US 20130205619A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2013/0205619 A1

(43) Pub. Date: Aug. 15, 2013

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(54) **DYNAMIC FOOTWEAR THAT ALIGNS THE BODY AND ABSORBS THE IMPACT**

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(21) Appl. No.: **13/767,502**

(22) Filed: **Feb. 14, 2013**

(30) **Foreign Application Priority Data**

Feb. 15, 2012 (GB) GB1202605.0

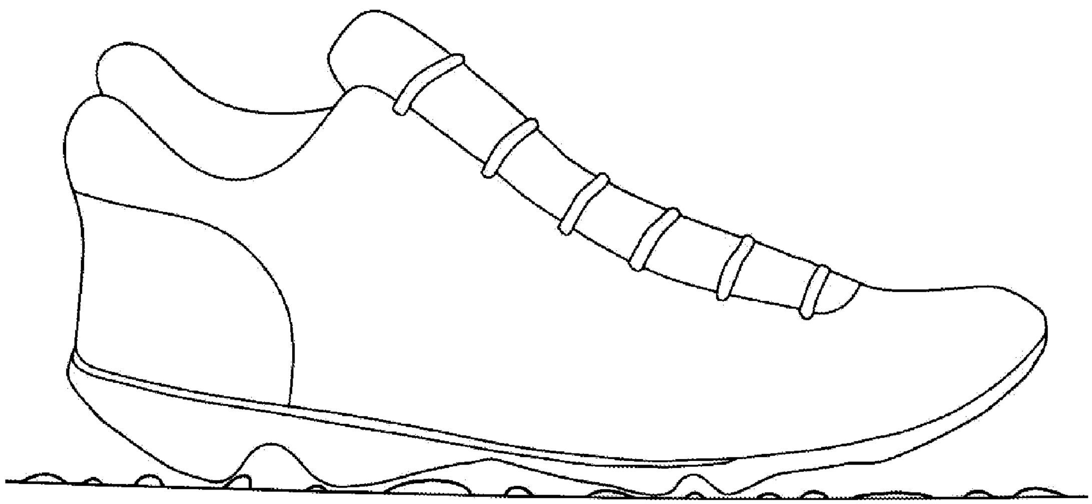
Publication Classification

(51) **Int. Cl.**
A43B 7/14 (2006.01)

(52) **U.S. Cl.**
CPC *A43B 7/14* (2013.01)
USPC **36/91**

(57) **ABSTRACT**

An article of footwear is disclosed. According to the present invention there is provided a light-weight shoe having a sole with a hard upper section in the form of a plate with high rigidity at the lateral part, and a highly compressible lower section. Due to the soft materials used in the lower section, and due to the recesses and grooves at the ground facing side, the total average density between the hard upper section and the ground is very low. Due to the specific location of the plate and the recesses the shoe facilitates optimal body alignment in standing, walking and running.



