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Foot and Foot-Related Injuries in the Young Athlete

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Sports-related pediatric foot problems can be divided into three categories, the first of which is macrotrauma or major trauma, the second being microtraumatic problems, and the third being foot-related lower extremity problems, such as chondromalacia patella and shin splints.

Because most of the problems encountered are of microtraumatic etiology and because most of the macrotrauma has been written about at length, this article will elaborate on the more common pediatric problems of the foot associated with microtrauma, which are often neglected in the literature. We will also discuss some of the foot-related lower extremity problems.

In our experience, most pediatric foot problems in sports are related to the biomechanics of the foot and lower extremity and most of our treatment is directed toward improving the immediate problem at hand and either at the same time or at a future time improving the biomechanics associated with the problem. It is this author's opinion that much of the macrotrauma is also related to the biomechanical parameters of the foot type and lower leg function, indirectly or directly contributing to the mechanism of injury. In this article we will elaborate on these mechanisms; however, the same biomechanics are generally associated with most of the foot problems we will discuss.

BIOMECHANICS OF THE FOOT AND LOWER EXTREMITY

Gait has been described as a series of falls. The foot serves as an instrument to absorb shock, to adapt the foot to the ground, to act as a rigid lever for propulsion, and to help transfer body weight forward. These functions are achieved mainly through subtalar joint and midtarsal joint motion. Inman points out the importance of the foot in gait when he states that the "single most important factor in achieving the conversion of the center of mass from a series of intersecting arcs to a smooth curve is the presence of a foot attached to the distal end of the limb."[9] The subtalar joint or talocal-

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caneal joint is a gliding joint with three articulating facets, the posterior, middle, and anterior facets. The axis of motion is oblique and passes through the calcaneus and talus from posterior, inferior, and lateral to anterior, medial, and dorsal. Motion about the joint is triplanar and is called pronation or supination.[2, 10, 13]

Pronation in the subtalar joint is motion in eversion, abduction, and dorsiflexion. Supination is the opposite, described as inversion, adduction, and plantarflexion. This motion can take place in weight bearing, which is described as closed chain (Fig. 1), and non-weight bearing or opened chain (Fig. 2). In closed chain motion, the leg segment is moving over the stationary foot segment and in opened chain motion the foot segment is moving around the leg segment that includes the talus. Therefore, in closed chain motion, pronation takes place in the subtalar joint when the calcaneal segment is stationary or moving in eversion. The talus, at the subtalar joint, moves in adduction and plantar flexion with the talo navicular joint moving in a manner to allow the foot to complement this subtalar joint motion. In a normal gait progression, the foot should make contact with the ground in a slightly supinated position, so that at foot contact or heel contact the calcaneus is slightly inverted. After the foot makes contact, the calcaneus begins to evert with pronation, which is initiated by the reactive force of the ground forcing the lateral aspect of the foot to be pushed up into pronation and the medial aspect of the foot to be forced downward, all taking place in the motion of pronation in the subtalar joint (Fig. 3). The midtarsal joint, which consists of the talonavicular and calcaneocuboid joints, compliments this foot adaptive phase of pronation by also pronating. The result of this motion is to have the foot adapt or make contact with the ground.[3, 8, 9, 17]

From the point of heel contact, there is or should be a pronatory phase for approximately 20 to 25 per cent of the stance phase of gait. That means that the foot should be pronating from heel contact until the forefoot makes full contact with the ground. At this point, the leg should be approaching a position perpendicular to the ground, and should be internally rotating as the foot pronates. From this point, that is, 25 per cent of the stance phase

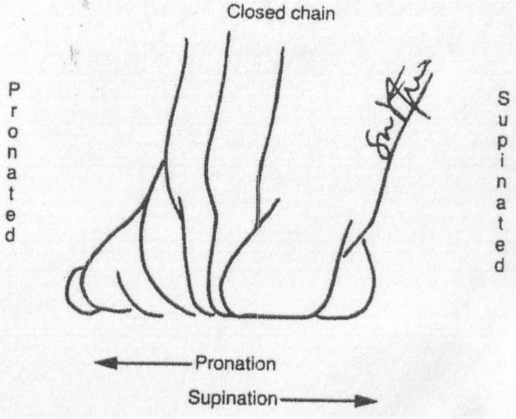


Figure 1. Closed chain (weight bearing) motion about the subtalar joint.

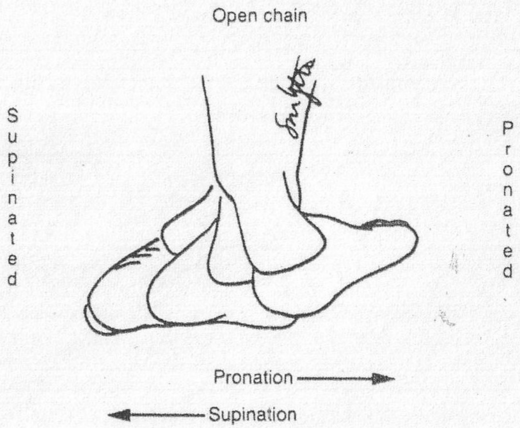
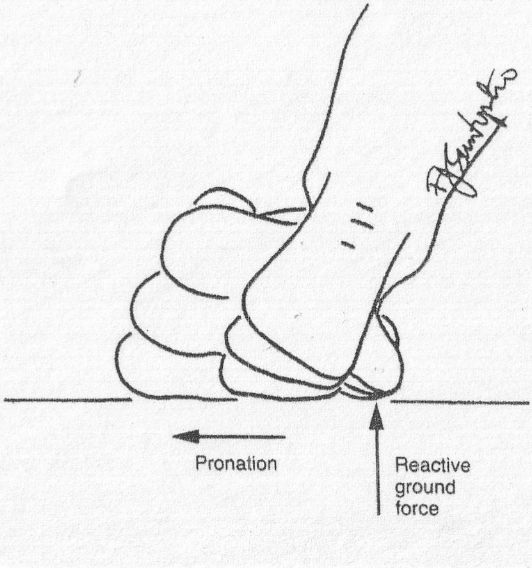


Figure 2. Opened chain (non weight bearing) motion about the subtalar joint.

of gait, the foot should begin to supinate or as is more commonly stated, the foot should begin to resupinate, and with this supination, the leg should externally rotate[3, 17, 21, 22] (Figs. 4*A* and *B*). The pronatory phase, along with the internal rotation of the leg, requires the medial tendinous structures to decelerate the foot in pronation and to aid in supination of the foot as the leg externally rotates. The ideal sequence of events is for the foot to contact the ground in a slightly supinated position, to pronate to 25 per cent of the stance phase and to begin to supinate from 25 per cent to toe off (Figs. 4*A* and *B*). A hyperpronator would tend to pronate beyond 25 per cent of the stance phase, resulting in a situation in which there would

Figure 3. Pronation at foot contact.



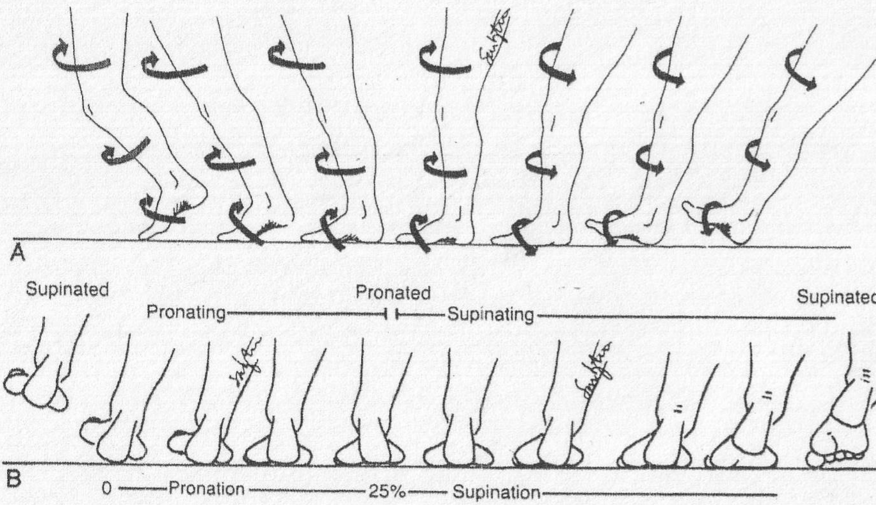


Figure 4. (*A* and *B*) Neutral foot.

be no supination or delayed supination (Figs. 5*A* and *B*). If no supination takes place, then the foot has made contact in a pronated position (everted, abducted, dorsiflexed), and therefore, has not gone through a range of pronation, resulting in a very hard heel strike and a lack of shock absorption

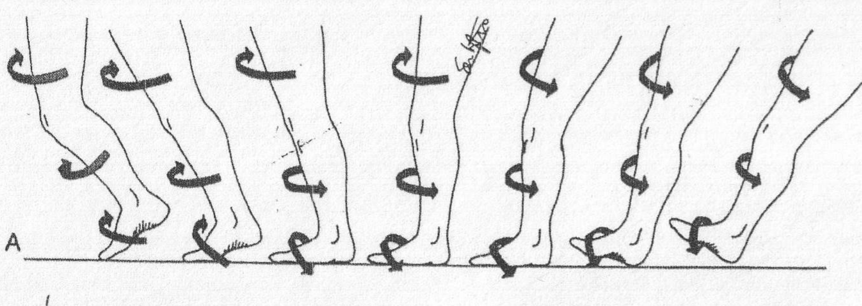


Figure 5. (*A* and *B*) Hyperpronated or flexible flatfoot.

