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(54) **ORTHOTIC SYSTEM**

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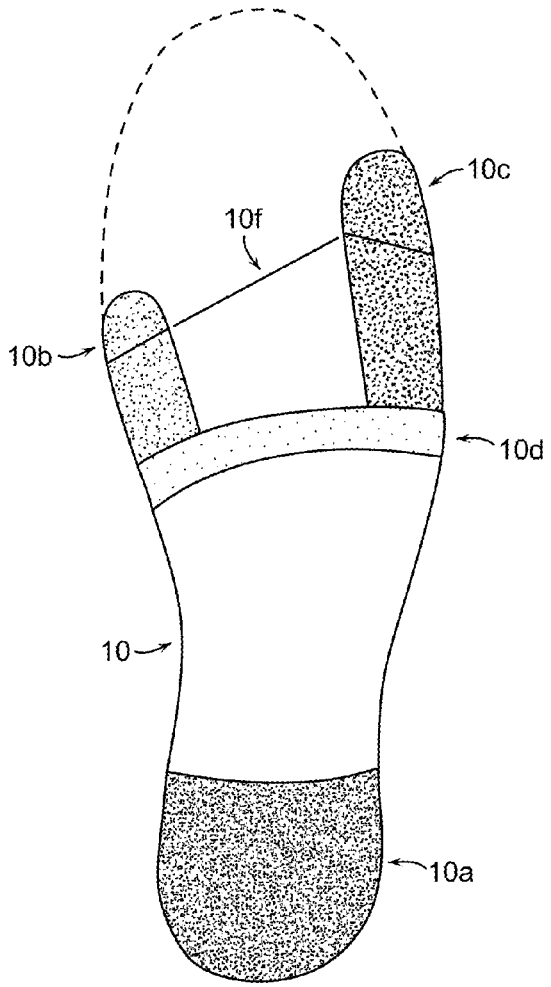
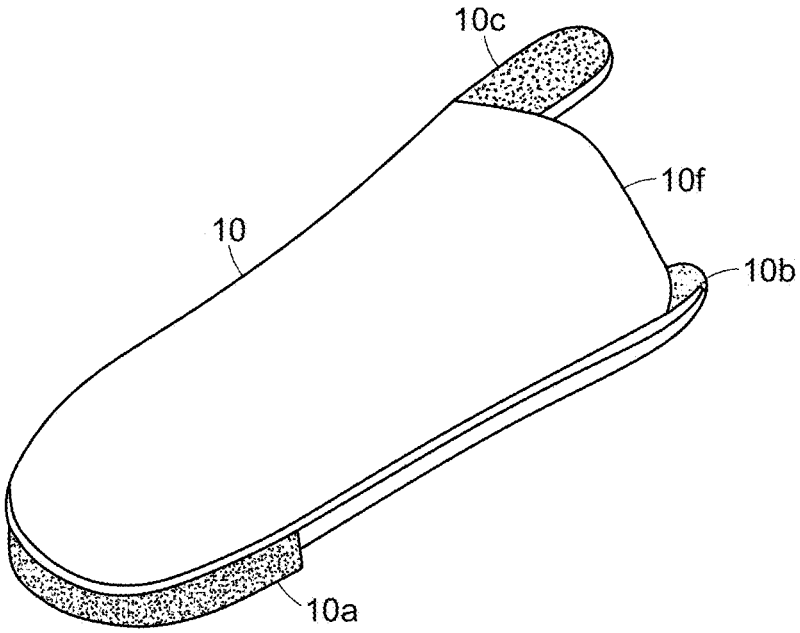
(57) **ABSTRACT**

A foot support system for any shoe; walking, athletic, men, women's dress shoes, children's shoes. The system includes a base that conforming to the contour of a human foot, a heel post attached to the base and extending substantially under heel bone to relieve pressure on contact and provide stability and heel support, a transverse metatarsal stabilization bar located posterior or behind the metatarsal heads in the mid foot for stability of control of the 2^{nd}, 3^{rd}, and 4^{th} metatarsal. A first ray extension originates at the metatarsal stabilization bar posterior to the metatarsal heads in the middle of the foot and ending distal-end to the mid-section of the first toe. Fifth ray extension originates at the transverse metatarsal stabilization bar posterior to the metatarsal heads in the middle of the foot and ending distal-end to the mid-section of the fifth toe. The orthotic system can be designed as an insert independent of a convention shoe sole, or may be incorporated into the sole of the shoe.