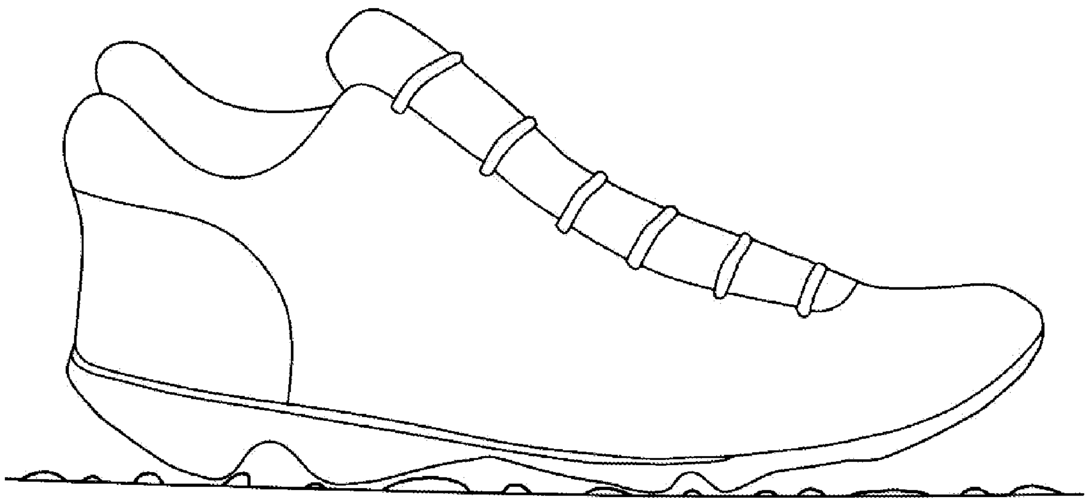


FIG .1

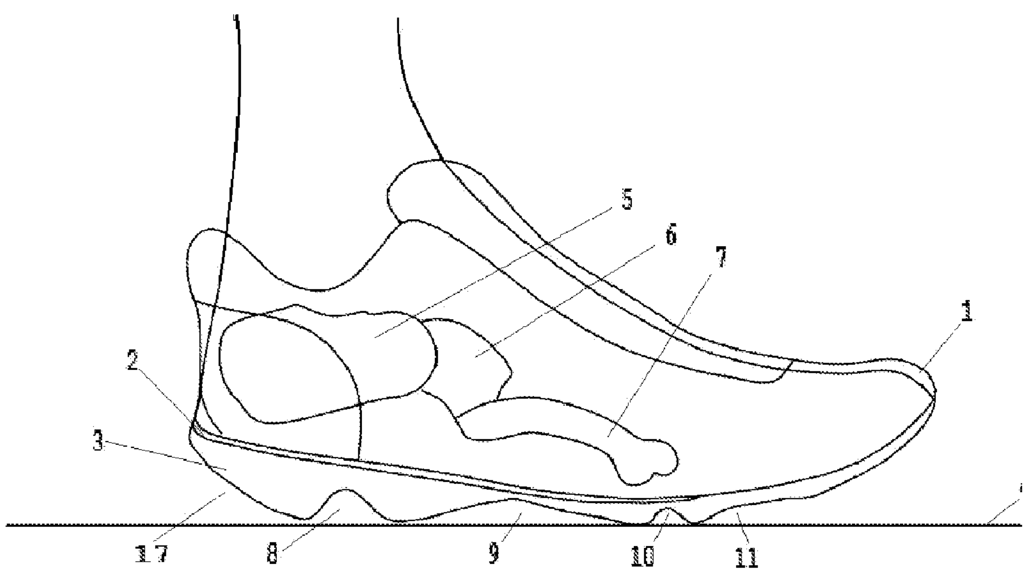


FIG . 2

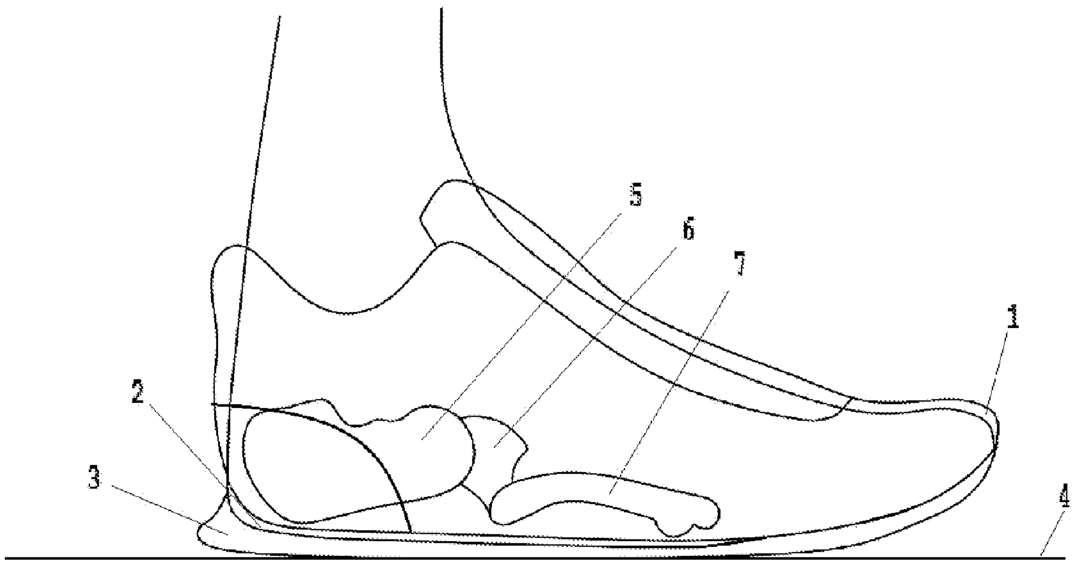


FIG . 3

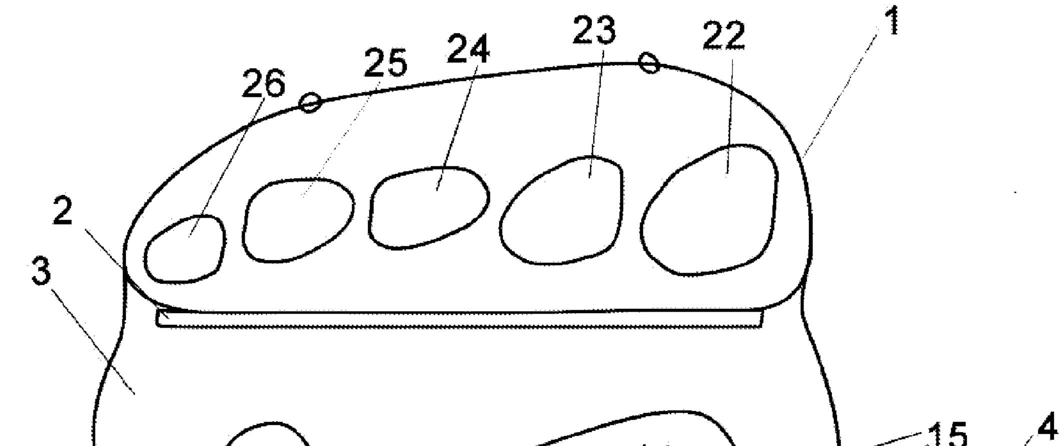


FIG . 4

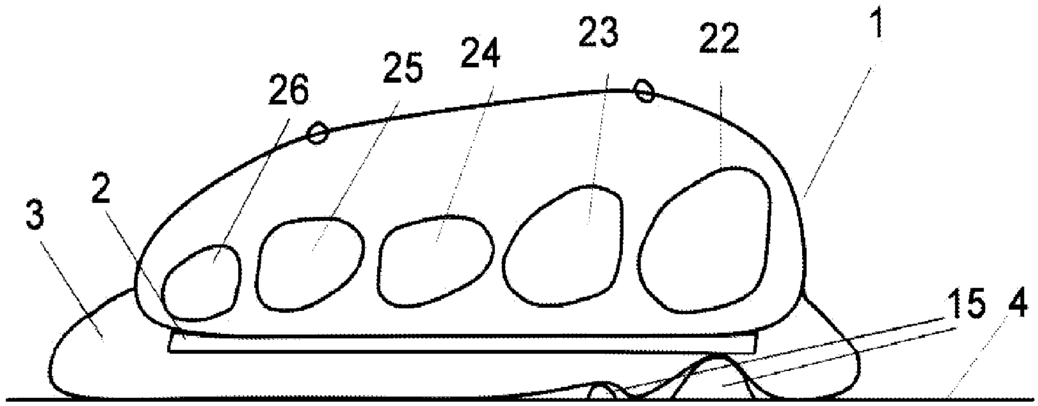