(Figs. 6*A* and *B*). Because there is no pronation (eversion, abduction, dorsiflexion), the reactive force of the ground is not dissipated through the natural deceleration of controlled subtalar joint pronation, which results in that force being transmitted to the heel and through the heel into the lower leg (Fig. 7). This lack of pronation, with the foot in a pronated position at heel or foot contact is responsible for many of the problems encountered in pediatric and adult sports medicine. This foot that hits everted, maximally pronated, and does not pronate during the stance phase, can be defined as a rigid flatfoot (Figs. 6*A* and *B*). A foot that hits inverted or supinated and pronates after making contact with the ground and stays pronated beyond 25 per cent of the stance phase and that supinates possibly at heel off or closer to toe off could be defined as a hyperpronated foot or flexible flatfoot (Figs. 5*A* and *B*).

So a hyperpronated foot can be defined in degree of flatness and in duration of flatness, both of which are abnormal situations and both of which cause problems associated with lack of shock absorption, overstretching of tendons, poor pressure distribution, whereby a particular part, either bone, ligament, or tendon, is overloaded, which also causes a chain of more proximal structural imbalances, resulting in a series of foot-related syndromes.

In addition to the degree and duration of pronation, we can also think in terms of the rate of pronation. Ideally, one likes to see a moderate amount and rate of pronation. Generally, if a foot pronates excessively, the rate of pronation, because of the reactive force of the ground pushing against the plantar lateral aspect of the foot, is considerably faster,[24] probably owing to the inability of the tendinous structures to control the in-

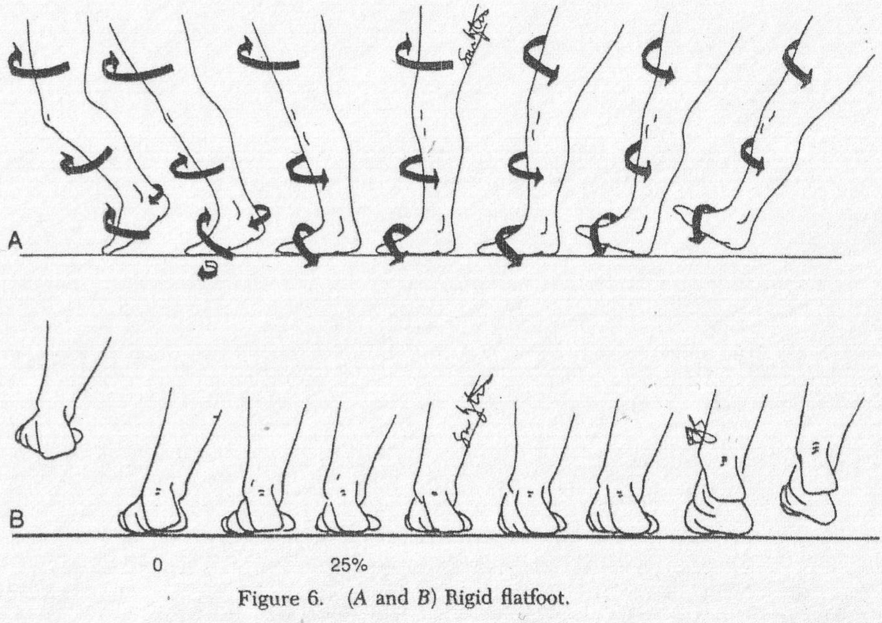


Figure 6. (*A* and *B*) Rigid flatfoot.

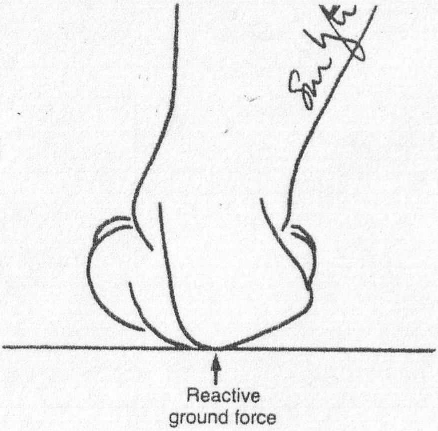


Figure 7. Foot already maximally pronated at heel strike or foot contact resulting in no shock absorbsion through subtalar joint pronation.

creased forces. As was stated previously, this results in either delayed supination or none at all. One must remember that the pelvis of the swing foot is internally rotating, and from the point of foot contact, the foot and lower leg are supposed to be adapting this internally rotating limb to the ground by pronation.[3, 9,21]

At a point about 25 per cent of the stance phase, just about the time when the foot should start to supinate, the pelvis of the contact limb will start to rotate externally and the limb should also start to rotate externally [12] (Fig. 4). External rotation of the contact limb commences with the beginning of swing phase of the opposite limb. As long as the body is still moving forward, the pelvis will externally rotate on the support limb. Because of different foot types (Figs. 8 to 10), one could consider that the pelvic sequence of internal and external rotation is more regular and less varied than the foot and lower leg sequence of pronation, supination, and internal and external rotation, respectively. When the pelvis of the support limb is internally rotating just prior to foot contact, the entire limb is also internally rotating. Pronation and internal rotation of the leg adapt this internal limb rotation, decelerate it, actually stop it momentarily, and then the foot begins the process of supination to coincide with the external rotation of the support limb and pelvis. As long as the motions of the support limb coincide, little to no torsional stresses arise. As long as the foot of the support limb is supinating when the leg, thigh, and pelvis of the support limb are externally rotating, and conversely, as long as the foot is pronating when the leg, thigh, and pelvis are internally rotating, little to no torsional stress occurs, resulting in a smooth transition from swing phase into and through stance phase and back to swing phase. It is important that all segments work in synchronization. As long as the body is moving forward and continues to do so, the internal and external pelvic motion will prevail, whether there is or is not pronation or supination. So when a foot pronates

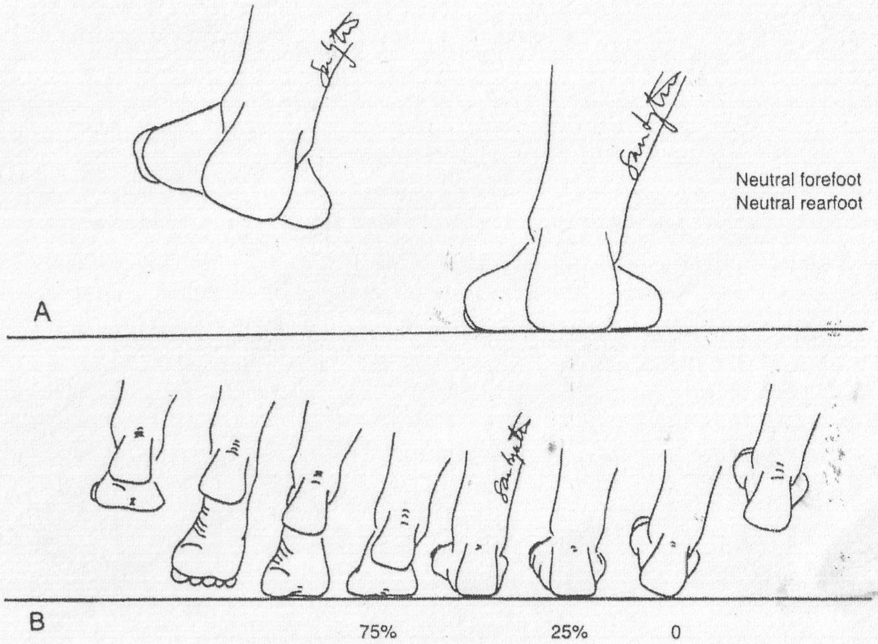


Figure 8. (*A* and *B*) Neutral forefoot.