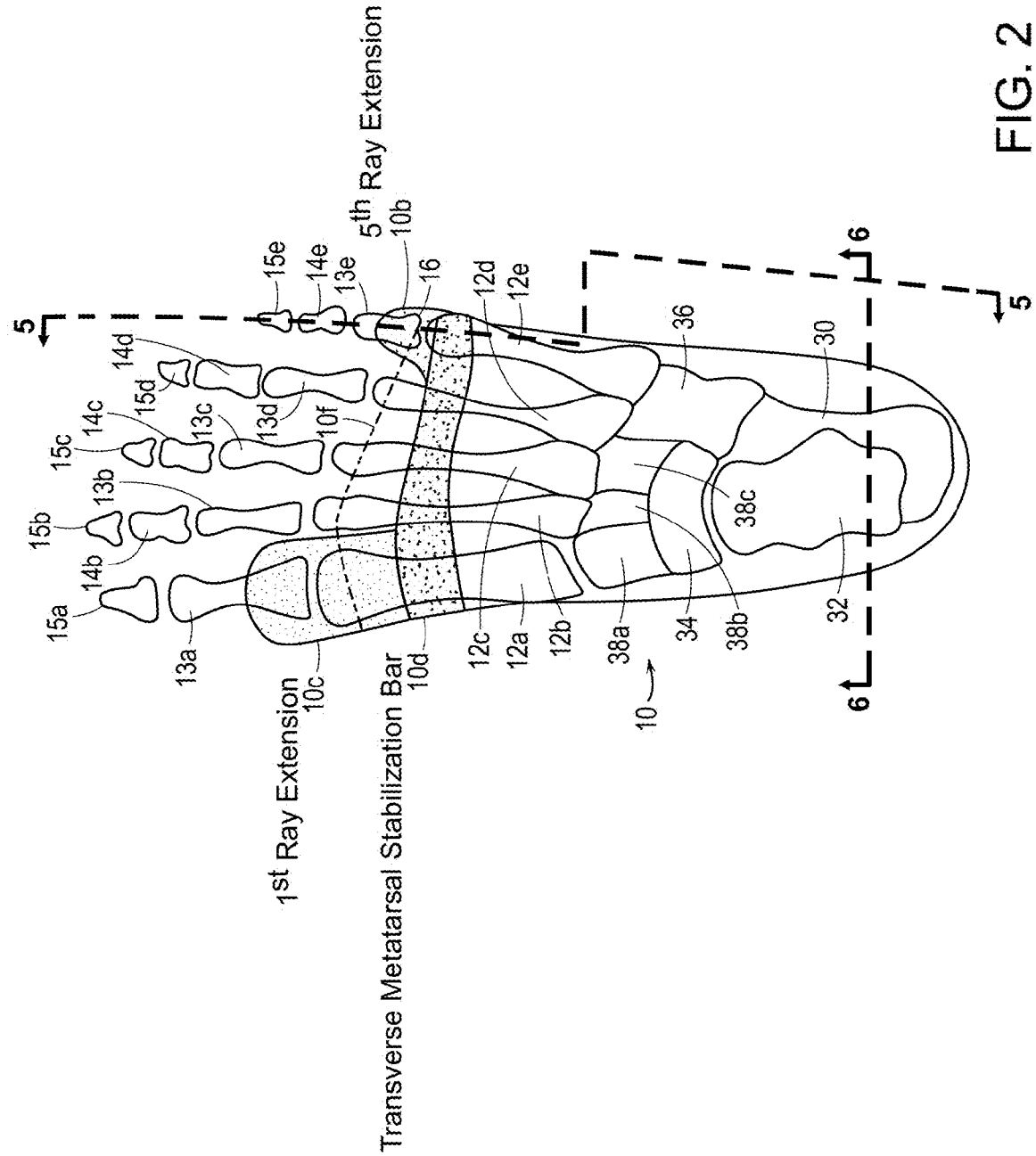


Bottom Right Foot View



Right Foot View

FIG. 1


5
6
5th Ray Extension
1st Ray Extension
Transverse Metatarsal Stabilization Bar
10
10b
10c
10d
10f
16
15a
15b
15c
15d
15e
14b
14c
14d
14e
13a
13b
13c
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12d
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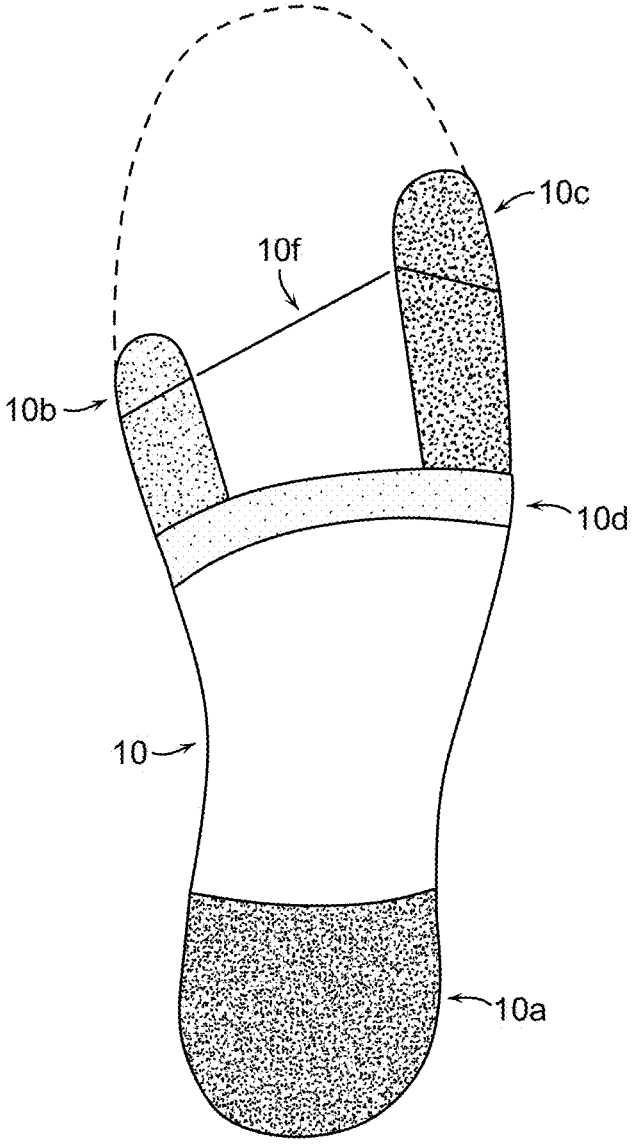
32
34
36
38a
38b
38c