FIG . 5

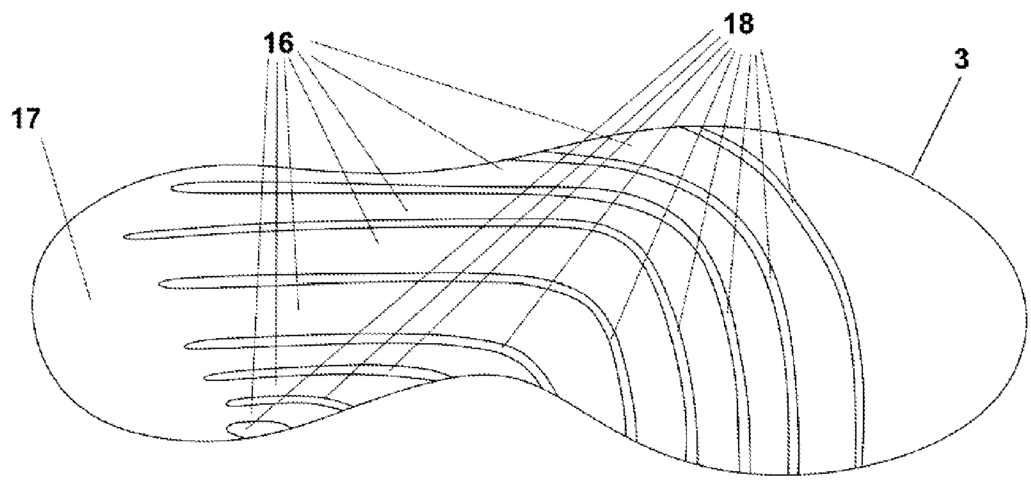


FIG . 6

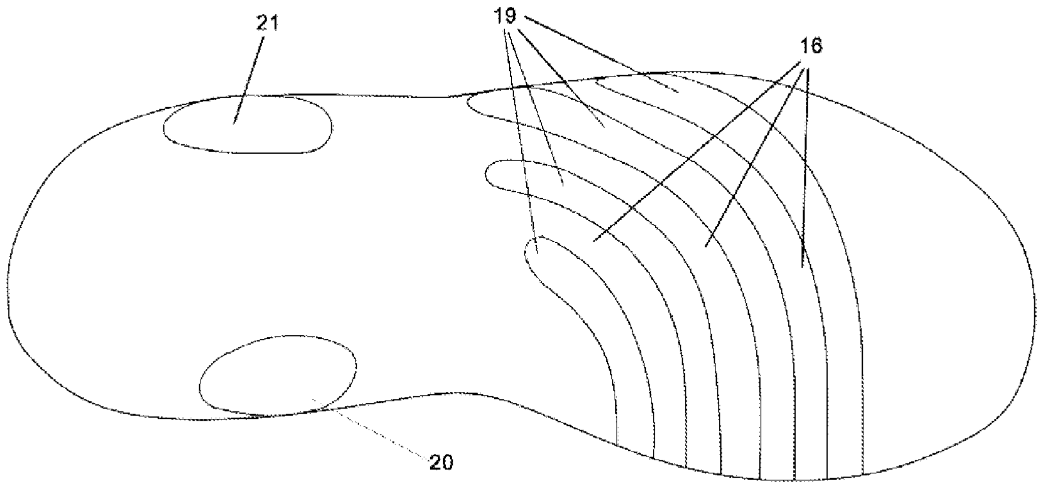


FIG. 7

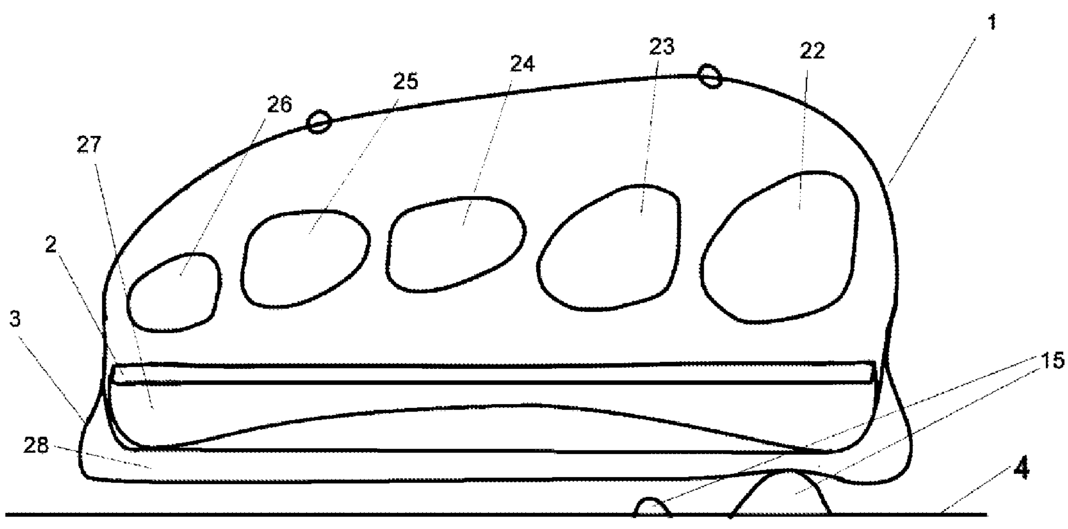


FIG. 8

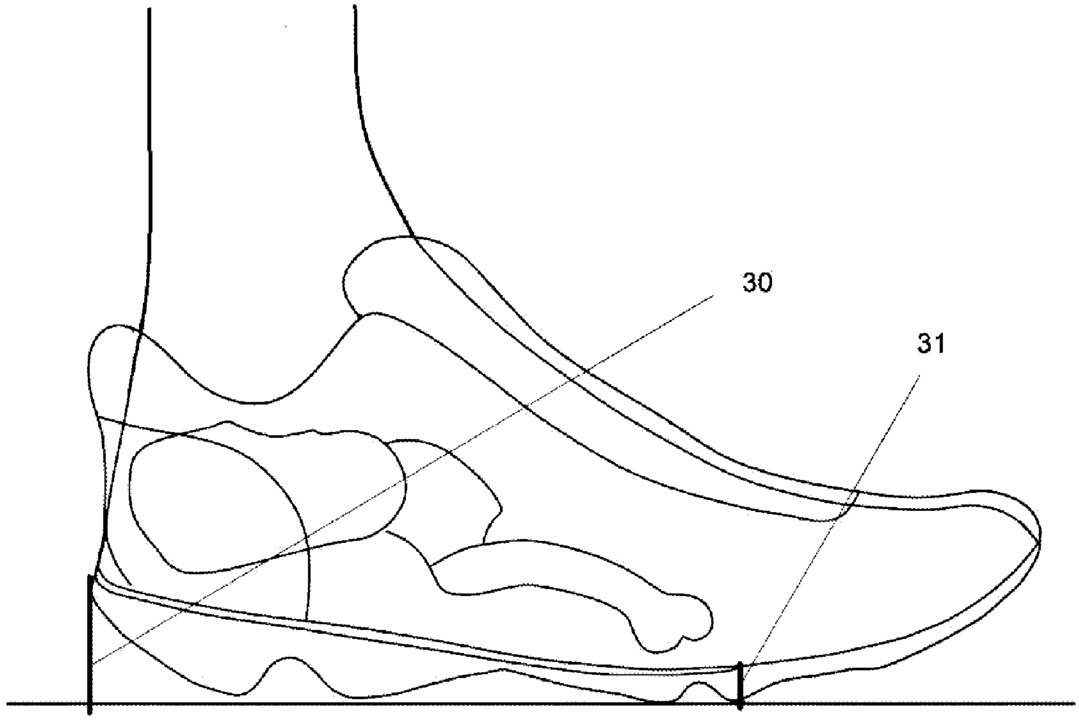


FIG. 9

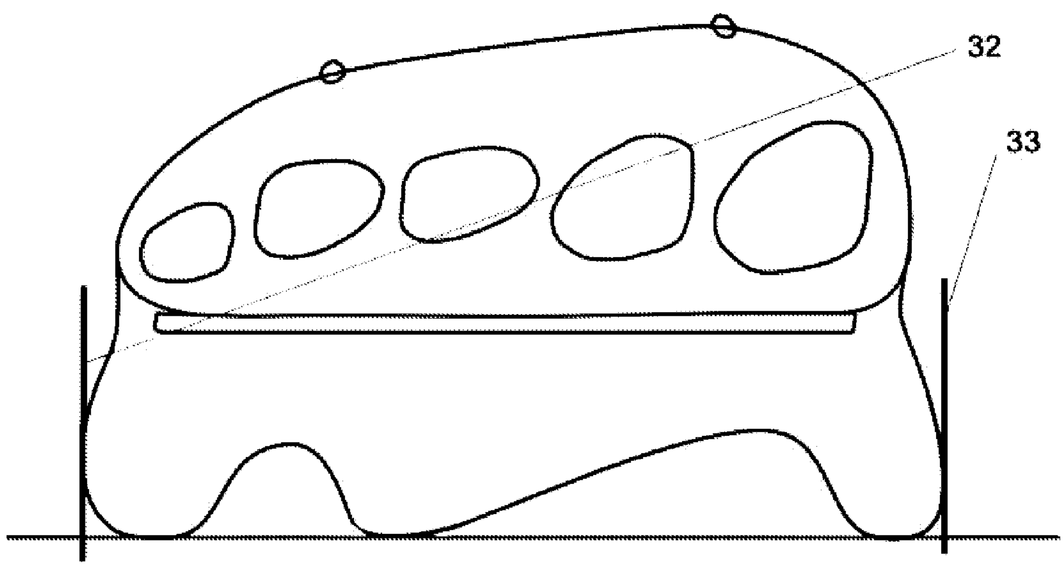


FIG. 10

DYNAMIC FOOTWEAR THAT ALIGNS THE BODY AND ABSORBS THE IMPACT

BACKGROUND

[0001] The present invention relates to a sole as part of footwear to stand in and to use for activities which involve brisk walking, running and jumping.

