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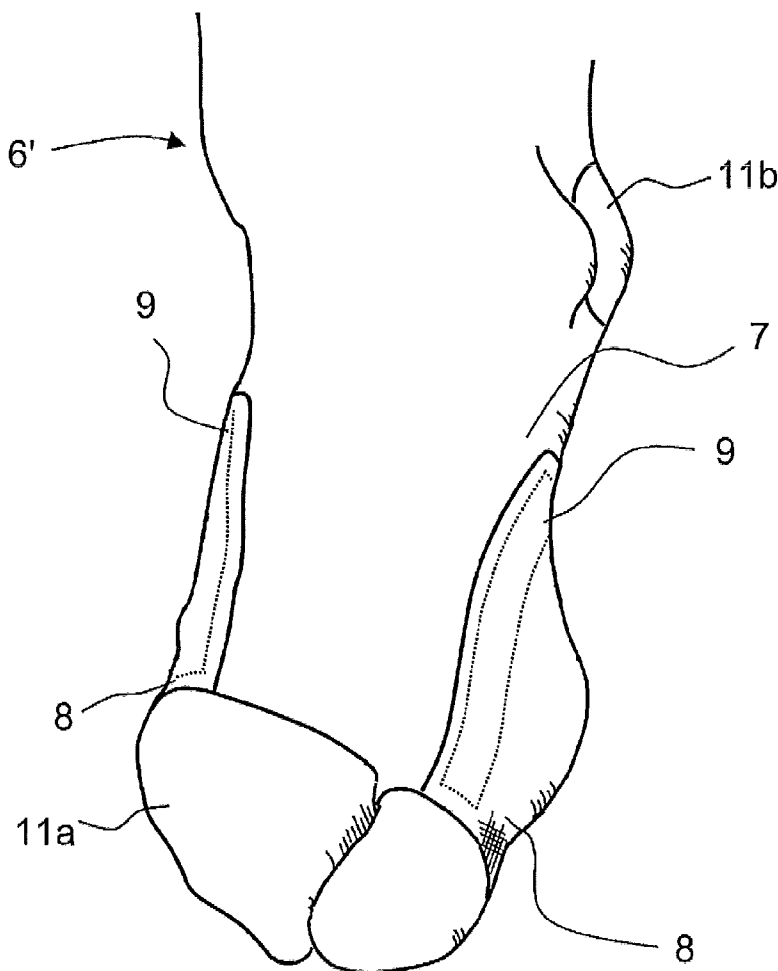
(19) **United States**(12) **Patent Application Publication**
Harada(10) **Pub. No.: US 2011/0088145 A1**(43) **Pub. Date: Apr. 21, 2011**(54) **SUPPORT STRUCTURE FOR PROPHYLAXIS
OR TREATMENT OF A DISORDER
ACCOMPANYING A FOOT DEFORMATION**(52) **U.S. Cl. 2/240**(76) **Inventor: Masanori Harada, Fukuoka-ken
(JP)**(21) **Appl. No.: 12/994,699**(22) **PCT Filed: Jan. 19, 2009**(86) **PCT No.: PCT/JP2009/050691**§ 371 (c)(1),
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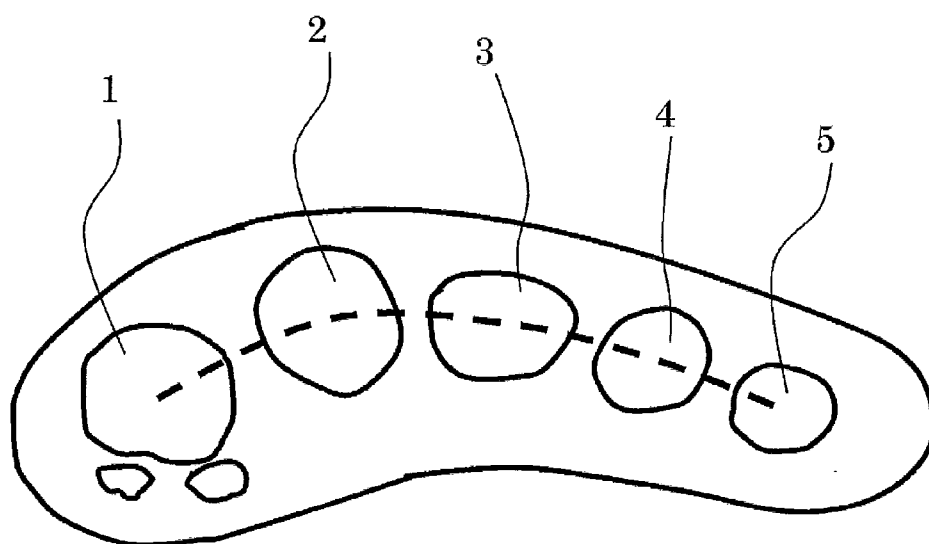
Publication Classification(51) **Int. Cl.**
A43B 17/00 (2006.01)(57) **ABSTRACT**

[Problems] To provide a supporter, socks or stockings which can maintain the transverse arch even under the user's weight, and enables comprehensive, effective prophylaxis and treatment of disorders accompanying foot deformation (e.g., splayfoot, hallux valgus and PTTD) without discomfort or pain.