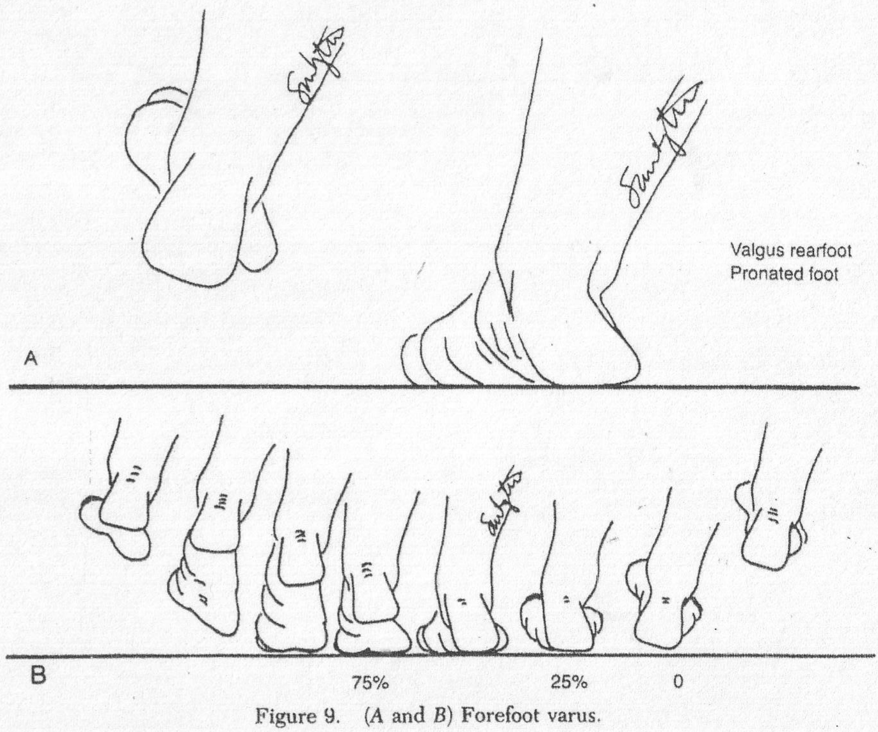


Figure 9. (*A* and *B*) Forefoot varus.

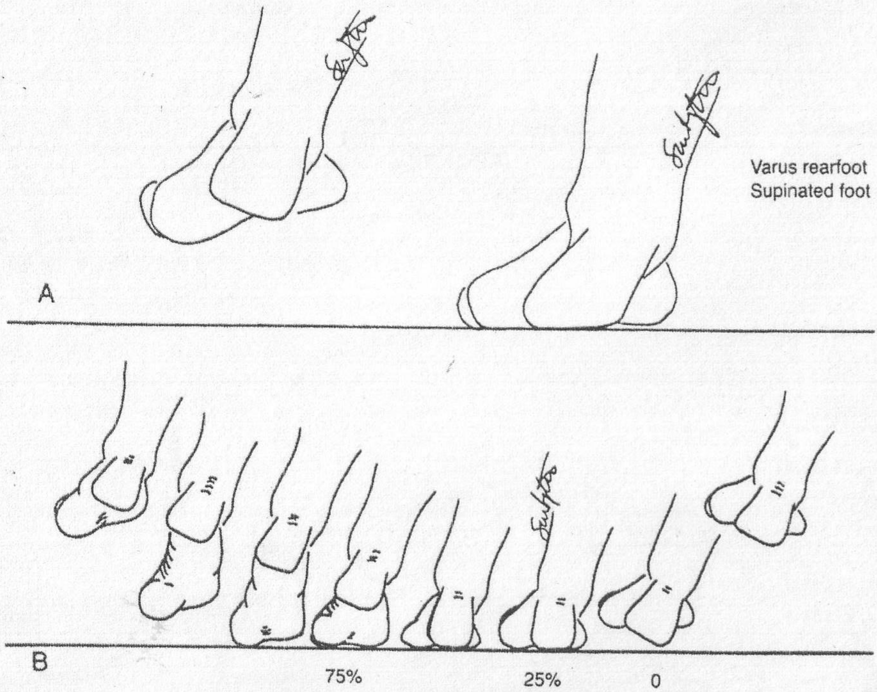


Figure 10. (*A* and *B*) Forefoot valgus.

too much and stays in the pronated position beyond the time it should (25 per cent of the stance phase of gait), torsional stress is created because the pelvis and femoral segment are externally rotating, necessitating some type of torsional stress relief, because the foot is not supinating and the leg not externally rotating (Fig. 6). This relief can occur at the foot to ground interface, at the foot to shoe interface, at the shoe to ground interface, or possibly in more proximal areas such as the hip joint. When this situation takes place (hyperpronation beyond 25 per cent), the femoral segment is externally rotating, the leg segment is locked in an internally rotated position and the patella, because it is attached superiorly to the quadriceps and inferiorly to the tibia, may tend to ride to the outside to the lateral ridge of the femoral condyle of the knee joint (Fig. 11). This mechanism may account for the relationship of patellofemoral syndrome and in later stages, chondromalacia patella and possibly other knee problems. This mechanism appears to be responsible for many of the problems discussed in this article.

The flat foot that hits everted and maximally pronated creates a problem of violent heel strike or foot contact, in addition to the torsional stresses associated with no pronation and no supination. These feet lack the shock-absorbing qualities of the subtalar and midtarsal joints that were mentioned before. So usually, this foot hits the ground with an everted heel, where the reactive force of the ground is not dissipated through subtalar joint and midtarsal joint pronation, but is directed through the calca-

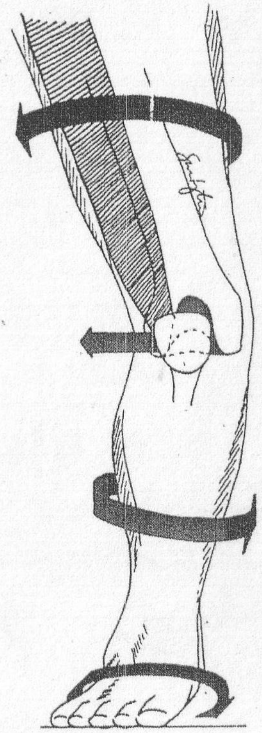


Figure 11. Hyperpronating foot with lateral deviation of the patella.

neous and talus, ankle joint, tibia, lower leg, knee joint, femur, and hip joint (Figs. 6*A* and *B* and 7).

Now if the ankle joint has limited dorsiflexion to absorb this reactive force of the ground, then the lower leg will absorb it, and if the knee does not flex to compensate or dissipate the reactive forces, they will continue up the next segment. One should also remember that a lack of functional gait subtalar joint motion and midtarsal joint motion, coupled with a lack of ankle joint dorsiflexion, as is often seen in a rigid flatfoot, will probably result in the functional inability of the knee joint to flex. The fact, however, that the foot is maximally pronated (everted, abducted, and dorsiflexed), compensates for the lack of ankle dorsiflexion, thereby allowing the lower leg to flex on the foot, and the knee to flex in conjunction with this ankle-subtalar joint dorsiflexion. In gait, without this flexion of the leg on the foot, either through the subtalar or midtarsal joint or through the ankle joint, there can be little to no flexion at the knee joint. In this author's opinion, this compensation or over-compensation of the subtalar-midtarsal joints, because of the excessively pronated position (everted, abducted, and dorsiflexed) in the rigid flatfoot and the motion of excessive pronation in the flexible flatfoot (resulting in excessively pronated flatfoot) may possibly result in a greater degree of internal leg rotation, a greater degree of medial knee displacement in the frontal plane, and a greater degree of knee flexion. Increased knee flexion has been shown to result in increased knee joint loading.[6, 9, 28] Internal rotation has been shown to increase proportionally as the knee articulates from full extension up to 90 to 120 degrees of flexion.[4, 16, 28] As long as there is forward motion, however, there will still be internal and external rotation of the pelvis and limbs, requiring, in this author's opinion, the need for synchronization between the foot and leg segment with the thigh and pelvic segment. No studies to date, to this author's knowledge, have dealt with the relationships between excessive pronation-supination with internal-external leg rotation, knee flexion, and frontal plane knee displacement, and the synchronization of these motions. The degree of pronation, the position of the pronated foot at contact and the other phases of the gait cycle, and the rate of pronation, as determined by the foot type or biomechanics, will play a major role in whether these segments are in synchronization, and whether there is torsional stress at the patellofemoral joint or not.

A similar situation for violent heel strike or foot contact is the rigid cavus foot. This often presents a picture of little to no subtalar joint motion, little to no midtarsal joint range of motion, and little to no ankle joint dorsiflexion (Fig. 12). This is also often accompanied by forefoot equinus that further increases the need for ankle joint dorsiflexion. It is the author's observation that this combination of biomechanics is often accompanied by an external tibial torsion in the person who walks and runs in a heel-toe progression. The external torsion of the leg probably results through Wolf's law from the lack of dorsiflexion in both the subtalar joint and ankle joint. The external torsion, in the author's opinion is an attempt by the body to decrease the lever arm of the foot making it functionally shorter so as to allow the body to fall forward in gait more easily (Fig. 13). Those with this biomechanic who do not compensate by external tibial torsion have been observed to be toe walkers or have a toe-heel progression in gait, in addition to a significant abductory twist (lateral whip) at heel off.

