running related musculoskeletal injuries.
Overuse Injury and Running

References


## Appendix A Manual Muscle Test at Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Right Ankle Strength</th>
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<tbody>
<tr>
<td>Dorsiflexion</td>
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<td>Plantar flexion</td>
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<tr>
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<tr>
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<tr>
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<th>Right Hip Strength</th>
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<tbody>
<tr>
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<tr>
<td>Hip Abduction</td>
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<td>4+/5</td>
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### Appendix B Manual Muscle Test at Discharge

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<tr>
<td>Hip Abduction</td>
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<tr>
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# Appendix C Exercise Programming

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<th>Session 5</th>
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<tr>
<td>Recumbent bike 5 minutes</td>
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<td>Treadmill Running 5 spd/ 5 minutes</td>
<td>Treadmill Running 5 spd/ 5 minutes</td>
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<td>Stretching 2x30secs glutes hamstrings quadriceps</td>
<td>Stretching 2x30secs glutes hamstrings quadriceps hip add Piriformis</td>
<td>Stretching 2x30secs glutes hamstrings quadriceps hip add Piriformis</td>
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<td>Box Squats 2x10</td>
<td>Overhead Squat to 16 inch box/ with green theraband around knees/ 3x10</td>
<td>Overhead Squat to 16 inch box/ 5lb bar/ with green theraband around knees/ 3x10</td>
<td>Overhead Squat to 16 inch box/ 5lb bar/ with green theraband around knees/ 3x10</td>
<td>Overhead Squat to 14 inch box/ 5lb bar/ w/ blue theraband around knees/ 3x12</td>
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<td>Lateral Ambulation</td>
<td>High plank hip abductions / yellow theraband/ 2x10 each</td>
<td>Lateral Ambulation w/ black theraband 2x20ft</td>
<td>Lateral Ambulation w/ black theraband/ 2x20 ft/ 5 kickouts</td>
<td>Lateral Ambulation w/ black theraband/ 2x20 ft/ 15 kickouts</td>
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<tr>
<td>2x20ft/ blue theraband</td>
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<td>Single leg dead lift</td>
<td>Quadraped hip abduction 5lbs/2x10 each leg</td>
<td>SLS w/ ball toss off rebounder/ yellow dynadisc/2x10 each leg/ 2.2lb ball</td>
<td>Box jumps 12inch box/ 18inch box/ 10 reps each box</td>
<td>Alternate lunge jumps 10lb vest sport cord/ 2x 1 minute intervals</td>
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<tr>
<td>1x15 each leg</td>
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<td>Butterfly sit ups 2x12</td>
<td>5 dot drill 1 minute 49 seconds</td>
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Overuse Injury and Running

Figure 1: Box Squat

Figure 2: Overhead Squat to box with theraband around the knees
Figure 3: Overhead squat with airex foam

Figure 4: Lateral Abduction with Theraband around the arch of the foot
Figure 5: High plank hip abductions with theraband around ankles

Figure 6: Lateral ambulation with theraband kickouts
Figure 7: Quadraped Hip Abduction

Figure 8: Single Leg Deadlift
Figure 9: Single leg stance w/ ball toss off rebounder

Figure 10: Box Jumps
Figure 11: Alternate Lunge Jumps

Figure 12: Butterfly Sit ups