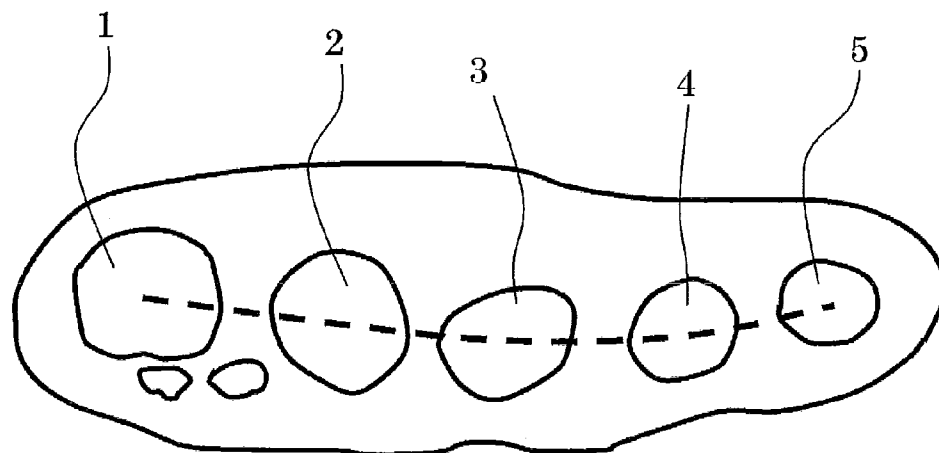
[Means to Solve the Problems] A support structure for prophylaxis or treatment of disorders accompanying a foot deformation, comprising an instep part, a sole part, and a pair(s) of slip-proof means for gripping the sides of the forefoot, wherein: the instep and sole parts are connected together to form a cylindrical structure such that the borders between the parts are aligned with the sides of the forefoot; the slip-proof means are attached to the inner surface of the cylindrical structure at portions thereof to be contacted with the sides of the forefoot; and the instep part exhibits a larger elongation than the sole part in the widthwise direction of the foot.



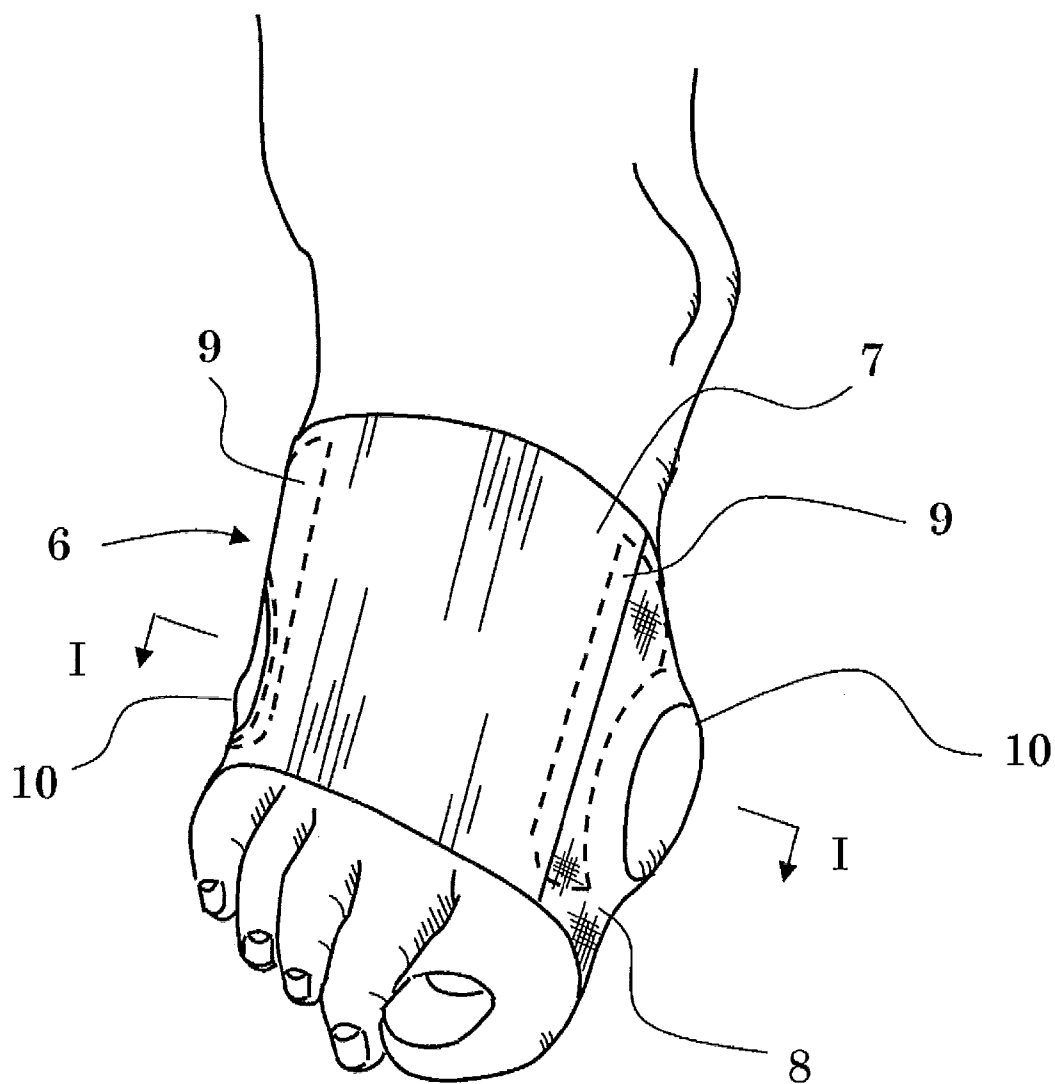
[Fig. 1a]