The basis of treatment, then, in those people who pronate excessively, is to control this pronation so that it follows in synchronization with the internal rotation of each segment of the limb and pelvis and to allow the foot to supinate and the leg to rotate externally at the same time that the femur and pelvis are externally rotating (Figs. 4*A* and *B*). In those people who pronate too rapidly, thereby causing the lower leg to rotate internally more rapidly than the thigh and pelvis, the object of treatment is to slow the rate of pronation, again to bring the lower leg and foot in synchronization with the thigh and pelvis.

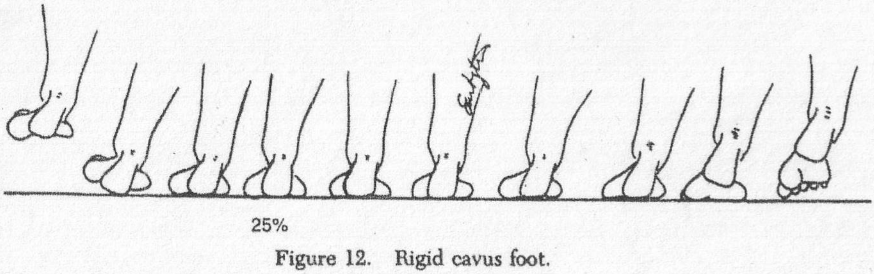


Figure 12. Rigid cavus foot.

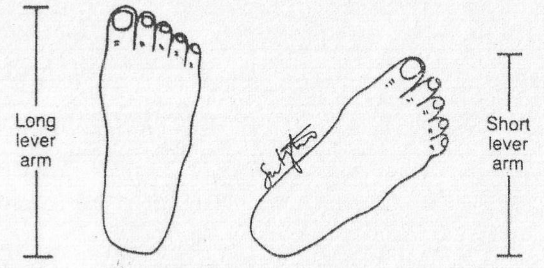


Figure 13. Decrease in lever arm strength by external rotation or external torsion of the leg.

In those individuals who have little to no pronation taking place after foot contact, whether they are high arched (cavus) or flat footed (rigid flatfoot, maximally pronated but does not pronate), the object of treatment is the same: to allow the foot to pronate in as controlled a manner as possible after foot contact, and to allow the foot to supinate from approximately 25 per cent of the stance phase to toe off.

Treatment of the rigid flat foot consists of supporting the foot in a supinated position from heel contact through the stance phase of gait. Most rigid flat feet have a range of supination both in the subtalar joint and in the mid-tarsal joint and with an orthotic can be supported in this position at heel contact and allowed to pronate gently up to 25 per cent of the stance phase. This orthotic allows the foot to function more flexibly, to use the subtalar and midtarsal joints to pronate in a controlled manner and therefore help dissipate the reactive forces of the ground, that is, to absorb shock. By allowing limited pronation, up to 25 per cent of the stance phase, the foot begins to supinate from 25 per cent to toe off, which allows for synchronization of the foot and leg with the thigh and pelvis thereby creating a smooth transition of moving the body forward.

The flexible flatfoot is treated in a similar manner, the only difference is that in the flexible flatfoot we are diminishing the amount of pronation and the rate of pronation, whereas in the rigid flatfoot we are trying to encourage pronation. The orthotic in both situations would be similar (Fig. 14).

In the rigid cavus or high-arched foot, because the author has found the subtalar joint to be maximally pronated in most of these feet, the object of treatment again is to encourage some degree of pronation, which means that we usually will support the foot in a slightly more supinated position so that at heel contact the foot will go from a more supinated position to a

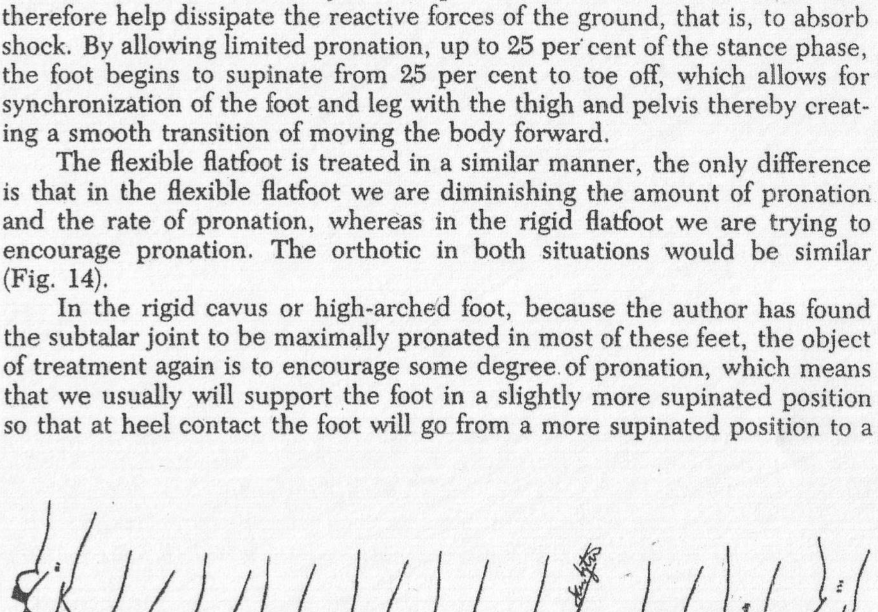


Figure 14. Hyperpronating foot with orthotic creating a normal progression.

less supinated one by the motion of pronation. Keep in mind that the calcaneus may not go beyond a perpendicular position to an everted position, but is going from a position of inversion to less inversion by the motion of pronation. This transforms a rigid high-arched nonabsorbing foot into one that absorbs a certain degree of ground reactive force by pronation.

Without the knowledge of the biomechanics, treatment for the microtraumatic and macrotraumatic foot problems of pediatric sports can be difficult. Other authors have pointed out the relationship of foot biomechanics causing running-related injuries both in the foot and more proximal structures.[18, 23, 25] Because most of the foot problems in pediatric sports are related to the biomechanics, it becomes useful to apply the principles discussed here in treating the specific problems. Many of the biomechanics and injuries discussed can be applied to adult problems, but discussion of injuries will be limited to those problems seen mainly in children. For the most part, we will be talking about problems in the skeletally immature individual.

CALCANEAL APOPHYSITIS

Calcaneal apophysitis, or what some describe as Sever's disease, is an inflammation of the growth plate of the heel that can occur in children with open calcaneal growth plates. The usual age for occurrence is from 8 to 13 years old but is sometimes found in children younger or older.[26] The onset is usually associated with an unusual amount of activity, usually running, often associated with a new sport or the beginning of a certain season such as soccer or an increase in running activity.

The child will usually experience pain manifested by limping that may be worse when standing after a period of rest. The heel is just about always sore to lateral compression. There is often swelling and some induration in the heel. Often the problem is bilateral and occasionally is associated with a concomitant achilles tendinitis. Most often the child will have a violent heel strike while walking and running that is characterized by a thumping or pounding, particularly noticed when a child is walking barefoot on the second floor of the house.

Frequently, this child has tight heel cords, a tendency toward in toeing secondary to internal femoral rotation or internal tibial torsion with a degree of compensatory subtalar and midtarsal joint pronation, a forefoot that is inverted in relationship to the rearfoot when the subtalar joint is held in the neutral position or what is referred to as a forefoot varus, all of which can force the heel to make violent contact with the ground in a maximally pronated position. This maximally pronated position forces the heel to make violent contact because there is no subtalar joint pronation after heel contact. The growth plate is a more sensitive area and responds to this injury by inflammation. This entity has been described as a traction apophysitis, but it is this author's feeling that the problem is related to the intensity at which this foot makes contact with the ground without the biomechanical stress relief of controlled pronation.

Treatment consists of keeping the child from walking barefooted and in a well constructed shoe with a heel height at least a half inch higher but preferrably three quarters inch higher than the front. A well-constructed running or basketball shoe is sufficient. We generally place a quarter to three-eighths inch heel lift in both shoes as well. In addition, we construct a functional semi-soft orthotic to control the abnormal amount of pronation or to allow normal pronation to take place. It is important when using orthotics that the shoe be well constructed and that there is sufficient room for the orthotic. We prefer shoes that have removable insoles.