[0002] Walking and running on hard roads and uneven and potentially slippery ground requires a shoe sole which protects the sole of the foot. This shoe sole needs to protect the body against sliding and against sudden or frequently repeated high impact forces on the body, as well as against acute sharp indenting into the foot sole. The shoe sole needs to be lightweight and must not hinder the normal and natural movement of the feet, ankles, knees and hips.

[0003] When running or jumping, at the time that the foot comes into contact with the ground, the human body experiences a sudden increase in vertical ground reaction force, commonly termed shock or impact loading. The repeated application of such loads to the human body during running or jumping activities can contribute to musculoskeletal injuries. The repeated high loads can cause the breakdown of components of the musculoskeletal systems: joints, ligaments, tendons, muscles and bones.

[0004] When standing the human body needs subtle muscle responses to stay upright and maintain a good posture. Failure of such subtle muscle responses leads to a loss of balance or the adoption of a posture which puts undue strain on the body. A loss of balance can lead to falls and subsequent injuries such as bone fractures. A poor posture contributes to musculoskeletal injuries and the development of osteoarthritis. During walking activities, excessive sideway twists on the foot can overstrain the body tissues of the legs. Injuries to body joints, ligaments, muscles, tendons and bones can be caused by sudden high forces on these structures, and also by frequently repeated medium forces on a particular body structure.

[0005] To prevent such excessive strain and therefore injury, the leg muscles stabilise the foot, ankle, knee, hip and spine joints during standing and walking. For example the calf muscles, the quadriceps, the gluteal muscles and some of the spinal muscles ensure that the body is extended and maintain an erect position. These muscles prevent the ankles, knees, hips and spine from flexing and the body from slumping. The effectiveness of the leg muscles in terms of control, speed and strength is highly dependent on the information they receive through the brain and the spinal cord. This information is generated by the sensory organs situated in the muscles, ligaments and skin of the leg when it comes into contact with the ground. Through a feedback and a feed forward system the right muscles generate the right tension at the right time to prevent excessive sideway twist and excessive shock on the body. The body's perception of these signals, which is called propriocepsis, can be provoked, but can also be reduced by footwear, depending on the construction of the shoes.

[0006] Both conventional protective footwear and minimalist footwear are a compromise for the wearer. The protective features of providing stability to the foot and ankle such as hard sole layers impede the natural roll of the foot during walking, running and jumping. In footwear with a plate as a top layer of the sole such as EP 10257770 by Adidas International B.V. the rigidity is not at the lateral part of the plate, where it would guide a natural roll of the foot. The features to provide shock absorption such as soft heels as in US 2010/032594 by Nike Inc. and EP 1240838 by Adidas International B.V. reduce the stability and encourage an unnatural heavy heel strike and therefore reduce the wearer's ability to maintain the body in a functional alignment.

[0007] A continuously soft shoe sole, such as various fashionable running shoes worn over the last 35 years, can reduce the sensory information the wearer receives, and therefore impede the reflexive feedback and feed forward system to optimise the functional activities. Footwear can give the wearer a broader base in standing and walking. A broader base can also discourage the muscles to work and encourage the wearer to adopt a slumped posture. The foot is longer than it is wide. When a person steps, the base of support in the medial-lateral direction is small and therefore the balance in this direction is precarious. Because of the length of the foot and the shoe sole the human body is more stable in the anterior-posterior direction. In a conventional shoe the base of support in the anterior-posterior direction is greater than in barefoot, which encourages the wearer to lean all its weight on the heels with the knees hyper-extended and the hips and spine flexed.

[0008] During walking, running and jumping activities, the shock on the body is reduced when the time between the outer sole of the shoe contacting the ground and the calcaneus (heel bone) coming to a standstill is increased. In conventional sports shoes and in those in patent EP 0458174 by Slaats et al, in patent WO 03/088777 by Louis Benoit and in patent EP 1002473 by Alberto Caberlotto, this time is quite brief as the sole part that is situated between the calcaneus and the ground is typically of limited thickness, continuous and made of medium and high density materials. The weight of such soles can impede the running action of the wearer. The sole materials are typically made out of visco-elastic materials. Therefore, during walking, running and jumping, such shoe soles will attenuate energy, which will not return to the body to be used to push the person upwards and forwards.

[0009] During walking and running activities in conventional shoes with a solid sole the wearer could inadvertently step on a stone and twist the foot and ankle. The continuous nature of the sole made from medium or high density material does not allow for the stone to move into the sole. The collision between the moving human body and the hard ground and stone can result in a sudden high increase in lateral ground reaction force on the body. This twisting force can cause a strain injury on the wearer of the conventional shoe with a solid sole. Because of the high compressibility of the sole, the present invention provides more stability for the human body compared to previous inventions of footwear with shock absorption.