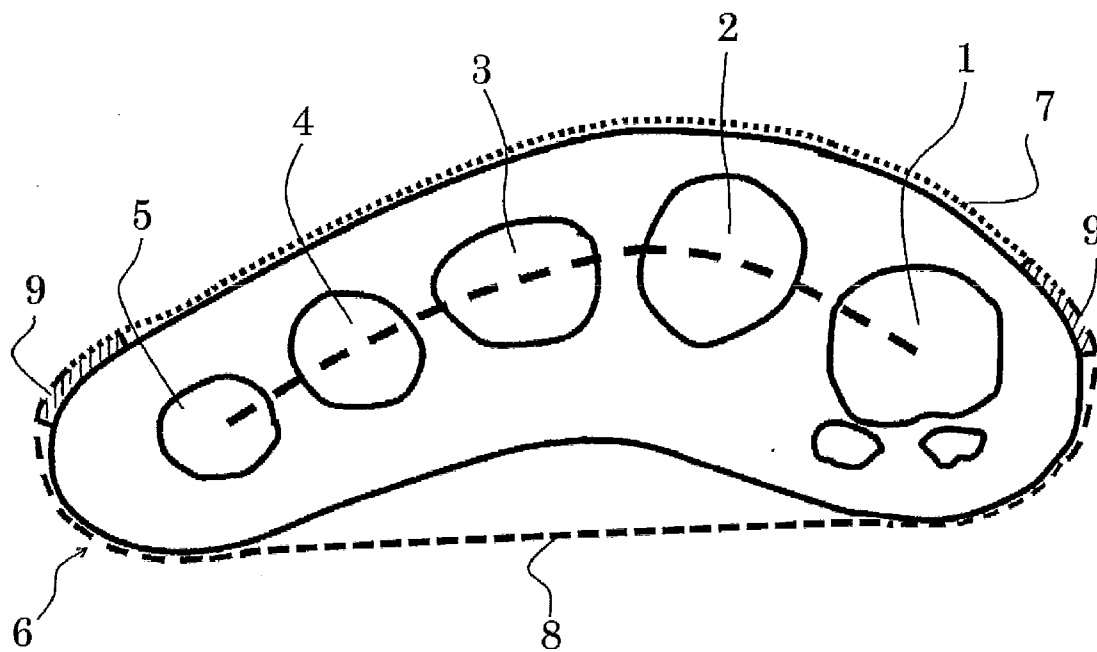
[Fig. 1b]



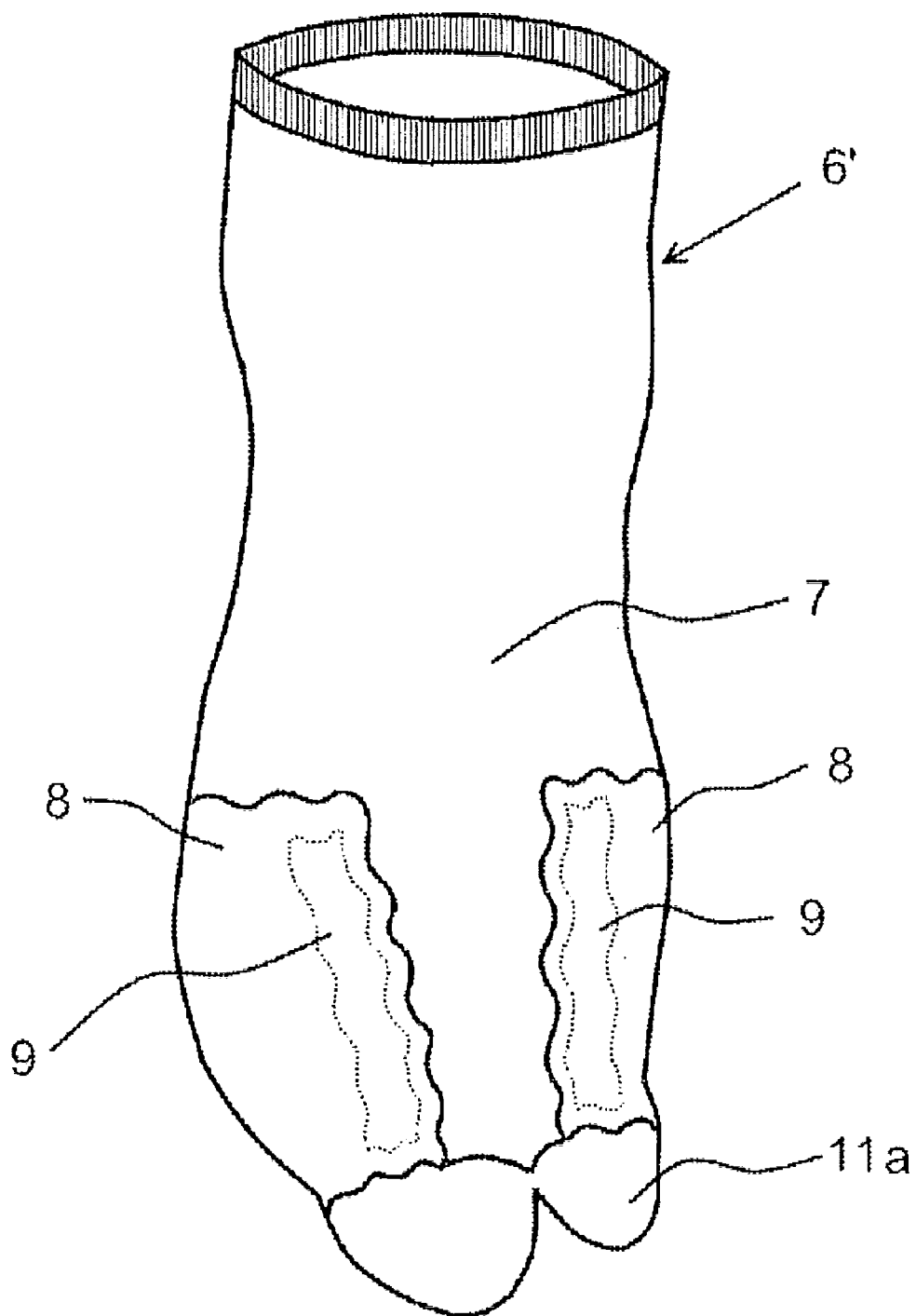
[Fig. 2]