Orthotics are constructed the same day as the initial visit. These are constructed from Foothotics Ready to Construct orthotic blanks by the doctor or the technician. After completing the biomechanical examination, an appropriate blank is used to outline the foot at the first and fifth metatarsal heads. Generally, a full-length orthotic is preferred unless the shoe precludes its use in which case a smaller or three-quarter length orthotic is constructed. The orthotic blank is then cut to fit the shoe and the appropriate prescription is ground into the orthotic. The orthotic surface starts out flat, but after 1 or 2 hours of wear in the shoe, it molds nicely and is comfortable. The method is quick, easy, inexpensive, and functionally controls the foot to the desired mechanics.[15] If time does not permit, a Foothotics Ready to Dispense orthotic is used.[18]

We generally, at initial visit, do not take radiographs, particularly when there is bilateral pain or the degree of swelling is minimal. The child is cautioned not to do any athletic activity for several days, not to go barefooted, and to always wear the orthotics and proper shoes that should feel comfortable right at the onset. With this type of orthotic, there should be little to no break-in period. A follow-up visit is scheduled in 1 or 2 weeks, at which time the pain and swelling should be gone. Generally, if this is not so, the child is most likely not following the regime, by going barefooted or persisting with running activities. Occasionally, it is necessary to cast a child who is resistant to treatment. A radiograph would be indicated at this time as well. It would be unusual to see a stress fracture of a calcaneus in a child; however, in one child with a fair amount of pain and swelling, a radiograph at initial visit revealed a needle imbedded in the heel that apparently had been there for some time, which required surgical removal. If casting is indicated, this is done with a fiberglass short leg cast that is left on for 1 week and is then bivalved, lined, and straps applied to make a removable fiberglass walking cast brace. This is worn for an additional week or two along with a prescribed exercise program of anterior group strengthening and posterior group stretching exercises. Our preference is to use the orthotics in just about every case. If this does not work well, we may use an anti-inflammatory medication and then use a cast as a last resort. After the cast is removed the child will go right back into his orthotics and shoes as a preventive measure.

SINUS TARSI SYNDROME

Another problem seen in the rearfoot is pain in the subtalar joint area manifested in the sinus tarsi. This presents as generalized pain, often with swelling in the dorsal anterior lateral portion of the foot just anterior to the lateral malleolus. It is frequently associated with running sports and particularly with the initiation of a new activity. Patients often will interpret this pain as ankle pain and will refer to it as a sprained ankle. There is generally pain with palpation in the sulcus of the sinus tarsi and there is often pain with forced pronation in that area. It is difficult to know whether this syndrome involves the subtalar joint or the midtarsal joints or both. Often, there also is noticeable swelling. This pain is sometimes difficult to distinguish from lateral ankle pain, but with careful palpation there usually is not pain along the anterior talo fibula ligament or the calcaneofibula ligament, but farther anteriorly in the sulcus. The vast majority of these feet maximally pronate in midstance or earlier in the gait cycle. The problem is treated readily by limiting or controlling pronation with an orthotic. This syndrome can sometimes be confused with subtalar joint arthritis or with tarsal coalition. Children with juvenile rheumatoid arthritis generally have a greater degree of swelling in this area and the problem is seen more frequently in both feet. They also will occasionally have other joint pain and swelling. In sinus tarsi syndrome, there is generally good range of motion in the subtalar and midtarsal joints, whereas in tarsal coalition and rheumatoid arthritis there is usually limitation of subtalar joint or midtarsal joint motion. In rheumatoid arthritis, there often is painful range of motion. Frequently, however, we have seen sinus tarsi syndrome or sinus tarsitis diagnosed incorrectly as juvenile rheumatoid arthritis. It is also not uncommon for the subtalar joint to be the initial site of juvenile rheumatoid arthritis (JRA), and as is often true in JRA and tarsal coalition, one can see a sinus tarsitis present as well. Orthotics have also been useful in children with rheumatoid arthritis who present with this problem. As with calcaneal apophysitis, it is important that the child wear good shoes or sneakers with strong heel counters and an adequately high heel.

Another syndrome can also be confused with this sinus tarsi problem. This syndrome is more related to inversion ankle sprain and is usually a result of an insignificant ankle sprain or several of these. Pain is usually in the area anterior to the lateral malleolus with or without associated swelling. It differs from sinus tarsi pain in that there is usually pinpoint pain right at the insertion of the anterior talo fibula ligament on the talus and little or no pain to palpation in the sulcus of the sinus tarsi and no pain with supination or pronation. This can be grouped with inversion ankle sprains as a chronic form and often needs to be treated with a short leg cast or fiberglass walking cast brace if orthotics do not resolve the problem. The foot types of rearfoot varus and forefoot valgus are usually similar to those implicated in chronic inversion ankle sprains.[18]

TARSAL COALITIONS

Coalitions can be seen in the pediatric sports population. The most common, reported by Harris,[7] being in the subtalar joint, the next most common between the calcaneus and navicular. Tachdjian's[26] and this author's clinical experience has found the calcaneal navicular coalition to be more common. They can also occur in the other tarsal bones. There usually is limitation of supination but it may not always be obvious. There is often pain and swelling of an acute or subacute nature, aggravated by extremes of subtalar joint motion either in pronation or supination, but especially in supination and frequently associated with peroneal spasm locking the foot in a pronated position and frequently associated with athletic activities that involve jumping. Etiology is not clear but may be congenital in nature or traumatic. The coalitions can be fibrous, cartilaginous, or osseous. Treatment again is directed at controlling the subtalar joint in the neutral position and generally trying to limit its range of motion, particularly in extremes of supination or pronation. In the acute stage, casting with a short leg cast is appropriate for a short period of time, followed by orthotic control. It is important when casting to place the foot in a neutral subtalar and midtarsal joint position and always in a comfortable position. This often is slightly supinated and plantarflexed. Heel lifts are placed in the cast boot or the cast boot is raised externally in the heel area. In a young child, surgery may be useful to restore motion in a calcaneal navicular coalition. Our results have been satisfactory in the few cases we have done. In the older child, we have been more reluctant to remove calcaneal navicular coalitions surgically except as a last resort. The results in the few cases performed have been satisfactory with improved function and abatement of pain. In most cases, however, conservative treatment of casting followed by orthoses has been good, precluding the need for surgery. One is always perplexed with the question of performing surgery in a nonsymptomatic child who has decreased range of motion, with the hope of restoring motion. The danger is that pain may result along with the possibility of further joint involvement. Generally, subtalar joint coalitions are not amenable to surgical release. We have, however, had very good results treating coalitions conservatively with shoes and orthoses.

NAVICULAR PROBLEMS

A common problem seen in the child athlete is navicular pain, both acute and chronic. This can involve the growth plate or just the prominence of bone. Frequently, the tibialis posterior tendon insertion is also involved. Often, there is an accessory navicular, the os tibiale externum. In just about all of these cases, there is a prominence of bone that is frequently inflamed with noticeable inflammation of the overlying skin. This foot, again, is generally pronated with the medial arch of the foot rolling over the medial side of the shoe. This is a particular problem with figure skaters, with the boot being straight and the medial arch of the foot being forced over the hard medial counter of the boot.

With excessive pronation, the forefoot abducts, resulting in a boomerang-shaped foot. This is very evident in children with any degree of internal tibial torsion whereby the talus is locked in the ankle mortise forcing the foot to pronate maximally at the subtalar and midtarsal joints. The talar head plantarflexes and adducts, and the navicular, along with the rest of the forefoot, abducts, causing the navicular to rub against the ground or shoe, eventually making that bone more prominent.

The solution, whether the problem is with the accessory bone, the growth plate, the tendon, or the prominence, is to attempt to control the excessive amount of pronation or to support the foot in a more supinated position. Generally, the prominence has to be shielded either with the orthotic or more frequently with a foam cut-out horseshoe dressing or with a cast, if very acute and not responding initially to orthotics. Very rarely, surgery is necessitated using a Kidner procedure or a modification of that procedure.[11] In very flat feet, it is necessary to begin with only a moderately high orthotic with the amount of forefoot and rearfoot wedging being minimal. Gradually, the orthotic should be raised, but the transition should be painless. This gradual raising of the orthotic should be done routinely whenever an orthotic is used. On a few occasions, it has been necessary to control the acute inflammation with a short leg cast for 1 or 2 weeks.

Another problem only very occasionally encountered is a stress fracture of the navicular. This appears as pain in the navicular, which is not always responsive to orthotic therapy. A bone scan will show the bone to be reactive and sometimes requires immobilization with a short leg fiberglass cast that is bivalved and lined and made into a cast brace. A program of physical therapy is also initiated. As soon as the foot is asymptomatic with walking, the cast is discontinued and orthotics with shoes are used, still keeping the athlete in a relatively nonactive state and very slowly increasing their activities. A cortical screw could also be used to fix the navicular surgically with a cortical screw; however, we have not yet found that to be necessary, and it may not be appropriate in the child athlete. Conservative treatment with casting requires a long period of time and a good deal of patience, particularly on the part of the athlete.