FIG. 2



Bottom Right Foot View

FIG. 3

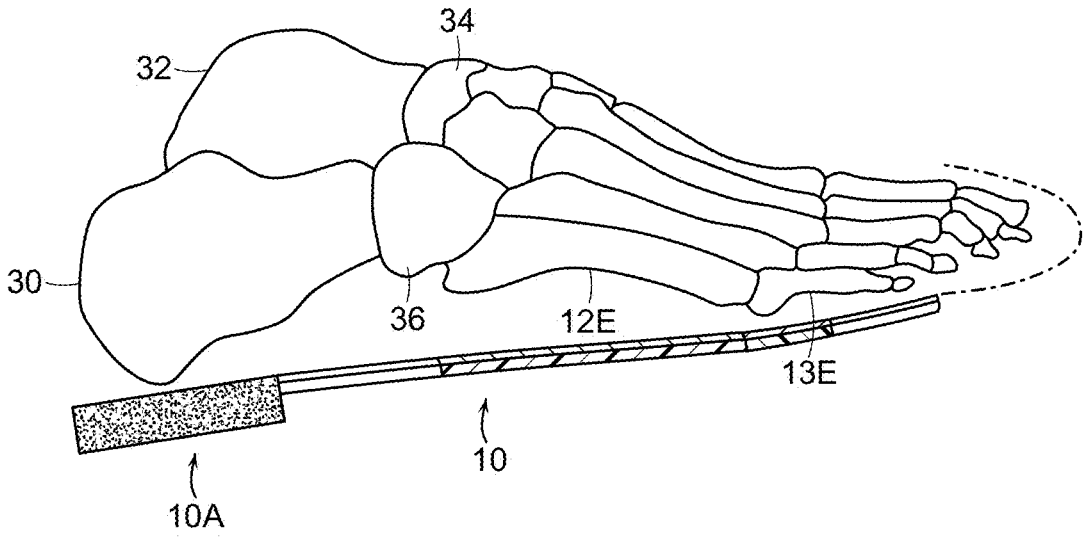


FIG. 4

ORTHOTIC SYSTEM

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of filing of U.S. Provisional Patent Application Ser. No. 62/266,835, filed Dec. 14, 2015, entitled "Biomechanical Stabilization System: BSS," the teachings of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The invention pertains to orthotics and other devices for correction and/or measurement of the human foot in action.

[0003] The inner border of this foot is unbalanced and unstable. In foot strike and weight bearing, it takes up the burden late thereby imposing a major part of the work inappropriately on the other forefoot bones. The result is collapse, pronation and flattening of the arch. An abnormal torque and twist is set up ascending through the foot to the leg, hip and beyond.

[0004] The prior art includes U.S. Pat. No. 4,813,159, entitled "foot support for optimum recovery, providing a forward recovery foot support system for any shoe but primarily for running and jogging shoes. The system includes a base conforming generally to the contour of a human foot, a first ray extension attached to the base and extending substantially only under the first proximal phalanx of the foot, a fifth ray extension attached to the base and extending substantially only under the fifth proximal phalanx of the foot, and a heel post attached to the base and extending substantially only under the heel bone and providing added elevation at the most lateral aspect of the heel bone to compensate for the natural inversion of 2°-3° that is present in most persons' heels. This support can be designed as an insert independent of a conventional shoe sole or may be incorporated into the sole of a shoe.

[0005] Though the foregoing represented an advance, more is needed.

[0006] One object of the present invention is to provide a support that can be added as an insert to or can be incorporated into walking, running, and other shoes.

[0007] Another object is to provide a support which fosters increased efficiency and safety in walking and running.

[0008] Still another object is to provide a support that can promote proper foot rotation, provide a forward thrust from the heel to the transverse metatarsal stabilization bar than to the toes and stabilizing the first and fifth rays during pronation and flexing.

[0009] Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

SUMMARY OF THE INVENTION

[0010] The present invention provides, in some aspects, a orthotic system for shoes, including walking, athlete, men's and women's dress shoes and children's shoes.

[0011] The orthotic system incorporates a heel posting to absorb shock and to control and balance. This uneven weight distribution to the heel of the foot compromises the body's balance and stability and the posture of the upper body. This repetitive pounding increases the development of osteoarthritis. Then moving forward a transverse metatarsal stabilization bar that is associated and attached to the fifth ray extension and the first ray extension posterior and behind the metatarsal heads and anterior or in front mid foot or middle region of the area takes into concentration of the transverse and oblique motion of the midtarsal joints, or middle of the foot. In turn, the transverse metatarsal stabilization bar gives the needed balance and redirects the forefoot with stability as it moves lateral, outside forefoot to the fifth ray which is the most pronatory ray in the forefoot. At this geometric anatomical point, the fifth ray extension which originates at the transverse metatarsal stabilization bar, posterior behind them metatarsal heads, ending distal to the mid-section of the fifth toe, begins to balance the pronatory motion of the lateral imbalance and creates stability as the motion and vector forces end up on the first ray. It should be realized that the three central toe-metatarsals of the forefoot base considerably more stable than the outer first and fifth rays. On passive examination of the foot, the three central rays (2^{nd}, 3^{rd}, 4^{th} metatarsals) individually exhibit only plantarflexion (downward) motion from the transverse plane in which they are locked during the midstance period of gait. In all actual fact none of the rays can be dorsiflexed (upward) above the loaded common transverse plane position of the metatarsal heads when the mid-tarsal joint (midfoot) is fully pronated during the mid-stance period. With the utilization of the first ray, it balances and stabilizes the rotatory force with a hypermobility short level arm and motion for a stable and balanced push off and the end movement for an improved forward recovery of motion.

[0012] The prior art has failed to provide a support that corrects and stabilizes the entire foot in a broad category of application, nor have they provided a support that can broadly protect an individual from serious strain and injuries caused at least in part by the natural imperfections of the human foot.

[0013] The human foot, when housed in a shoe, is a black box mystery. It no longer has the proper forces for forward motion. When utilizing my invention however, there is a triplane stabilization factor. This helps compensate for the short first and fifth metatarsals, so common in the human foot. As the foot makes heel contact, it is stabilized by the heel posting. This, in turn, helps control the forward motion to the midfoot. At the midfoot point, a U-shape raised posting acts anatomically moving forces under the midtarsal/midfoot. This unit construction of a transverse metatarsal stabilization bar supports the transverse and oblique axis of the midtarsal/midfoot. This bar then incorporates the first and fifth ray extensions to correct the forward motion of the foot.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] A more complete understanding of the invention may be attained by reference to the drawings, in which:

[0015] FIG. **1** is a perspective view showing a Foot support made according to the present invention;

[0016] FIG. **2** is a top plan view of the Skelton structure of the right foot showing the relative size, shape and position of the foot support embodying the invention;

[0017] FIG. **3** is the bottom plan view of the support shown in FIG. **2**; and

[0018] FIG. **4** is a longitudinal vertical section taken along the line of FIG. **2**.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

[0019] The foot is an architectural marvel, an engineering master piece, which has 26 bones, four times the number of ligaments, and an intricate network of tendons which support the arches. When these components are perfectly stable and balanced, the foot can handle any amount of work, however, even a minute deviation from normal can cause adjustments that will eventually produce disease, either in the foot or its supporting muscle and tendons. We have discovered that the majority of the individuals have an inherent susceptibility with a short first and fifth metatarsal. We now realize that susceptibility is a biomechanically imbalanced foot, a foot that has inherent structural difficulties. These structural problems make the individual prone to develop any one or more variety of foot, leg, knee, hip and lower back illnesses. A biomechanically unbalanced foot is structurally inadequate to its task of balance and stability of the forefoot and rearfoot. Distributing weight on the forefoot is due to the most common unbalance foot type: the Morton's foot. It is easily recognized by congenital short first metatarsal, a hypermobile first metatarsal segment, and a long second metatarsal toe.