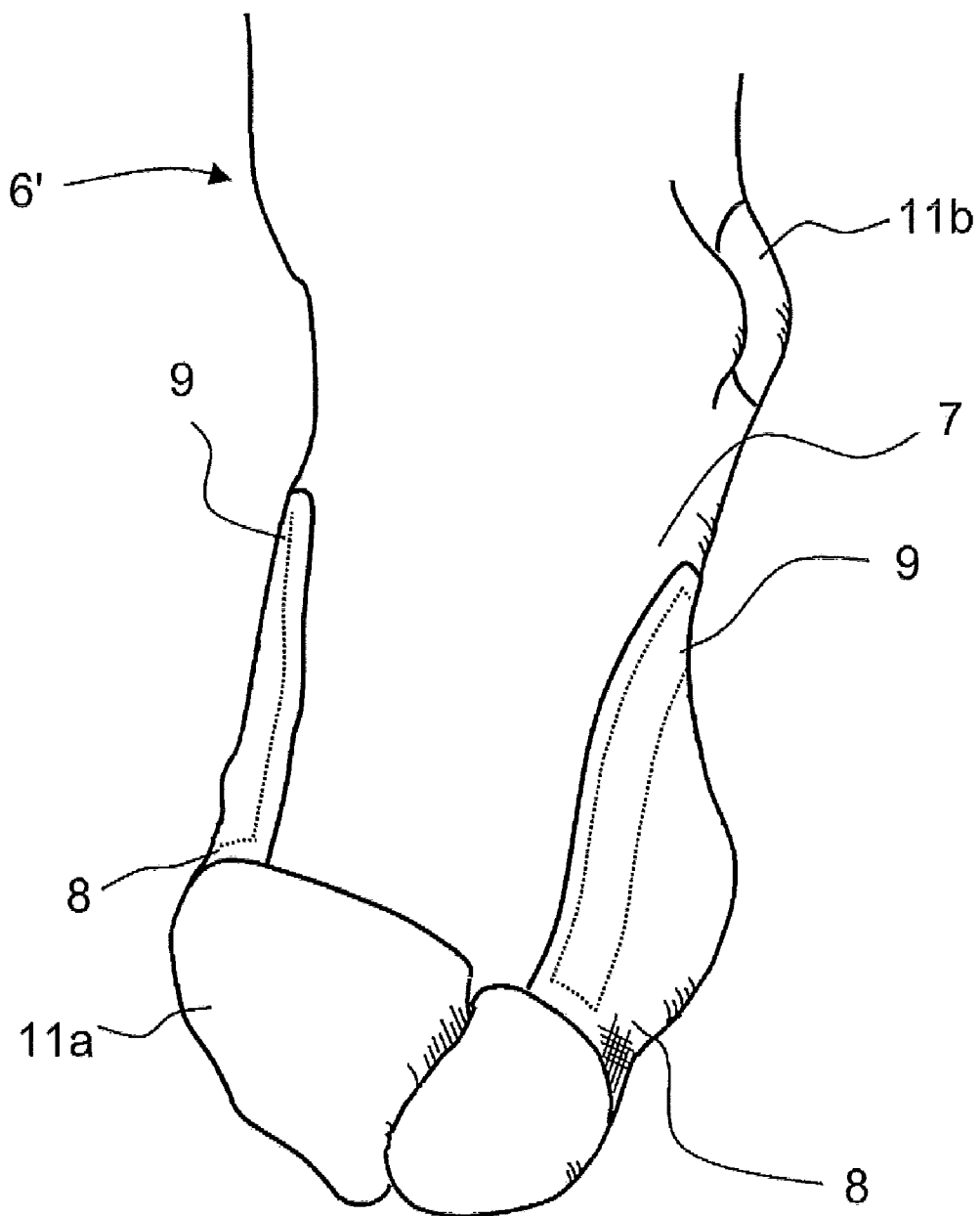
[Fig. 3]