FIRST METATARSAL CUNEIFORM JOINT

This joint occasionally presents with pain. Sometimes pain occurs dorsally in the joint associated with an exostosis and at other times the pain is within the joint. Most often these problems are a result of hypermobility of the first metatarsal secondary to rearfoot or subtalar joint pronation, forcing the first metatarsal to dorsiflex when weight is thrust medially, causing a jamming of the metatarsal cuneiform joint dorsally. This is usually solved easily by preventing excessive rearfoot pronation. Sometimes the first metatarsal is plantarflexed and nonflexible, which can again cause jamming, particularly in an athlete who runs up on the forefoot. In this case, the rearfoot is supported with an orthotic and the first metatarsal is allowed to float so that it is less prominent in plantarflexion. This plantarflexed first metatarsal is seen in both the flat foot and the high-arched foot. It appears from our observation that most of the first metatarsal cuneiform problems occur in the flexible to semirigid plantarflexed first metatarsals, more frequently seen in feet that pronate excessively, with the first metatarsal, through the action of the peroneus longus, attempting to limit this excessive pronation.

On one occasion, an osteochondritis in this joint was found that was particularly difficult to diagnose even with the use of bone scan and tomograms. This would not respond to conservative treatment and required fusion of the joint. On investigation of the joint, a denuded area of cartilage, 1 cm in diameter, on the lateral aspect of the joint, was found. The patient has done well postoperatively and is participating in sports.

FIRST METATARSAL PHALANGEAL JOINT PROBLEMS

Problems with the first metatarsal phalangeal joint, while numerous in the adult population, are relatively few in the pediatric population. There are, however, a significant number of children who have hallux abducto valgus, most of whom are not usually symptomatic with sports activities. When problems arise, it is often due to the bunion rubbing against the side of the shoe causing irritation. Most frequently, significant pes planus is associated with the formation of the bunion. Another problem often seen in association with this is internal tibial torsion and internal femoral rotation with compensatory pronation. A metatarsus primus adductus (metatarsus primus varus) is often seen in this condition. Hallux valgus, however, is not limited to people with flat feet but is seen less frequently in the high-arched foot as well. When seen in early years, treatment should be directed at the causative biomechanical factors, which includes treating the torsional problems at the earliest age possible, holding the foot in a neutral position in gait with orthotics and proper shoes, and trying to encourage exercise to foster equal muscle balance. In treating torsional problems, we have used night splints in the form of fiberglass long leg cast braces as well as Dennis Brown type splints. Even in children in the 8- to 14-year-old range, we have had an encouraging amount of success with these splints, providing the patient, the parents, and the doctor are willing to cooperate and follow through with a steady course of treatment for a period of 1 to 2 years or more. We have also tried splinting of the hallux and forefoot to treat the laterally deviated toe. This is helpful early in the formation of hallux valgus but not as useful once the joint has structurally changed and the articular set angle is substantial. Usually, with the use of orthotics and good athletic shoes, the bunions can be made asymptomatic. In severe cases, surgery is indicated. This almost always requires an osteotomy type of procedure to improve the metatarsus primus angle. In children with open growth plates, it is usually better to perform a distal osteotomy of the first metatarsal, such as an Austin procedure (horizontal V osteotomy),[1] however, a closing or opening wedge osteotomy of the base distal to the growth plate can also be performed. My preference is to wait until the growth plate is closed before using an osteotomy at the base. In patients with a large metatarsus primus angle and a large proximal articular set angle (structural deviation of the first metatarsal articular cartilage, so that the joint faces and flexes laterally), it may be necessary to use two osteotomies, but this type of procedure requires a longer healing time. With the V osteotomy, it is easy to achieve correction of the articular set angle with correction of the metatarsus primus angle at the same time. There are some modifications of this procedure that can also be used for bicorrectional variations.[5] The Hawkins (Mitchell) procedure, a stepdown midshaft osteotomy, can also be used when there is a long first metatarsal, however, this procedure, in our opinion, should only rarely be used. When the deformity is not severe, a soft-tissue procedure, such as a McBride,[14] may suffice.

Occasionally, we see pain in the child athlete along the dorsal aspect of the joint, similar to what we would see in turf toe. Sometimes the extensor tendon is involved as well. This pain is most often seen with a flat foot and is the result of jamming of the first metatarsal phalangeal joint. The reason for this may be that in the pronated foot, weight is being borne abnormally on the first metatarsal with this bone being maximally dorsiflexed and the hallux being forced to dorsiflex high on the articular cartilage of the first metatarsal causing an abnormally high degree of stress at the top of the joint. When weight is redistributed so that at midstance, heel off, and toe off, the forces are directed more correctly over the center of the foot, there is less stress on the joint and pain will almost always abate. This is facilitated with a full-length orthotic, particularly in athletic shoes that have removable insoles. The wedging in these orthotics is generally carried forward under the metatarsal heads and toes where it tapers off. Because most sports involve running or sprinting, the full-length orthotic, in our opinion, is more efficacious because the heel may not make contact or may make contact after forefoot contact. Generally, the faster a runner, the more likely he or she is going to make contact with the forefoot before the heel. We have had good results using these in runners, football players, and other athletes.

SESAMOID PROBLEMS

A problem not infrequently seen in children participating in sports is pain in the sesamoid bones. The tibial sesamoid is more frequently affected, but pain can also be located in the fibular sesamoid. The onset of pain in the sesamoid is usually gradual but can be sudden as well. Pain in the tibial sesamoid can be divided into two distinct areas, the first being at the proximal portion of the bone where the conjoined tendon of flexor hallucis and abductor hallucis insert. With palpation of this area there is pain only at that localized point and not directly in the joint. This pain can be defined as more of a tendinitis of the conjoined tendon where it inserts onto the sesamoid. This is usually the result of excessive stress on this area, secondary to excessive pronatory forces and the resistance of the first metatarsal to these pronatory forces. With this, we usually see a plantarflexed hypermobile first metatarsal. This type of sesamoid pain responds readily to orthotics and proper shoes, rest, and occasionally requires the need for anti-inflammatory medication.

The second type of sesamoid pain is the type more frequently associated with bruised or fractured sesamoids. Fractures of the sesamoids are relatively few in relationship to the number of people seen with painful sesamoids. Usually, the tibial sesamoid is affected more frequently and when palpated directly over the bone causes pain deeply. There usually is no pain with motion. The fibula sesamoid is also affected on occasion. In a child, one can also see a growth plate injury in the sesamoids, which is quite difficult to distinguish from a fracture or bruise. Radiographically, the diagnosis is generally not clear. In all cases, except the very severe, treatment is the same, initially consisting of shielding the injured bone with foam padding or constructing orthotics or a combination of both. If symptoms are severe, a cast may be indicated. This is usually fiberglass and after a week we bivalve and line this to form a removable cast brace. This facilitates an exercise program to mobilize the joint with gentle range of motion. Frequently, the protective foam pad is placed on the foot before casting. We use a felt-backed foam when placed on the skin. Unless there is an absolute need to know, we do not generally order a bone scan but prefer to treat it as though it may be a stress fracture. The response to initial treatment is usually very good. More resistant cases are sometimes followed by bone scan or tomograms. On only one occasion has it been necessary to remove the sesamoid surgically in an older child. This followed a long course of conservative treatment including, in the stage just prior to surgery, local injections of steroid. The patient has done well since the removal of the tibial sesamoid. In one case of sesamoid fracture confirmed by bone scan in an older runner, a long period of recovery lasting 8 months and the use of electrical bone stimulation, orthotics, special pads, and physical therapy finally resolved the problem without the need for surgery.

Another rarely encountered problem that can sometimes confuse the diagnosis of a sesamoiditis is a neuroma along the sesamoid area of the medial branch of the medial plantar nerve. On one occasion it became necessary to remove the palpable mass just over the tibial sesamoid bone surgically. In this particular case, there was a positive Tinel's sign and a small amount of local anesthesia injected superficially around the nerve temporarily relieved the pain, helping to confirm the diagnosis.