[0020] After years of treating thousands of orthopedic cases of different foot and ankle related, knee, hip and back complaints in children and adults. The present invention overcomes the problems and disadvantages of the prior art by maximizing the knowledge gain in the individual walking gait, running, and all other normal activities and sports. It also overcomes the U.S. Pat. No. 4,813,159 patent where the heel post attached to the base and extending substantially under the heel bone and providing added elevation at the most lateral aspect of the heel bone to compensate for the natural inversion of 2-3 degrees that is present in most person's heels, is no longer present as it is not as functional and stabile. In the new orthotic system according to the invention this is not utilize, as it has been found that it does not control the motion and the stability of midtarsal-mid foot's as to the transverse and oblique axis of motion as it now superior with utilization of the transverse metatarsal stabilization Bar. The Orthotic system support compensates for imbalance at the heel post, transverse metatarsal stabilization bar as it then encompasses the kinetic force to stabilize motion at the first and fifth ray of a foot and corrects the forward motion of the foot.

[0021] To achieve the objects and in accordance with the purpose of the invention, as embodied and broadly described herein, the invention comprises a foot support for a wearer's foot comprising a heel post extending only under the heel bone of the foot, a transverse metatarsal stabilization bar posterior or behind the metatarsal heads in the middle of the foot-mid foot. A fifth ray originates at the transverse metatarsal stabilization bar into the middle of the foot and ending distal end to the mid-section of the fifth toe compensating for lateral imbalance of the foot by establishing an effective amount of inward rotation of the foot for efficient forward motion and preventing outward rotation of the foot and maximizing effective foot and body balance and stability. The first ray means originates at the transverse metatarsal stabilization bar posterior to the metatarsal heads in the middle of the foot and ending distal end to the mid-section of the first toe for stabilizing the first toe and controlling hypermobility of the first toe.

[0022] The orthotic system will also off-load all anatomical bone structures to prevent sharing forces to the bone segments that may create tissue breakdown with faulty biomechanical balances.

[0023] In order to fully explain and describe the present invention, it is first necessary to explain the principles of walking and running, along with the problems associated with the foot. When we walk and run, we exert forces in one direction in order to propel ourselves in the opposite direction. So, for every action, there is an equal and opposite reaction. In order for one to apply force to the running and walking surface and get back the reciprocal forces necessary for locomotion, we need to apply and receive those forces through two very critical levers—our feet.

[0024] To understand this invention function with the human foot, there has to be an understanding of the contact, midstand, and push off phase of the gait cycle. The leg muscle plays a major factor on the heel strike. The majority of the individuals that have the short first and fifth rays also have a tight or shorten calf muscle or gastrocnemius and soleus. These muscles together form a muscular mass which is described as the triceps surae which the common tendon insertion of the gastrocnemius and soleus is the Achilles tendon or heel cord, which is the thickest and strongest tendon in the body. The function of the gastrocnemius is to plantarflex the foot compress the motion of the heel to the ground. The effects of a tight calf/gastrocnemius Achilles tendon apparatus (gastroc-equnus) which makes a pre-mature hard heel contract with the ground or the supporting surface—thrusting motion forwardly.

[0025] The framework of the foot is composed of the combination of bone segments bound together by ligaments. The foot provides the for sustaining weight and kinetic forces and transmitting them from the ankle to the points of contact of the foot with the ground. In a normal stride, the heel of the foot first contacts the ground and sustains the person's weight and the kinetic stresses and applied to the midfoot, the forefoot, and the toes.

[0026] The proper way to gain biomechanical balance both in stride length and stride rate is to increase flexibility and elasticity, thereby improving the ability of our limbs and levers to move easily through a full range of motion. Any increase in flexibility automatically increases the ease with which we can move a limb. Increased ease of movement allows us to move farther on each stride (stride lengths). In addition, because the effort to move the leg is less, the same effort makes the leg go faster (stride rate). Therefore, a foot support preferably should increase the elasticity of the muscles, tendons, ligaments and muscle sheathing involved in walking and running. To be effective, a foot support must at least reduce the strain placed on these connecting tissues and promote body movements and motions that promote the most effective and least stressful transfer of forces through these tissues. For proper foot function, a foot support also should maintain balance and stability throughout the stride.

[0027] When a person walks or runs, his foot progresses through a series of phases. These phases are generally described as the heel strike phase (when the heel first strikes the ground), the contact phase (when the heel contacts the ground and rotates), the midstance phase (when forces are transferred through the midfoot to the forefoot), the propulsion phase (when the toes and foot push off and propel the

body forward), and the toe off phase (just before the foot leaves the ground) Applicant has discovered that the shape, size, characteristics and support of a person's heel, little toe and big toe can significantly affect the efficiency and safety of walking and running.

[0028] In the average person, the heel of the foot is inverted 2°-3° (tilted outwardly because it is lower on the outside (lateral side) than on the inside (medical side). This characteristic may cause abnormal pronation (inward rotation) during the gait cycle. When the heel first strikes the ground, the heel is inverted this initial 2°-3°. After the heel contacts the ground, the foot begins to pronate (rotate inwardly). Typically, the total degree of pronation during a gait is 4°-6°. Obviously, if the heel at contact is inverted 2°-3° and pronates through the neutral axis to 4°-6° of pronation, the foot and its members will be subject to a total of 6°-9°. This degree of rotation places considerable stress on the foot and its connective tissue and can have adverse effects on the other phases of the gait.

[0029] In the majority of individuals, the first metatarsal (big toe) of a human foot is shorter than the second metatarsal. This increases an imbalance in locomotion. The 5^{th} (small toe) metatarsal is the shortest and the most unstable of the five metatarsals in the human foot. The first metatarsal and fifth metatarsal have independent motions available to them in dorsiflexion and plantarflexion (up and down motion) and also have some lateral movement available to them. As a result, the first and fifth metatarsal and toes are unstable.