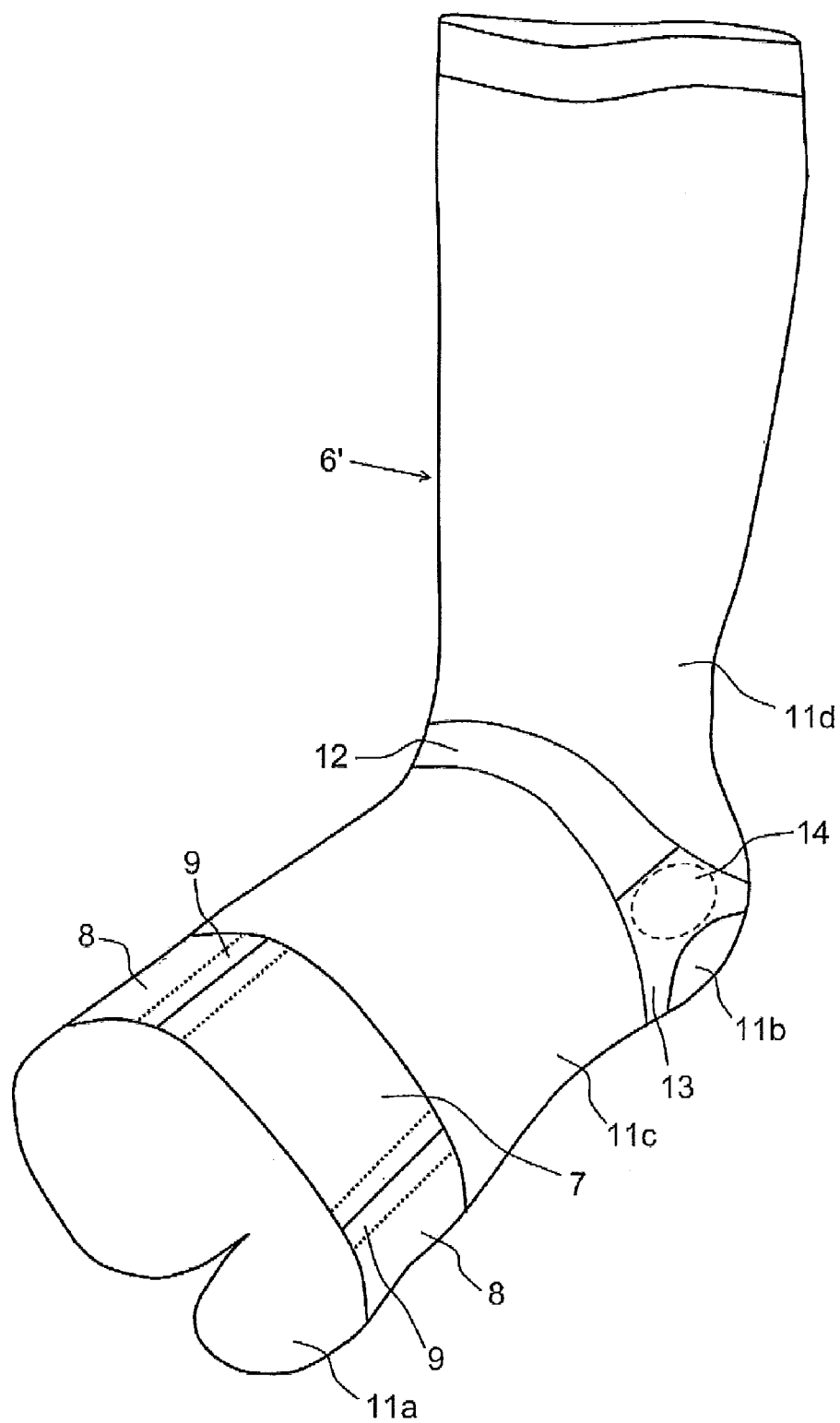
[Fig. 4]



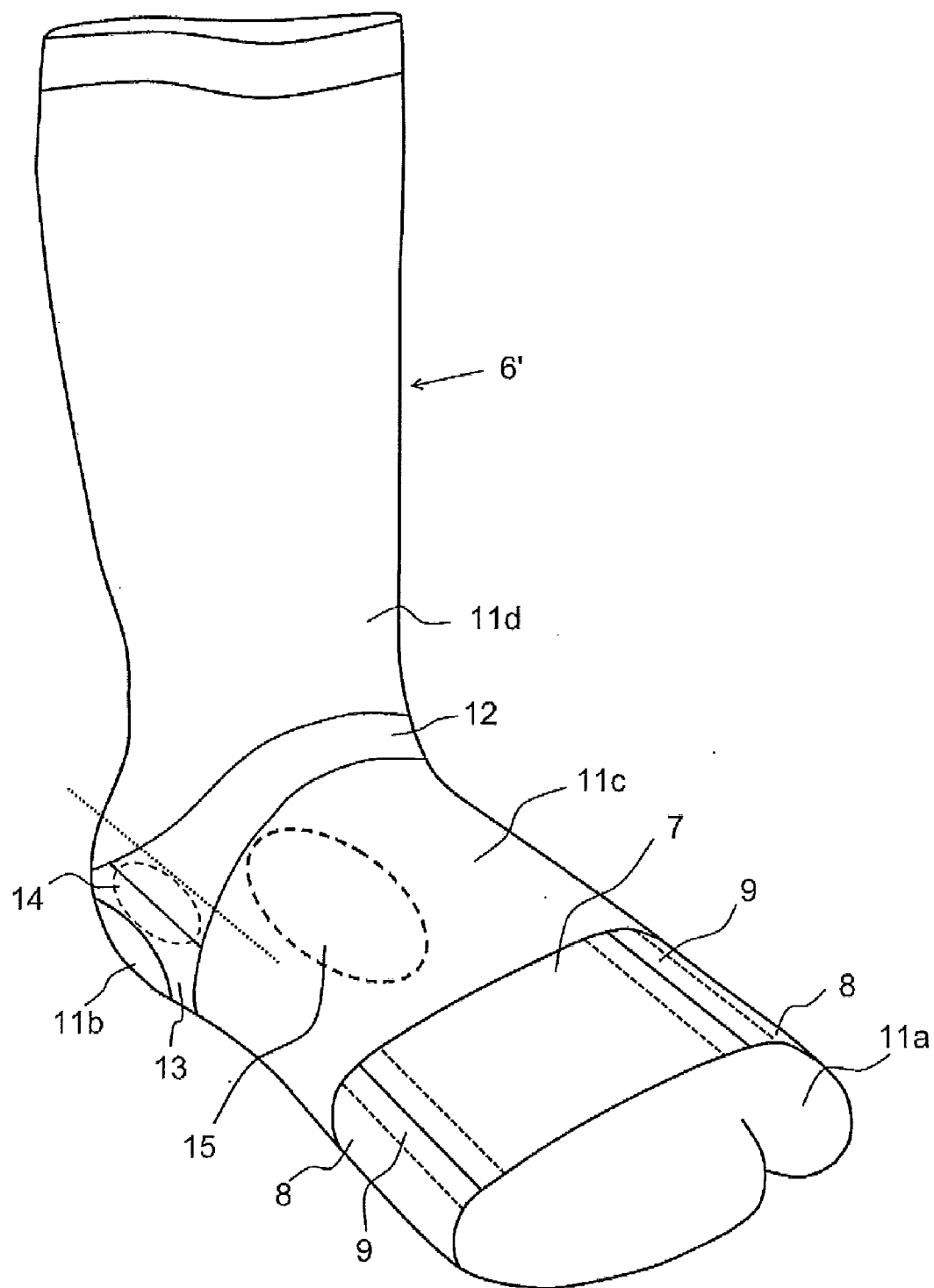
[Fig. 5]