METATARSAL HEAD PROBLEMS

Generally, metatarsal head problems in children are rare, with the exception of Frieberg's infraction or more correctly an avascular necrosis of the metatarsal head. It is not that the foot does not undergo stress at the metatarsal heads but that children do not experience the pain as readily as adults. If they do have stress to the metatarsal heads it is usually described as generalized foot pain. In Frieberg's, the second metatarsal is frequently affected and is generally the result of chronic microtrauma usually seen with a pronated foot with associated hypermobility of the first metatarsal causing an undue amount of stress on the fragile growth plate of the second metatarsal head. The onset can be sudden or gradual, and is characterized by pain and some swelling over the metatarsal head. There is pain to palpation directly on the head. The head will also feel somewhat enlarged. Radiographs will sometimes show a characteristic flattening and widening of the head but early on may not show any changes. The treatment here, again, is to control the pronation with a full-length functional soft orthotic with a sturdy shoe. Occasionally, it is necessary to have the sole of the shoe stiffened with hard rubber or leather to prevent flexion at the metatarsal head or to have a rocker bottom sole added to the shoe. Occasionally, it is necessary to use a short leg cast in the acute stages.

The fifth metatarsal can sometimes be enlarged forming a tailor's bunion with associated soft-tissue swelling. This usually is not common in children but can occasionally be a problem. This problem is often seen in the flatfoot, which causes the forefoot to be abducted in relationship to the rearfoot and makes shoe wear difficult because the curved shape of the foot does not conform to the straight shoe. This results in friction of the fifth metatarsal and fifth toe resulting in hyperostosis of the metatarsal head. This can infrequently warrant surgical removal. We have, however, had very good results using orthotics.

OTHER METATARSAL PROBLEMS

Another common problem of the metatarsals has been stress fractures. We will occasionally see them in children and more frequently in adults at the neck of the metatarsal, but also in the midshaft. Again they are more frequently seen on the second metatarsal as a result of hypermobility of the first metatarsal in association with excessive pronation, but can be seen on any of the metatarsals. Pain is present in the metatarsal neck-shaft region along with swelling and a palpable thickening. Radiographs are usually not helpful in the first 10 to 20 days until the bone starts to heal, at which time bone callus may begin to appear. It is rare that these need to be casted. The treatment involves determining the proper orthotic prescription to take pressure away from the fracture site or possibly the use of a stiff-soled shoe, preferrably a regular shoe with a stiff leather or rubber sole added to it.

The fifth metatarsal can also be the site of stress fractures, particularly the base of the metatarsal. The typical Jones fracture is located in the proximal shaft of the metatarsal. The onset of this is usually sudden and has a history of being difficult to treat. We have not seen this fracture with any great frequency in children, but it can sometimes occur with ankle sprain or with running activity. When it occurs with running activities, there usually is a biomechanical predisposition. Frequently, this is seen in the individual with a high degree of rearfoot varus as seen in severe bowed legs, accompanied with a high degree of forefoot varus. At foot contact, the outside of the foot along the fifth metatarsal base makes initial contact. Because of its acute angle, the foot bears a great deal of stress momentarily at the base, possibly accounting for the fracture. The object of treating this biomechanically is to neutralize the pressure across the entire foot, so that at foot contact a large plantar surface area of the foot makes contact at the same time. Often, a short leg fiberglass cast is used for 3 weeks, which is then bivalved and lined and made into a cast brace prior to using orthotics.

Rather than a fracture, one occasionally sees inflammation of the growth plate that is sometimes seen at the fifth metatarsal base of the child's foot. This is treated exactly the same way.

It has been our experience that treating these fifth metatarsal problems has been considerably easier when the biomechanical problems have been addressed. The poor results, historically, with treatment of Jones fractures, for example, are probably due to the nonrecognition of this entity as a biomechanical condition that requires neutralization of the foot to ground interface, whether using nonsurgical or surgical means.

TOE PROBLEMS

The most frequent toe problem seen in the pediatric sports population is ingrown toenails. Usually this occurs in the hallux along the medial nail fold but also occurs very frequently along the lateral border as well. The term ingrown toenail implies a situation in which the nail plate causes pressure along the nail fold causing a paronychia, which is an inflammation of the soft tissue surrounding the nail. This paronychia is characterized by pain, redness, and occasional swelling, but not necessarily infection, purulence, or the formation of granulation tissue. The nail plate may actually cut into the surrounding tissue causing an ulceration of the skin, possible production of granulation tissue and infection. Often the nail plate is incurvated but may not be. Mechanically, the foot often pushes off medially along the hallux instead of in a straight direction. Treatment is directed at relieving the acute problem by excising a portion of the nail plate or the entire plate with or without local anesthesia, from the free edge toward the base of the nail. When the paronychia is severer, anesthesia may be necessary and is usually injected at the base of the toe circumferentially. The medial or lateral border of nail may then be removed as was mentioned before or avulsed from the free edge to under the posterior eponychial fold. Lukewarm normal saline baths for 5 to 10 minutes three times a day are used until the inflammation clears. Orthotics are then used to help the foot toe off in a straight direction. In a pronated foot that toes out, the orthotic will improve the angle of gait by keeping the foot in a more supinated (adducted) position, so that there is less stress along the medial hallux. If the problem recurs and is severe, surgery is considered to remove the medial or lateral border of the nail permanently. We prefer to use a cutting nail procedure as opposed to a cauterizing type of procedure, because, in our experience, the rate of recurrence and formation of postoperative cysts has been greater with the phenol cautery procedure, in addition to the excessive drainage frequently seen with most cauterizing procedures. In the few instances when we used cauterizing procedures, we follow cauterizing with curretting to remove any necrotic tissue created by cauterization. This has helped to decrease the drainage considerably.

Hammertoes are occasionally a problem in the young athlete. When these occur, they are usually the result of either a high-arched or cavus foot or a significantly pronated foot. The imbalances created by these foot types require the foot to be stabilized by the intrinsic and extrinsic muscles through the toes. The contractures often become fixed or permanent over a period of time and this occasionally can be seen in the child. Treatment is directed at the source of the problem, which is the cavus or flat foot. It is encouraging to see these contractures reverse frequently in the pediatric patient with the use of orthotics. In those resistant cases of fixed contracture, surgery is sometimes indicated. Generally, fusion is avoided in preference to using an arthroplasty type of procedure in which the proximal phalangeal head is removed and the toe straightened. Sometimes, the extensor tendon is lengthened and the metatarsal phalangeal joint capsule is released.

PLANTAR LESIONS: CALLUSES AND WARTS

Plantar warts can frequently cause problems in the pediatric patient. These are almost always found in areas of callus formation or areas of stress in the plantar aspect of the foot. They are caused by a virus that grows in the epidermis with attachments to the dermis. Common areas of occurrence are the plantar metatarsal head areas and the medial plantar heel. In addition to treatment with debridement and 40 per cent salicylic acid pads, we attempt to decrease the amount of stress on the plantar aspect of the foot or wherever the wart is located, particularly by controlling any abnormal biomechanics. Resistant warts are excised by blunt dissection after a period of attenuation with salicylic acid. We have used 40 per cent salicylic acid pads applied on a daily basis by the patient. These are applied and paper tape placed over them to ensure that they do not move. These are kept on for 24 hours, removed, and washed vigorously, allowed to dry followed by reapplication. This is carried out for a period of a week followed by redebridement. This, in conjunction with orthotics generally will work well, precluding the need for surgical removal. When surgery is indicated in the resistant case, blunt removal of the wart is preferred. Under local anesthesia, usually with a weak solution of epinephrine to control bleeding, the wart is circumscribed and a blunt instrument such as a groove director, currette, or Freer elevator is used to remove the wart from the underlying dermis. The dermis can then be cauterized for a short period of time with phenol, being careful not to damage the dermis. No stitching or incisions are made. The wound is dressed with petroleum gauze and a pressure dressing of elastic tape. It will usually heal in 4 to 7 days. Laser treatment for the more resistant warts can be used, however, we have not yet found this necessary.

TENDON PROBLEMS

Tendo Achilles Problems

These are occasionally seen in children and often they are bilateral. These children will complain of pain just above the insertion at the calcaneus. They have some swelling and usually are painful to lateral compression of the tendon. Frequently, as was mentioned before, the tendinitis is associated with calcaneal apophysitis. The mechanism of injury appears to be similar. Frequently, we see a tight heel cord with limited ankle joint dorsiflexion particularly with the knee extended. This is frequently associated with a compensatory pes planus, because lack of ankle joint dorsiflexion is most often compensated for by the dorsiflexion of pronation in the subtalar joint. This sets up a heel that is maximally pronated or everted, abducted, and dorsiflexed at heel strike resulting in a lack of shock absorbtion at heel strike. The treatment, therefore, is similar to that of calcaneal apophysitis, specifically to establish a controlled degree of moderate pronation after heel strike. This is true both for the flatfoot as well as the high-arched foot. Heel lifts in both shoes and a shoe with a moderately high heel are helpful in establishing the foot in a more supinated position. Orthotics are usually necessary as well as a stretching program.