[0010] When walking and running on slippery ground in footwear without its gaps and grooves being situated between the shoe and the ground, such as in U.S. Pat. No. 5,461,800 by Adidas AG, and in U.S. Pat. No. 7,941,939 by Nike Inc., the shoe sole could easily slide across the ground with as a result a loss of balance by the wearer.

BRIEF DESCRIPTION

[0011] To promote a good alignment of the human body and to reduce these injury risks, the present invention proposes a sole, which is the bottom part of footwear, and which has two sections with the upper section being hard and situated between the foot of the wearer and with the bottom section being highly compressible and situated between the upper section and the ground.

[0012] The upper section is a hard plate, which supports the weight bearing bone structures of the foot: one or more of the metatarsal heads and the calcaneus. When the shoe is used, the area of the plate between directly underneath the tuber calcanei (posterior half of the heel bone) and directly underneath the fifth metatarsal head has a high rigidity. This rigidity is substantially higher than in the area between directly underneath the tuber calcanei and directly underneath the first metatarsal head. With these characteristics the natural movement of the rolling in of the foot is not impeded. Previous inventions of shoes with plate like structures in the sole, for example RYN footwear and U.S. Pat. No. 6,341,432 by Muller, do not have the differential rigidity in the plate and do not have the gaps and elastic response as the present invention has.

[0013] The bottom section of the present invention is highly compliant to the weight and movement of the wearer of the footwear, and also to the various characteristics of the ground surface. Compared to conventional footwear this bottom section is highly compressible due to the lower density of the material and due to the gaps situated at the ground facing side. There are multiple and various recesses between the ground and the sole, which reduce in size when the wearer applies the full body weight on to the part of the plate, which is situated above the particular gap or gaps. Therefore a shoe sole constructed in the manner described above provides improved impact cushioning to the body as the calcaneus and the metatarsal bones are decelerated over a longer distance.

[0014] Further features of the invention are described in relation to embodiments of the present invention described with reference to the accompanying drawings in which:

[0015] FIG. **1** shows a side view of a shoe with a shoe sole according to an embodiment of the present invention;

[0016] FIG. **2** shows a partial cutaway view of the shoe of FIG. **1** including the outline of a wearer's foot and selected bones of the wearer's foot;

[0017] FIG. **3** shows a similar view of the shoe and wearer's foot to FIG. **2** with the mid sole compressed;

[0018] FIG. **4** shows a cross-section of the shoe and the metatarsal bones of the wearer's foot of FIG. **2** at the level of the metatarsal heads

[0019] FIG. **5** shows a cross-section of the shoe and the metatarsal bones of the wearer's foot of FIG. **2** at the level of the metatarsal heads with the sole compressed;

[0020] FIG. **6** shows a bottom view of shoe sole constructed according to an alternative embodiment of the present invention.

[0021] FIG. **7** shows a bottom view of the shoe sole constructed according to another alternative embodiment of the present invention.

[0022] FIG. **8** shows a cross-section of the shoe and the metatarsal bones of the wearer's foot according to an alternative embodiment of the present invention.

[0023] FIG. **9** shows a partial cutaway view of the shoe of FIG. **2** with two perimeters of the area which are used to measure the density of the compressible section of various embodiments of the present invention.

[0024] FIG. **10** shows a cross-section of the shoe of FIG. **4** with the shoe resting on the ground in an uncompressed state, with two further perimeters of the area which is used to measure the density of the compressible section of various embodiments of the present invention.

DETAILED DESCRIPTION

[0025] According to various embodiments of the present invention the sole arrangement has no ground engagement straight underneath and behind the tuber calcanei (the rear part of the heel bone), when the user does not put more than 40% of his/her body weight on the shoe. In use, when the body weight impacts on the rear of the sole, the gap between the wearer's heel bone and the ground greatly reduces. In standing this downwards movement of the heel bone and the backward tilt of the rigid sole portion results in a subtle stretch on the bodies' extensor muscles. This provokes the stretch shortening cycle, which is an important aspect of human movement control. Such muscle responses give the body balance and an upright posture.

[0026] In various embodiments of the present invention the high compressibility of the bottom sole section is achieved through a combination of the compressible materials used, and the various gaps between the sole and the ground. The resulting average density between the hard plate and the ground is less than 250 kg/m^3 when the sole rests on the ground and is in an uncompressed state. This can be accurately measured using the outer perimeters of the sole as described in FIG. **9** and FIG. **10**.

[0027] Therefore the present invention provides improved shock attenuation and energy return for walking, running and jumping with less shoe sole weight. In conventional sport shoes such as patented by Nike Inc. (US 2012/0023781) and Hoffer (US 2005/0217150) and shoe patents such as by Krueger (DE 29818243U) the compressible sole section together with the grooves and recesses between the sole and the ground do not have as low a density as the present invention. Footwear that incorporate these concepts, without a hard upper section, would not give enough protection to the foot if the average density of the compressible area between the upper layer of the sole and the ground would have an average density below 250 kg/m^3.