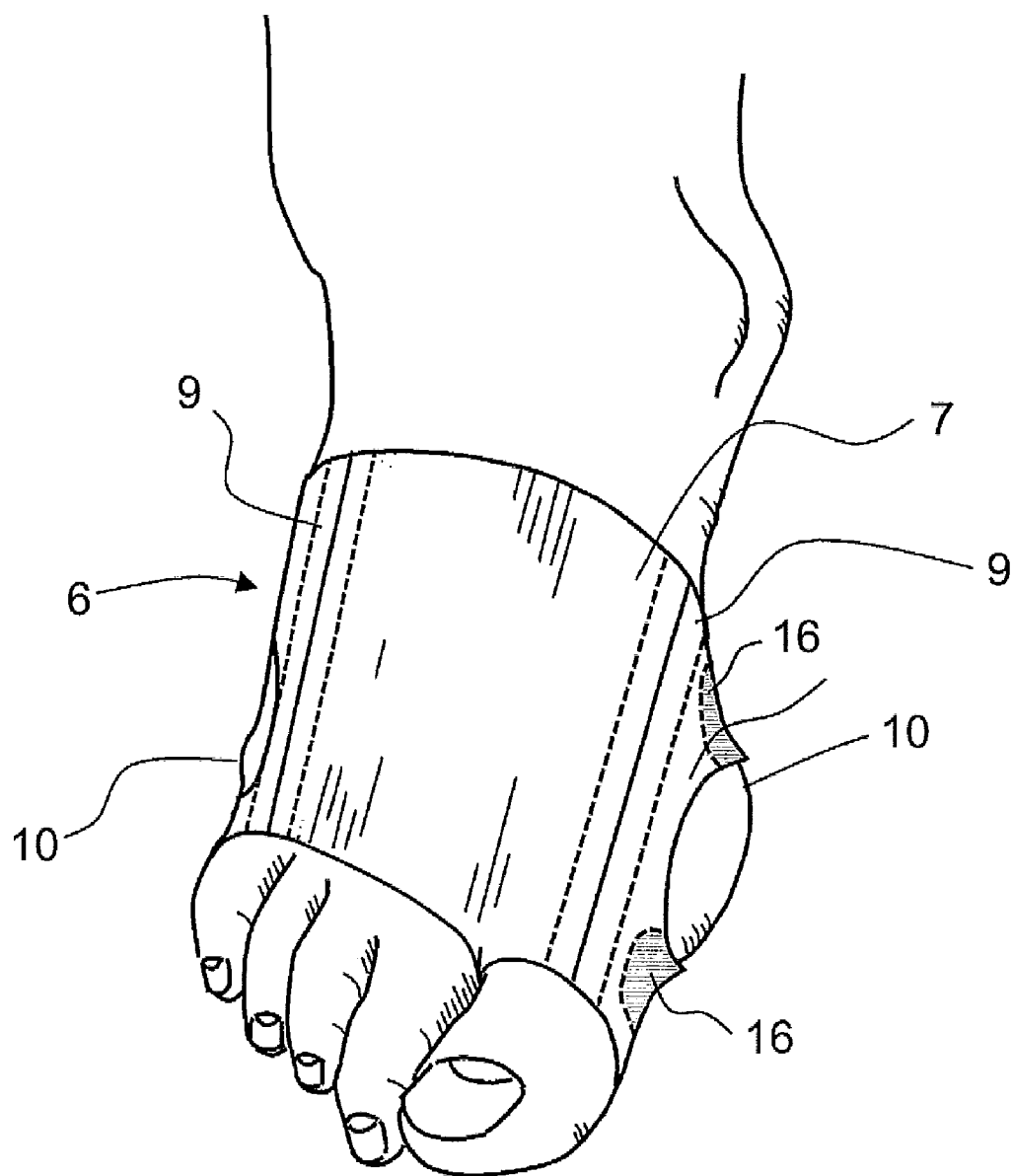
[Fig. 6]



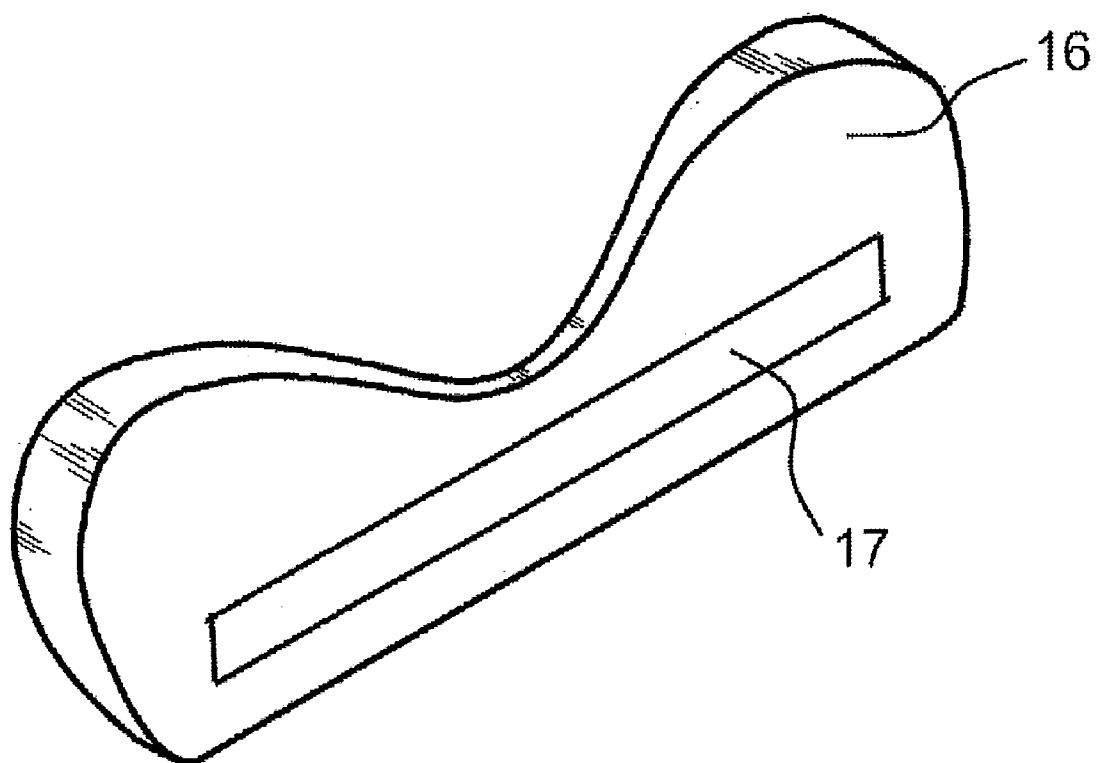
[Fig. 7]