[0030] The three central toes of the foot are considerably more stable than the outer toes. On passive examination of the foot, the three central rays (2^{nd}, 3^{rd} & 4^{th} metatarsals) individually exhibit only plantarflexion (downward) motion from the transverse plane in which they are locked during the midstance period of gait. In fact, none of the rays can be dorsiflexed (upward) above the loaded common transverse plane position of the metatarsal heads when the midtarsal joint (midfoot) is fully pronated during the midstance period.

[0031] From a biomechanical standpoint, the function of the foot during walking or running can be described generally as follows. At the contact phase when the foot first hits the ground, the normal weight distribution first is applied to the lateral (outside) side of the heel. The heel then pronates or rolls medically to shift the weight distribution toward the inside of the heel. The heel also rolls laterally or forwardly so that the weight moves forward along the lateral weight bearing surface of the bottom of the foot to the fifth metatarsal head. The forefoot then pronates or rolls inwardly so that the weight shifts across the fourth, third and second metatarsal bones toward the first metatarsal bone. Then the weight moves forward through the first toe with the remaining toe aiding in the lift off.

[0032] When walking or running the natural rolling motion of the foot is initiated when the heel bone makes contact with the ground. For the best transfer of forces, the foot should then roll in a manner such that the rolling motion is directed forwardly so that the toes, particularly if the big toe, roll straight ahead. Applicant has discovered that the natural inversion of most heels at a 2°-3° angle deters proper heel pronation and forward transfer.

[0033] As weight is transferred to the forefoot, the ball of the foot at the little toe touches the ground first. Then the foot rolls forward shifting weight forward on to the toes which bend and unbend as the person's body moves forward over and be on the toes. This bending and unbending of the toes produce a springy forward functional thrust to the forward motion of the running body. As a person's weight moves forward from the ball of the foot onto the toes, the foot rotates slightly inward (pronates) due to the staggered arrangement of the toes in the contour of the ball of the foot. This inward rotation is a natural part of the foot movement which enables each toe in secession, beginning with the little toe, to contribute its own component of springing forward thrust. However, if the foot is latterly imbalance, or if the metatarsal bone which precedes the little toe is unnaturally short, there will be insufficient inward rotation for the most efficient forward thrust, or worse, there will be outward rotation which tends to throw the body off-balance, impeding efficient motion or perhaps even causing a sprain or a pulled muscle.

[0034] During a normal gait with its contact, mid stance, propulsion and toe lift phases, there is a continual shifting of forces and torque. The torque on the foot peak at the end of the mid stance phase, and a supination and pronation forces on the foot are greater after the mid stance phase. Thus the maximum torque force and supination and pronation forces are applied to the forefoot area during the propulsion phase.

[0035] A runner with the greatest continuity of motion will be the one with a normal foot that produces linear shear forces against the flight during contact and again during propulsion. Lateral shear forces—side to side—are generally not as significant during normal walking locomotion. However, and running and jogging they may have a greater effect. Moreover, these lateral forces may be accentuated by any of several pathological conditions which exaggerate lateral motion such as lateral imbalance. Applicant has designed the support of the present invention to overcome the problems associated with the over inversion of the heel and the instability of the first and fifth toes.

[0036] Referring to the drawings, the orthotic system includes a base fifth ray extension, **10**B, first ray extension, **10**C a transvers stabilization bar, **10**D a heel post, **10**A. The bottom surface of the rear portion of the foot includes a heel bone, **30** known as the calcaneus, which is connected to the forefoot through a series of bones show and generally as navicular, **34** cuboid, **36** cuneiforms **38**A, **38**B, and **38**C.

[0037] As a person walks or runs, the heel bone swings relative to the navicular, cuboid, cuneiforms (mid tarsal joints) and metatarsals as the foot rolls forward.

[0038] Foot has five metatarsal bones. The first metatarsal, **12**A, on the inside of the foot followed by the second, **12***b*, third, **12**C, fourth, **12**D, and fifth metatarsal, **12**E. The principal bones of the toes are the proximal phalanges, **13**A to **13**E, which extend forward in line from the respective metatarsal bones to which they are joined by flexible joints at the toe base. The other toe bones are the middle phalanges, **14**B to **14**E and a distal phalanges, **15**A to **15**E to the large toe having no middle phalanx.

[0039] Each proximal phalanx is composed of a base at the proximal end, and base where a head at the distal end and a neck, which is that elongated portion between the head and a section would have less area than the greatest sectional area of the head or base.

[0040] The forward edge of the foot support **10** F, extends across under the foot of the line generally of the forward of the metatarsal bones. That line extends approximately through the joints between the metatarsal bones in the

proximal phalanx bones. This one should be near the joints only extending proximally from the joints up to a centimeter. Preferably, the line extends approximately about 5 millimeter just behind the joints.

[0041] The support or base can be made from a variety of materials. The base preferably is substantially soft or stiff and made of any suitable material such as fiberglass, reinforced plastic resin impregnated with polypropylene. The base conforms generally to the contour of the sole of the foot and extends from the heel to approximately the distal end to the metatarsal.

[0042] At the rear end of the base it seat is shaped to conform to and cradle the wearer's heel.

[0043] A heel post is included or attached to the underside of the base. The heel post is made of resilient material, such as hard rubber, and is attached to the base by glue or similar means. Heel post preferably should have shock absorbing qualities. The heel post extends from the medial (inside) add to the base to the lateral (outside) edge. The heel post extends longitudinally from the posterior of the heel bone to the anterior portion of that bone. That heel post includes post members. If used with the shoe or insert, the heel post can begin at the rear end of the insert or shoe, but it should not extend beyond the front of the heel bone. The heel post therefore, is significantly shorter in length than a typical heel of a shoe.

[0044] The heel post preferably is made of resilient material and extends cross the entire width of the heel portion of the base. However, the heel post could not extend beyond to anterior portion of the heel bone.

[0045] The first ray extension and the fifth ray extension from the front edge of the transverse metatarsal stabilization bar in the mid-middle of the foot and are aligned with the first and fifth phalanges, respectively.

[0046] The first ray extension and the fifth ray extension extends from the front edge of the transverse metatarsal bar. The extensions are attached by glue or leather cover which in turn is glued to the base. The base, heel post, leather cover, transverse metatarsal bar, and ray extensions therefore combined to form a unitary support.