[0028] In one embodiment of the present invention FIG. **2** and FIG. **3** represent a longitudinal cross section of a shoe **1** with a shoe sole with the upper section **2** attached to bottom section **3** situated below the calcaneus **5**, cuboid bone **6** and fifth metatarsal bone **7** of the wearer of the shoe, which rests on the ground surface **4**. Gaps **8**, **9**, **10** and **11** and heel-less recess **17** are situated between bottom section **3** and the ground **4**. FIG. **2** represents the embodiment when the wearer applies less than 10% of the bodyweight on to the sole of the shoe and the ground. FIG. **3** represents the same embodiment when the wearer applies all his/her bodyweight on to the sole and impacts on to the ground. The downward force, which has been applied on the sole by the wearer, has closed down the gaps.

[0029] The bottom section is of lower weight and has greater gaps and recesses than functional footwear that is worn for protection and for performance such as running speed. Without a plate situated on top of a low density sole, the very soft sole part would bottom out during running and jumping and would not give sufficient protection from stepping on various stones and glass. The upper section of the present invention provides Sole Force Distribution which is a mechanism that spreads the load across the low density sole part below the plate. As a result the resistance to high vertical ground reaction forces is much greater per ratio of sole weight.

[0030] Various previous inventions with gaps in the outer soles do not close down as much at a given downwards force as the present invention because of the higher density of the sole as compared to the present invention. Other patented footwear with gaps and grooves at the bottom of the sole, such as US 2008/0289224 by K-Swiss Inc., US 2005/0252038 and US 2008/0209766 both by Braunschweller, do not have a plate as in the present invention. Therefore the average density of the compressible part of these sole designs needs to be higher to give the wearer sufficient stability and to give enough protection from stepping on stones. Such shoe concepts do not protect the body as well due to different sole shapes and different materials.

[0031] The compressible section of the present invention is made out of a material which is elastic, e.g. a polyurethane compound. Therefore, the gap will increase in size as soon as the downwards force, which impacts on the area straight above the gap, reduces. The shoe sole will then return a proportion of the absorbed energy back to the user for upward and forward movement with the sole functioning as a spring.

[0032] The footwear facilitates automatic muscle responses which align the body. These muscle activities give the body a good alignment with which it can function better with less strain on the body.

[0033] When the wearer walks, runs or jumps whilst wearing a shoe with a sole constructed in the manner described and inadvertently steps on a stone, the stone will protrude into the compressible bottom section. Therefore, unlike shoe soles with a less compressible bottom section, stepping on stones is less likely to lead to excessive twisting forces which result in injury.

[0034] In various embodiments of the present invention less than 30% of the bottom surface area is ground engaged or within 3 mm distance of the ground, when the wearer applies less than 50 Newton of force from his body weight on to the sole. Because of the shape of the bottom section and the compliance of the compound that the bottom section is made out of, the multiple and various gaps between the ground and the sole close up. This takes place when the wearer applies the body weight on to the part of the plate, which is situated above the single or multiple gaps. In various embodiments of the present invention the gap directly below the tuber calcanei only fully closes up when the user applies more than 700 Newton of force on to the calcaneus of the weight bearing leg.

[0035] In alternative embodiments of the present invention the compressible bottom section has various projections or grooves which constitute spaces of various shapes, and which close down when sufficient downwards force is applied by the wearer, as is presented in FIG. **3**.

[0036] In one alternative embodiment of the present invention FIG. **4** and FIG. **5** represent a transverse cross section of a shoe **1** with shoe sole with the upper section **2** attached to bottom section **3** as in the area of the metatarsal heads **22**, **23**, **24**, **25** and **26** of the wearer of the shoe. Gaps **13** and **14** are situated between bottom section **3** and the ground surface **4** with stones **15**.

[0037] FIG. **4** represents the embodiment when the wearer's foot and shoe has not yet fully reached the ground surface **4** during a dynamic activity such as running. FIG. **5** represents the same embodiment when the wearer applies all his/her bodyweight on to the sole whilst impacting on to the ground. The downward force which has been applied on the sole by the wearer has closed down the gaps. The stones **15** have protruded into the compressible section and have not caused a twisting force for the wearer.

[0038] In various embodiments of the present invention the upper section **2** is made of natural fibre or carbon fibre reinforced composite, such as polypropylene, with a Shore A hardness being greater than 80. In one such embodiment the Shore A hardness is between 80 and 90. In another such embodiment the Shore A hardness is 85 and 95. In yet another such embodiment the Shore A hardness is between 90 and 100.

[0039] In various embodiments of the present invention the bottom section **3** is preferably made of a highly elastic material, such as natural rubber, that may itself not compress, but moves laterally and medially when the wearer applies sufficient downward and sideways force, as shown in FIG. **5**. In this way the lateral and medial protrusion of the material provides a stabilising effect on the foot and therefore reduces sudden sideways forces. This can prevent injuries such as ankle strains.

[0040] The compressible bottom section **3** in FIGS. **1-10** is ground engaging and as such may be configured appropriately to impart the required grip properties with the ground **4**. Typically, the bottom section may be textured and is provided with projections or grooves of various shapes and sizes. Therefore there are multiple and various gaps between the compressible section **3** and the ground **4**. Section **3** together with the gaps and grooves between section **3** and the ground **4** may be configured with any average density of between 20 kg/m^3 and 250 kg/m^3.