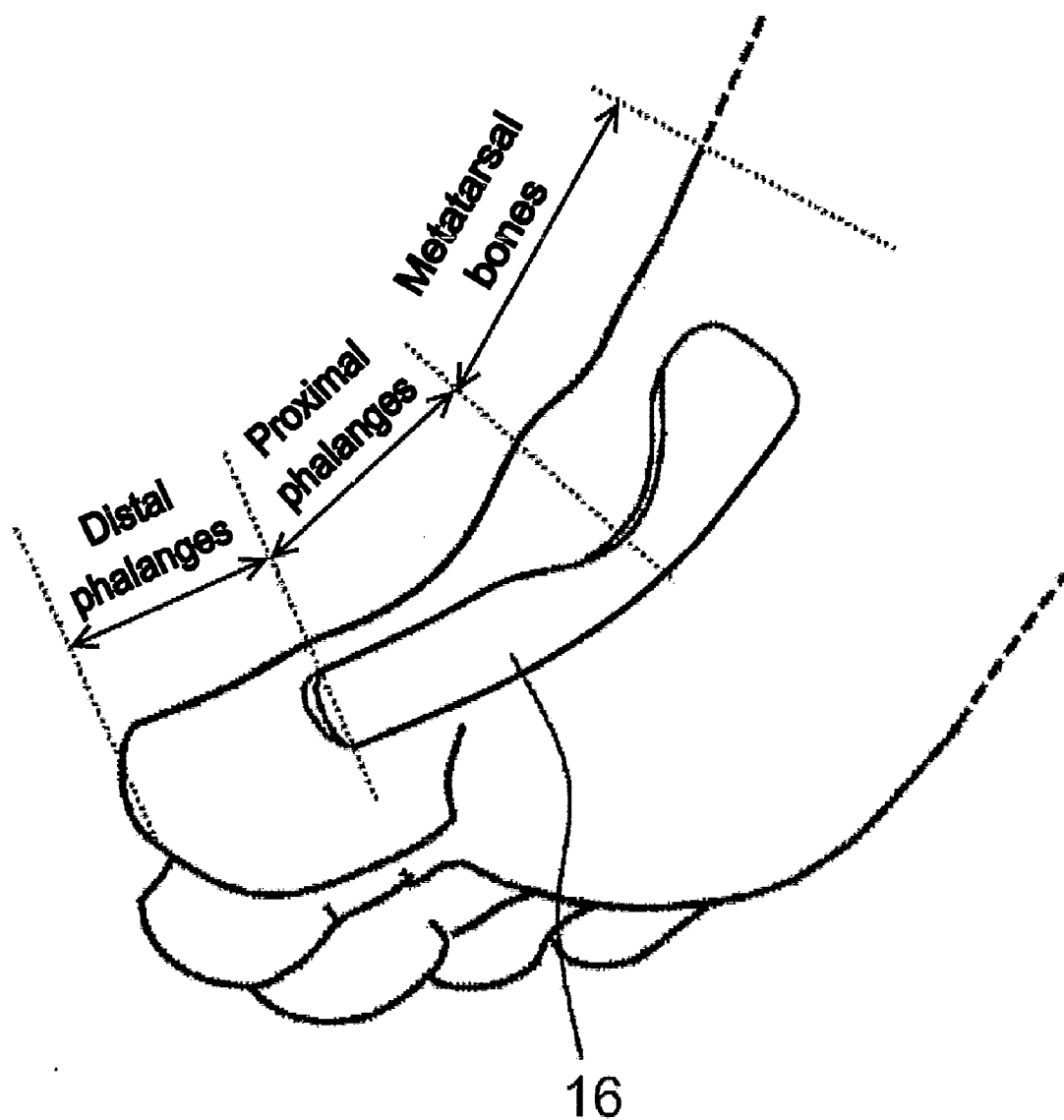
[Fig. 8]



[Fig. 9]



[Fig. 10]