[0047] The toe extensions are more flexible and resilient than foot support which is made of a stiff material. The toe extensions and transverse metatarsal bar may be a variety of forcible materials, such as rubber. While they preferably should have some resiliency, they should also have sufficient strength and resistance to do the formation to support the toes and place a resistant force against the toes as they bend.

[0048] The first ray extension is an extension of the transverse metatarsal stabilization bar in the mid-middle of the foot and terminates distally beneath the middle of the first toe. The first ray extension has a width equal to or slightly larger than the thickness of the first toe.

[0049] The fifth ray extension is an extension of the transverse metatarsal stabilization bar in the mid-middle distally beneath the middle of the fifth toe. The fifth ray extension has a width that is equal to or slightly larger than the thickness of the fifth toe.

[0050] Through continue experimentation and study, applicant has discovered that the heel post, transverse metatarsal stabilization bar, the first ray expansion and fifth ray extension of the present invention provides the additional benefits described here in more over; applicant has discovered that these four elements in combination cooperates to provide a support that promotes optimal rearfoot and forefoot stabilization for forward recovery.

[0051] The heel post of the present invention increases the surface contact of the support and provides both stability and shock absorption. The heel is well padded and solid for bone and tissue structure. Applicant has discovered that because of the strength, the heel can except forces that are sufficient degree to prevent undesirable pronation and promotes correct forward force transfer, without causing trauma or injury to the heel. Therefore, corrective force is applied to the heel post to not create undue stress. Instead, the heel post applies a force of contact equally throughout the bottom of the heel

[0052] The heel post also decreases the degree of pronation applied to the foot since the range of rotation is decreased by several degrees. In addition, because the heel post ends at the distal end of the heel bone, it applies the corrective posting forces directly on that bone, rather than the bones adjacent to the heel bone. The heel post also allows free relative movement between the heel bone and the other bones of the foot, because it ends at the joint.

[0053] The heel post across medial to lateral aspect of the heel bone, and can be 2-4 degrees vertical posting for shock absorption and stability. This can be made of a soft material or semi-rigid material.

[0054] Transverse metatarsal stabilization bar is located posterior or behind the metatarsal heads in the mid foot or middle of the foot for stability and control of the 2^{nd}, 3^{rd} and 4^{th} metatarsals, or the first and fifth rays have independent motion and are controlled and stabilized by the first and fifth extension. The first and fifth ray extensions originate at the transverse metatarsal stabilization bar posterior or behind the metatarsal heads in the mid foot or middle of the foot, and ending distal or end to the mid-section of the toes.

[0055] As the stride continues, the heel post tends to spread the weight and kinetic forces forwardly and moves equal to the toes. As the weight and kinetic load is supplied from the heel through the midfoot to the transverse metatarsal stabilization bar, and into the fifth Ray, the fifth of ray extension stabilizes the foot and promotes efficient pronation of the foot and transfer of forces. The fifth ray extension projects and extends forward push off and thrusting, disperses shock, and retards lateral forces. It also acts as a stabilizer for all of the muscles that insert anatomically into the fifth toe. The extension in combination with the transverse metatarsal stabilization bar and heel post directs the foot action in a forward extended position to promote the most efficient and release stressful manner for producing motion.

[0056] The point in the foot which gives the greatest range of Dorsiflexion is the oblique axis of the midtarsal joint or midfoot. The positioning of the fifth Ray extension allows it to use the oblique axis vector forces as well as the muscle dynamics of the lumbricalis and interossei muscles which insert into the middle of the fifth toe. The fifth ray extension is most functional where the muscle action has greatest motion as a movement arm of a muscle tendon apparatus. The relatively short movement of the fifth ray extension provides better motion then a long movement arm, which may create a rolling motion.

[0057] The fifth ray extension preferably is made of a material that does not fully collapse under the bodies' weight in propulsion so that the small toe can curve over the extension during mid stance and propulsion so the extension can act as a lever. The extension provides a stabilization

system that directs the foot action forward simultaneously with all lesser digits in a stable forward recovery extended position for the most efficient in the least stressful manner for producing motion. The extension is flat but the thickness may, but need not necessarily, be made such as to compensate for functional lateral and balance as measured across the foot at the distal portion of the metatarsals or the mid portions of the fifth toe. The extension having some thickness does compensate in any event for lateral imbalance at the mid portions of the fifth toe. The extension should be flat and as wide as or somewhat wider than the fifth toe. Preferably, the remainder of the foot proximal to the middle of the fifth toe is also supported by the base that is contiguous and/or integral with the fifth ray extension. This foot support preferably should be composed of a semi-rigid material thereby permitting a pivotal movement of the extension relative to the support.

[0058] The anatomical position of the 5^{th} ray extension is such that it extends to the middle of the proximal phalanx for dynamic balance and pathomechanically for better function control and stability in forward motion. This position is optimum because the lumbricalis and the interossei muscles attach to the phalanges at approximately this position.

[0059] The lumbricalis muscle during locomotion (1) extends the phalanges joint of the four lesser toes during the midstance and propulsion period, (2) assist in stabilizing the proximal phalanx of the lesser toes in a plantarflexion direction against ground reaction forces during propulsion, and (3) provide slight adduction stability of the proximal phalanx of the lesser digits which resists the abduction force of ground reaction during propulsion. The tendons attach these muscles by a small slip to the medial-dorsal aspect (middle-top) of the area of the middle of fifth toe. Without the participation of the lumbricalis muscles, the forefoot does not have the capability of extending the phalanges of the lesser digits forward.

[0060] The interossei muscles also help the forefoot to function during locomotion. They (1) stabilize the bones of the proximal phalanges of the four lesser toes against their metatarsal heads and (2) stabilize the bases of the proximal phalanges transversely. They provide adductor-stabilizing factors to the toes at the metatarsal phalange joint. There are seven interossei muscles: four are dorsal and three are called plantar interossei. These interossei insert into the medial and lateral sides of the base of the proximal phalanges. They have longer lever arms from the vertical axis than from the transverse axis. Therefore, they exert a strong adduction-abduction force upon the proximal phalanges.