Peroneus Longus Problems

Peroneus longus tendinitis is occasionally seen as a problem in the young athlete. This is characterized by pain along the peroneal tendon just behind the lateral malleolus. The biomechanics associated with this problem is most often a plantarflexed first metatarsal either flexible, semirigid, or rigid. Pain can frequently be elicited by palpation or by dorsiflexing the first metatarsal to stretch the tendon. In our experience, the most frequent foot type associated with this problem is the flat foot with a plantarflexed first metatarsal, similar to the foot type seen frequently in sesamoid problems. This is often characterized by an everted heel with a first metatarsal that is plantarflexing or attempts to plantarflex through the effort of the peroneus longus in an attempt to prevent the foot from pronating. By keeping the rearfoot from everting and supporting the second through fifth metatarsals in its anatomic relationship to the rearfoot, and allowing the first metatarsal to remain plantarflexed or in a relaxed position, the tendinitis will usually resolve very readily.

Tibialis Anterior Problems

This tendon is frequently affected by excessive pronation and its attempt to resist the excessive pronation. It is most often associated with the flexible flatfoot in that the foot starts off in a relatively neutral or supinated position, but pronates severely and rapidly, causing the tibialis anterior tendon to resist and become strained in the process. Controlling the excessive pronation will allow the tendon to work less hard and prevent strain.

Extensor Hallucis Tendinitis

This is seen occasionally in children in sports, particularly in the child with tight heel cords. The lack of ankle dorsiflexion is usually accompanied by extensor tendon substitution forcing the extensor tendons, especially the extensor hallucis longus, but also the extensor digitorun longus and brevis, to work hard to dorsiflex the big toe and lesser toes so that they do not stub the ground. This can be seen both in the high-arched and flat foot. In the flat foot, the extensor tendons also work hard to pronate the foot along with the peroneals, prior to heel strike, if there is a lack of ankle joint dorsiflexion. In the stance phase, the extensor tendons work in conjunction with the flexors to stabilize the toes. In flat or high-arched feet, the toes will hammer as a result of excessive extensor and flexor contraction as an attempt to balance the foot. Again, the entire foot needs to be neutralized so the toes have no need to hammer and the extensors and flexors no need to contract excessively. Obviously, a slightly heeled shoe or heel lifts are helpful along with an orthotic to stabilize the forefoot and rearfoot.

Tibialis Posterior Tendinitis and Tarsal Tunnel Syndrome

Tibialis posterior tendinitis is not uncommon in the young athlete and, as was noted before, is sometimes associated with naviculitis. It is also seen sometimes with plantar fascial strain. It is not usually seen with the high-arched foot but with the pronated or flat foot. The treatment is to control the rearfoot and forefoot to prevent excessive pronation and allow for normal gentle pronation.

A problem sometimes associated with this but also seen independently is tarsal tunnel syndrome. This condition is relatively rare in children but occasionally is seen as a temporary tibial nerve compression that causes transient numbness or paresthesias on the plantar aspect of the foot. There may or may not be a Tinel's sign. This is usually aggravated by shoes that are rigid or have a high arch. It is occasionally seen in ice skaters (figure) who have very flat feet. The arch of the foot does not conform to the skate in the arch area and the shoe compresses the dedial arch nerves including the dedial and lateral plantar nerves. It can also be seen in running sports. Nerve conduction tests are usually equivocal. Treatment is designed to take pressure away from the nerves by having the shoe conform to the foot so that there are no prominent hard areas in the arch by using orthotics in conjunction with the shoes to hold the foot in as neutral a position as possible to keep stress away from the medial nerve compartment. Often, because of the degree of flatness it may be quite difficult to control the foot in a neutral position. Skates often require a custom-made boot in conjunction with orthotics. Again, we prefer the semisoft functional orthotics and have had good results with this both with runners and skaters. Occasionally, casting or cast bracing is necessary to allow the nerves to repair.

CHRONIC INVERSION ANKLE SPRAINS

This entity is mentioned in this article because it is often associated with specific foot types, namely, high-arched feet with a forefoot valgus and rearfoot varus.[18] This can occur with walking, running, or jumping. Rearfoot varus results from an excessive amount of tibial varum or an inverted or supinated rearfoot, causing the heel to make contact in an excessively inverted position relative to the ground. A forefoot valgus is a position of fixed forefoot eversion in relationship to the heel. This is often characterized by a rigid plantarflexed first metatarsal. In walking and slow running, the heel or rearfoot varus plays more of a role in influencing the foot to invert excessively, whereas in jumping, the forefoot valgus seems to play more of a role in supinating the foot. This combination, along with the plantarflexed rigid first metatarsal, forces the subtalar joint to supinate sometimes excessively, possibly causing a myotatic reflex in the peroneous longus muscle, which further plantarflexes the first metatarsal tilting the foot into inversion. It is our suspicion that the plantarflexed first metatarsal in a flat foot can also cause inversion sprains when the peroneous longus is suddenly stretched when the rearfoot and forefoot excessively pronates causing it to overfire, resulting in rapid supination of the foot. Those chronic ankle sprains with flatfeet have responded well to controlling the flatfoot with orthotics, possibly because of relaxing the stress on the peroneal tendon. Those chronic ankle sprains with high arched-feet have also responded well to neutralizing the forefoot valgus with orthotics.

ORTHOTICS

There are basically four types of orthotics commonly used by most foot specialists. They are preorthotics or orthotic arch supports, rigid, semirigid, and semisoft functional orthotics.[15] In our early years of practice, we were more inclined to use rigid orthotics to control or alter the foot biomechanics. After a considerable amount of experience using various orthotics, we have for several years used the semisoft functional orthotics. The system, which was developed here at Children's Hospital, became popular because of our need for a functional orthotic (an orthotic that acts to alter the biomechanics favorably) that was easy to construct in the office at the first visit, that was comfortable to wear immediately, that could be adjusted easily, and that was affordable by our entire patient population. The result was the Foothotics system of Ready to Dispense[19] and Ready to Construct orthotics.[15] These functional soft orthotics are actually a misnomer because although they are semisoft, they do hold the foot biomechanically in gait around a neutral position as well as or better than the more rigid orthotics.[24] In addition, they have been shown to decelerate the foot better than the more rigid devices.[24] A major advantage that we have found is the ability to carry the correction from the rearfoot to the forefoot, beyond the metatarsal heads into the toe area. We have found, particularly for sports, that a full-length orthotic is superior to any type of three-quarter length device. A rigid orthotic must end proximal to the metatarsal heads. Therefore, in sports that require any type of sprinting activity, the forefoot, in our opinion, is not well controlled with rigid orthotics because the orthotic does not continue under the metatarsal heads and beyond. The full-length functional soft orthotic, however, has functional wedging or posting from the heel to the toe area. This we have found to be a great advantage in controlling the running athlete. The full-length orthotic also allows for more surface area of the foot to be controlled biomechanically. Some other advantages of the soft orthotics are their light weight, their ability to allow some cushioning in addition to control, their conformity to the shoes, and their ability to allow for pinpoint shock absorption anywhere under the foot without rocking the foot into supination or pronation, for example, if one stepped on a stone. These orthotics are considerably durable and do not crack as do the rigid acrylic plastic type. We frequently have patients return who have been using the same orthotics for 5 or more years.

Another benefit of using the functional soft orthotic is the fact that the doctor has complete control of the construction, allowing any adjustments to be made immediately. After the initial orthotic is constructed and worn, the patient returns for an increase in the amount of wedging, allowing for a pleasant transition of mechanical realignment. At this time the orthotic is then laminated with a sixteenth- or eighth-inch EVA or cork material and the appropriate wedging increased according to this prescription. The same orthotic can be used for both the young child or the older child and adult as well as geriatric patients. This cuts down inventory and allows flexibility. Construction of these orthotics has been described elsewhere.[15, 19]

SHOES

In order for any orthotic to work well, substantially good shoes are necessary. In general, a good athletic shoe has a strong, well-fitted, deep heel counter, a relatively high heel (at least five-eighths inch higher in heel than forefoot), flexibility in the forefoot, good rearfoot stability, and the ability to limit excessive pronation and supination.[15, 20] One must remember that in order to control excessive pronation and supination and allow normal pronation and supination, the reactive force of the ground must be transmitted from the ground through the sole, through the orthotic if one is present, and to the foot. If there is an excessive amount of softness in the midsole or outersole, or motion between the upper and midsole, or the upper with or without an orthotic rolls over the midsole, then the shoe will not do its job of neutralizing the excessive reactive forces of the ground and excessive aberrant mechanics of the foot.

CONCLUSION

In conclusion, we have discussed many of the common injuries found in the young athlete. We have emphasized the biomechanics of these injuries, particularly in the microtraumatic category, because we think that just about all of these injuries are a result of aberrant biomechanics. It is the exception that anything other than orthotics, shoes, and exercises are needed to resolve these problems.

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