[0041] To establish good functional characteristics as well as the novelty of the present invention, the area over which the average density is measured is defined as the area between the ground, the upper section **2**, the perimeters **30** and **31** of FIG. **9** and the perimeters **32** and **33** of FIG. **10**. This average density is measured with the shoe sole in an uncompressed state. In various embodiments of the present invention the average density in this area is between 20 kg/m^3 and 250 kg/m^3.

[0042] In one such embodiment the average density in this area is between 180 kg/m^3 and 250 kg/m^3. In another such embodiment the average density in this area is between 100 kg/m^3 and 200 kg/m^3. In yet another such embodiment the average density in this area is between 80 kg/m^3 and 150 kg/m^3. In yet another embodiment the average density in this area is between 20 kg/m^3 and 100 kg/m^3.

[0043] In another alternative embodiment of the present invention FIG. **6** represents a bottom view of the bottom section **3** with grooves **16**, heel-less recess **17** and projections **18**. This example of the present invention has 9 projections which are situated within 3 mm of the ground when the shoe rests on the ground when less than 10% of the body weight of the wearer is applied on the shoe. The projections run from lateral at the level of the calcaneus to medial at the area of the metatarsal heads followed on towards lateral at the area of the toes. This follows the natural path of the centre of pressure of the human body on the ground when walking and running. There is provided a recess, which in use, is situated below the posterior half of the heel bone: the tuber calcanei, and to the medial and lateral and rear of this part of the sole. This recess **17**, named heel-less recess, has extended more anteriorly at the medial side than at the lateral side because the projections at the lateral side are more extended to the rear than at the medial side. In this way the wearer is particularly discouraged to put the force of their body weight on to the medial rear corner of the foot. Therefore the sole induces a more natural walking and running movement which are steps without forceful heel strikes and without excessive pronation of the ankle and foot.

[0044] In yet another alternative embodiment of the present invention FIG. **7** represents a bottom view of the bottom section **3** with grooves **16** and projections **19**, **20** and **21**. This example of the present invention has 6 projections, which are situated within 3 mm of the ground when the shoe rests on the ground when less than 10% of the body weight of the wearer is applied on to the shoe. The projections **19** run from rear lateral to medial anterior following the natural path of the centre of pressure of the human body on the ground when walking and running. Projection **20** serves as a medial stabiliser to prevent excessive pronation movement of the ankle and foot. Projection **21** serves as a lateral stabiliser to prevent excessive supination movement of the ankle and foot. Projection **20** and **21** may be made of a different material, such as solid natural rubber to ensure more durability of the sole.

[0045] In a further alternative embodiment of the present invention FIG. **8** represents a transverse cross section of a shoe **1** with shoe sole with the upper section **2** attached to bottom section **3** as in the area of the metatarsal heads **22**, **23**, **24**, **25** and **26** of the wearer of the shoe. The upper section **2** constitutes a hard layer of a shoe insole. The bottom section **3** is compressible and contains 2 parts: the compressible bottom layer **27** of the insole, and the compressible outer sole **28** of a shoe **1**. When the full weight of the body impacts on to the metatarsals of the foot the compressible layer of the insole, the outer sole and the gap between these two parts reduce greatly in volume. The weight of the body affects a greater change in density between the top layer of the sole and the ground than with other patented footwear. Therefore the shock absorption of the proposed sole unit will be greater.

[0046] Embodiments of the present invention may have any number and shapes of projections and grooves in the bottom section at any location of the sole, provided the sole functions as is described above.

1. Footwear with a sole that has two sections:
an upper section being a plate with a Shore A hardness greater than 85, that is situated directly under the metatarsals, cuboid bone and calcaneus of the foot of the wearer, and that has high rigidity only in the area under the fifth metatarsal, cuboid bone and calcaneus and
a highly compressible lower section with gaps and recesses which together with the sole material have an average density of between 20 kg/m^2 and 250 kg/m^2.

2. Footwear as claimed in claim **1**:
in which less than 30% of the bottom surface area is ground engaged or within 3 mm distance of the ground, when the wearer applies less than 50 Newton of force from his body weight on to the sole, and
in which the gap directly below the tuber calcanei fully closes up only when the user applies more than 700 Newton of force on to the calcaneus of the weight bearing leg.

3. Footwear as claimed in claim **1** wherein projections at the bottom of the bottom section run from rear lateral to medial anterior following the natural path of the centre of pressure of the human body on the ground when walking and running.

4. Footwear as claimed in claim **1** wherein a recess in the bottom section is provided, which in use, is situated below the posterior half of the heel bone: the tuber calcanei, and to the medial and lateral and rear of this part of the sole and has extended more anteriorly at the medial side than at the lateral

5. Footwear as claimed in claim **1** wherein one of the projections of the bottom section is situated medially at the sole and, in use, anteriorly of the tuber calcanei acting as a medial stabiliser to prevent excessive pronation movement of the ankle and foot.

6. Footwear as claimed in claim **1** wherein one of the projections of the bottom section is situated laterally at the sole and, in use, anteriorly to the tuber calcanei and posterior to the metatarsal heads, acting as a lateral stabiliser to prevent excessive supination movement of the ankle and foot.

7. An insole to be fitted inside footwear with a sole that has two sections as claimed in claim **1**.

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