[0061] The fifth ray extension ends just posterior to the middle of the fifth toe where there is a dynamic center-of-pressure due to these strong muscle inserts. The 5^{th} ray extension therefore tends to create a trampoline or spring lever effect where the pressure is greatest. The fifth ray extension has a stabilizing and cushioned effect on the muscles and acts as a spring lever in forward propulsion.

[0062] In addition, the fifth ray creates a stabilizing extension on the outside of the foot that prevents undesirable outward rotation of the foot while at the same time promoting an effective and controlled amount of inward rotation for efficient forward thrust. As a result, the fifth ray maximizes effective foot and body motion and minimizes strain and trauma.

[0063] The use of the heel post in combination with the transverse metatarsal stabilization bar and the fifth ray is particular effective, since the heel post directs the forces more equally over the toes and initiates proper pronation. Therefore, the fifth ray can redirect the forces and promote proper pronation without placing any injurious forces or strains on the smaller structure and tissues of the small toe.

[0064] As the vector forces from the heel and the muscles are placed into motion from the transverse metatarsal stabilization bar, to fifth ray extension, it is important to enhance as much balance and stability from the first ray which again also has independent motion. The anatomical position of the first ray extension is such that it extends to the middle of the great toe or hallux, for dynamic balance and stability of the foot. This balance and stability is important, since the first ray is where the last part of weight is dispersed in a projector forward force, and the muscles of the foot extends a substantial propelling force on the first ray. The first ray extension acts as a stabilizer for the muscles that insert into the first ray.

[0065] The normal locomotion of the first ray requires 65-75 degrees of first metatarsal phalangeal joint dorsiflexion during propulsion. A smooth, gliding articulation between the base of the proximal phalanx, first metatarsal head and sesamoids (2 small bones under 1^{st} metatarsal head) is necessary. As the foot enters the propulsion phase of gait, the great toe hallux must be stabilized against the ground so that it can bear the weight transmitted through the first metatarsal.

[0066] As the heel lifts off the ground during the propulsion phase, the reaction of the ground forces dorsiflexion of the stabilized hallux. Hallux stability and first metatarsophalangeal joint function require a stabilized, plantarflexed first ray, as well as normal sesamoid function, and proper strength and alignment of the muscles. The flexor halluces brevis inserts into the tibial (outside) and fibular (inside) sesamoid bone and continues forward and inserts into the base of the proximal phalanx plantarly. The flexor hallux longus inserts into the base of the terminal phalanx. The abductor-hallucis-attaches to the sesamoid apparatus medially and then to the medial plantar portion of proximal phalanx. The adductor halluces arises from the medial side of the shafts and bases of the second, third, and fourth metatarsals. It courses forward and medially. The transverse head arises from the capsule tissue covers the metatarsal heads and the plantar ligaments of the third, fourth, and fifth metatarsophalangeal joints and from deep, transverse metatarsal ligament. It courses medially. The two heads meet in the first intermetatarsal space and insert primarily onto the sesamoid apparatus as a conjoined tendon. From the sesamoid, it continues forward to the medial and plantar portion of the base of the proximal phalanx. These muscles all act to stabilize the hallux or great toe against the ground.

[0067] Plantarflexion of the first ray to the ground is effected by the pull of the peroneus long (muscle from the lateral or outside of the leg which courses down under the lateral aspect of the ankle down under and across the foot to the medial or inside as it inserts into the base of the first ray) about a rigid lateral column and lesser tarsus. The fifth ray extension helps to stabilize this muscle if it becomes contracted or tight.

[0068] As a ground reaction forces dorsiflex the hallux and the first ray plantarflexes, the distal aspect of the first metatarsal head articulates more and more with the sesamoids. The sesamoids function as pulleys for the muscles that stabilize the hallux. As the distal surface of the metatarsal

head contacts the sesamoids, the base of the stabilized (not moving) phalanx glides along the dorsal articular surface of the metatarsal head. The actual transverse axis (instant center of motion) of sagittal plane first metatarsophalangeal motion migrates dorsally and proximally. Only at end range dorsiflexion does the base of the phalanx begin to compress into the dorsal aspect of the articular surface of the metatarsal head. Without the normal plantarflexion of the first ray during propulsion, only 25-30 degrees of metatarsophalangeal joint dorsiflexion could occur before the phalangeal base would begin to compress into the metatarsal head. The first ray extension helps to stabilize the ground reactive force as well as the muscle.

[0069] The first ray extension also compensates for the problems caused by a shorter first metatarsal. When the first metatarsal fails to support its share of support, the unsupported force is transposed to the second metatarsal, and to a lesser degree, the third metatarsal. This can cause trauma and injury. For example, when the heel of the foot is lifted, weight is thrown upon the toes of the supporting foot. If the second metatarsal is longer than the first (the normal condition), the major share of the bodyweight becomes increasingly concentrated upon the second metatarsal. This abnormal distribution of weight and kinetic force upon the weaker second metatarsal imposes undesirable stresses upon the bones and tissues of the foot. These strains can result in damage to or breaking of the bones, injury to muscles and ligaments, and early fatigue, aches and spasms in the feet and the legs.

[0070] The first ray extension overcomes this problem by effectively extending the first metatarsal and thereby providing a supporting surface for the forces which extend down the first phalanx. The first ray extension also stabilizes the first ray itself, thereby minimizing the hypermobility of the first ray. In addition, the first ray extension prevents undesirable over pronation of the foot and instead promotes forward rolling of the first phalanx. Since the first ray extension ends at approximately the mid-portion of the big toe during propulsion flexes over the end of the first extension, providing an increased lever effect.

[0071] The fifth ray extension and the first ray extension may be attached to the transverse metatarsal stabilization bar. The ray extension may also be a part of a unitary layer of flexible resilient material applied over the entire sole.

[0072] While the fifth ray extension stabilizes the lateral aspect of the foot, with all the muscle functions being controlled and stabilized, the first ray extension provides an equal and opposite reaction on the medial side stabilizing and controlling motion. The first and fifth ray extensions is combination control, balance, and stabilize the foot, create a forward projector force, and provide a unique forward recovery system. The heel post, transverse metatarsal stabilization bar, first ray extension, and fifth ray extension combines to create a total support system which minimizes trauma and creates optimum movement and efficiency.

[0073] In the embodiment disclosed, the base, heel post, transverse metatarsal stabilization bar, first ray extension and fifth ray extensions are each made from separate pieces and are then constructed as a unit. It should be apparent, however, that the support in the present invention can be formed of a single piece of material or can be molded as a single unit. The present invention, therefore, can readily be made as an insert for shoes, incorporated into the sole of the shoe or as an orthotic.

[0074] It should also be apparent that all or certain elements of the present invention can be incorporated into a shoe design. The heel post of the present invention could be easily added to a shoe by elevating the heel either at the inside or the exterior of the shoe. The heel post is shorter in longitudinal length than a standard shoe heel. The transverse metatarsal stabilization bar present in the mid-middle of the arch where the first and fifth ray extension originates. The first and fifth ray extensions can be incorporated into the sole of a shoe, and these extensions preferably would be made of a more rigid material than the sole of the shoe. The extension preferably would extend proximally only under the first and fifth toes mid-way.

[0075] It will be apparent to those skilled in the art that various modifications and variations can be made in the foot support of the present invention and in the construction of this foot support without departing from the scope and spirit of the invention. Such embodiments of the invention will be apparent to the skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

In view of the foregoing, what I claim is:

1. A foot support for wearer's foot comprising; a heel post extending only under the heel bone of the foot extending under the heel bone of the foot from medial to lateral, it is elongated in addition rounded anterior, with thickness of 4-6 degrees as it cradles and protects the heel to relieve pressure on contact and provide stability and heel support. It should not extend beyond the front of the heel bone and preventing over pronation of the heel during walking and running; the transverse metatarsal stabilization bar balances midtarsal-midfoot stability of the transverse and oblique axils of motion at the midtarsal midfoot, then forward motion is control by the first ray means originating from the transverse metatarsal stabilization bar and ending under the mid-section of the first toe and controlling the hypermobility of the first toe, said first ray means extending to about the mid portion of the first toe of the foot.

2. The foot support of claim **1**, comprising fifth ray means originating from the transverse metatarsal stabilization bar and ending under the mid-section of the fifth toe of the foot for compensating for lateral imbalance of the foot by establishing an effective amount of inward rotation of the foot for efficient amount of inward rotation of the foot for efficient forward thrust and preventing outward rotation of the foot and maximizing effective foot and body motion.

3. The foot support of claim **1** wherein said heel post extending under the heel bone of the foot, from medial to lateral.

4. A forward recovery foot support for a wearer's foot comprising: base conforming generally to the contour of a human foot; a first ray extension originate at the transverse metatarsal stabilization bar and extending substantially only under the midpoint of first toe of the foot for stabilizing the first toe and controlling the hypermobility of the first toe. Said first ray extension extending to the mid portion of the first toe of the foot and fifth ray extension originates at the transverse metatarsal stabilization bar and extending substantially under the fifth toe midsection of the foot for compensating for lateral imbalance of said foot by establishing an effective amount of inward rotation of the foot for

efficient forward thrust and preventing outward rotation of the foot and maximizing effective foot and body motion.

5. The foot support of claim **4**, where the fifth ray extension originates at the transverse metatarsal stabilization bar to about the mid portion of the fifth toe of the foot.

6. The foot support of claim **4**, further comprising a heel post attached to said base and extending substantially under the heel bone of the foot from medial to lateral to protect the heel to relieve pressure on heel contact providing stability and support preventing over pronation of the heel during walking and running.

7. The foot support of claim **6** wherein said heel post is made of many materials, soft rubber, firm plastic

8. (canceled)

9. The foot support of claim **4**, wherein said heel post is a lift that cradles the heel and extends longitudinally from the posterior end of the heel of the foot to the anterior end of the heel of the foot and extends medial and laterally across at least the width of the foot.

10. The foot support of claim **9** wherein said heel post is attached to the bottom of said base.

11-15. (canceled)

16. A forward recovery foot support for a wearers' foot comprising a base conforming generally to said base being located back from transverse metatarsal stabilization bar in the midtarsal-midfoot posterior behind the First, second, third, fourth and fifth metatarsal bones. The first ray extension originated from the transverse metatarsal stabilization bar and extends distal to the mid portion of the first toe of the foot for stabilizing the first ray and controlling the hypermobility of the first toe; and the fifth ray extension originates at the transverse metatarsal stabilization bar and extending to the mid portion of the fifth toe of the foot for compensation for lateral imbalance of said foot by establishing an effective amount of inward rotation of the foot for efficient forward thrust and preventing outward rotation of the foot and maximizing effective foot and body motion.

17. The foot support of claim **16** wherein said base mean is substantially stiff, but may be soft and flexible.

18. The foot support of claim **17**, wherein transverse metatarsal stabilization bar, the fifth ray extension and first ray extension may be stiff or soft and flexible with a depth of 1/16 to 1/8 inch in thickness.

19. The foot support of claim **17** wherein said transverse metatarsal stabilization bar, first and fifth ray extension are resilient for maximizing the effective forward thrust provided by the bending and unbending of the toes of the foot during walking and running.

20. The foot support of claim **19** wherein said foot support is a shoe insert for a shoe, or build into a shoe.

21. The foot support of claim **15** wherein said transverse metatarsal stabilization bar is the width from the anterior portion of the midfoot post where in turn it originates at the first ray means where it begins, and extends to the midportion of the first toe of the foot and has a width which is approximately the width of the first toe of the foot and the fifth ray extension extends to about the midportion of the fifth toe of the foot and has a width which is approximately the width of the fifth toe of the foot.

22. The foot support of claim **21** wherein the transverse metatarsal stabilization bar is a separate element that extends forward in the midfoot proximal from the heel post, and where the origination of the first ray extension is a separate element that extends forward to the midportion of the first toe of the foot.

23. The foot support of claim **4**, where in the transverse stabilization bar, the first and fifth ray extension are made from the same material.

24. The foot support of claim **22** where in the transverse metatarsal stabilization bar, first ray extension and fifth ray extension form a single, integral unit.

25. The foot support of claim **20** wherein said foot support is a shoe insert, or build into a shoe.

26-27. (canceled)

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