SUPPORT STRUCTURE FOR PROPHYLAXIS OR TREATMENT OF A DISORDER ACCOMPANYING A FOOT DEFORMATION

FIELD OF THE INVENTION

[0001] The present invention relates to a support structure for prophylaxis or treatment of a disorder accompanying a foot deformation. Particularly, the present invention is concerned with a support structure for prophylaxis or treatment of a disorder accompanying a foot deformation, which comprises an instep part for covering an instep of a forefoot, a sole part for covering a sole of the forefoot, and at least a pair of slip-proof means for gripping the lateral and medial sides of the forefoot, wherein: the instep part and the sole part are connected together to form a cylindrical structure such that, when the support structure is fitted on a foot, the borders between the instep part and the sole part are aligned with the lateral and medial sides of the forefoot; the slip-proof means for gripping the lateral and medial sides of the forefoot are attached to the inner surface of the cylindrical structure at respective portions thereof to be contacted with the lateral and medial sides of the forefoot; and the instep part exhibits a larger elongation than the sole part as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. By the use of the support structure of the present invention, it becomes possible to not only maintain even under the load of the user's weight the transverse arch formed by fitting the support structure on a foot, but also suppress the clothing pressure applied by the support structure against the instep to a relatively low level so that the occurrence of edema and paralysis can be prevented. Accordingly, the present invention enables comprehensive and effective prophylaxis and treatment of various disorders accompanying foot deformation (such as splayfoot, hallux valgus, falling of the foot arch (flattening of a sole) due to posterior tibial tendon dysfunction (hereinafter, frequently abbreviated to "PTTD"), and heel valgus) without inflicting discomfort and pain on the user. In addition, the above-mentioned excellent effects of the present invention can be accomplished by the use of thin materials and a simple structure, whereby the support structure of the present invention can be easily fitted on a foot and can be used in combination with outdoor or indoor footwear. This means that the daily use of the support structure is easy so that the above-mentioned excellent prophylactic and curative effects of the present invention can be easily enhanced to a larger extent by daily use of the support structure.

BACKGROUND OF THE INVENTION

[0002] A human foot has three arches, namely a transverse arch connecting the base of a first toe (i.e., big toe or hallux) and the base of a fifth toe (i.e., little toe or digitus minimus), a medial longitudinal arch connecting the heel and the base of the hallux, and a lateral longitudinal arch connecting the heel and the base of the little toe. The foot arches function as springs during movements with the body weight placed on the foot such that the arches alleviate and absorb the impact from the ground, and are important for maintaining the balance of the body. Especially the transverse arch is like a spring composed of metatarsal ligaments and muscles, and is important for distribution of the impact applied to the tip of the foot and balancing the whole body during walking. Nowadays, however, people suffering from splayfoot caused by a collapsed

transverse arch are increasing. Specifically, the splayfoot is a condition where the transverse arch is collapsed (i.e., flattened) so as to cause the foot to spread out fan-wise as viewed from above. Such condition is caused by loosening of the metatarsal ligaments which occurs due to, for example, the weakening of muscles and increase in weight caused by lack of physical exercise, and the use of high-heeled shoes. Symptoms of splayfoot include pain caused by the contact between the inner surface of a shoe and bases of the first and fifth toes. Especially the splayfoot often occurs in women who wear shoes with narrow toes and high heels for a long time, and in many cases, the splayfoot leads to symptoms of hallux valgus, namely the first toe being fixed in a state where the first toe turns in from its base toward the second toe and the joint at the base of the first toe protrudes outwardly at the medial side of the foot. The splayfoot and hallux valgus cause not only pain, but also unnatural walking posture which leads to lumbago and fatigue of the whole body.

[0003] Further, with respect to the posterior tibial tendon having a function of maintaining the above-mentioned arches of the foot, there are cases where foot deformation is caused by tendon dysfunction resulting from aging or the like. Such posterior tibial tendon dysfunction is generally called "PTTD" and is attracting attention as a cause of various foot deformations, such as heel valgus and flat foot.

[0004] Focusing on the importance of foot arches, various socks and supporters for improving the athletic performances have been developed. Patent Document 1 discloses a pair of socks each having a continuous high-elasticity section and separate low-elasticity sections, wherein the continuous high-elasticity section encompasses parts of the sock corresponding to a region traversing the plantar arch and a region traversing the upper portion of calcaneus bone, and the separate low-elasticity sections encompass remaining parts of the sock. This sock is capable of lifting up the plantar arch of a foot without causing excessive tightening of the instep and, therefore, decreases fatigue and improves the athletic performance of the user by correcting the longitudinal arches. However, Patent Document 1 has no description about the correction of the transverse arch and the importance thereof.

[0005] Patent Document 2 also discloses a pair of socks for smooth foot motion during walking. The socks are produced by varying the knitting design and material depending on the positions of the sock so that the angle between the longitudinal axis of a sole part and the transversal axis of a toe part becomes larger than 0° and not more than 80°. Further, an instep part of this sock is made of a material which reduces elongation in a direction corresponding to the longitudinal direction of the foot on which the sock is fitted. Patent Document 2 also describes the use of a locking region encircling a portion of each sock which is to face the metatarsal bones and/or metatarsophalangeal joints of the foot on which the sock is fitted. The locking region prevents the occurrence of hallux valgus by appropriately pressurizing the metatarsal bones and/or metatarsophalangeal joints to thereby spread out the toes of the user. However, this document has no description about the restoration of the transverse arch or amelioration of the splayfoot.

[0006] Proposals have been made on various supporters and socks for correcting splayfoot and hallux valgus by tightening the metatarsal ligaments and restoring the transverse arch. For example, Patent Document 3 discloses a supporter for correcting hallux valgus, which has: openings formed by punching out holes at respective positions of the supporter

which are to face the joints at the bases of the big toe and the little toe of the foot on which the supporter is fitted, a conical cushion protruding from a portion of the sole which is to face the meridian point called “Yusen” of the foot, a cylindrical joint wrapping part covering the whole of the metatarsal bones and wrapping around the sole and instep of the foot for obtaining compression and acu-pressure effects, and pads individually inserted between the big toe and the second toe and between the little toe and the fourth toe for applying a corrective force in a direction opposite to the direction of the compression force to thereby rectify the transverse arch. Since the supporter of Patent Document 3 has a structure which covers all of the metatarsal bones and compresses the metatarsal ligaments, the compression forces applied from the lateral and medial ends of the metatarsal ligaments in a direction towards the middle of the foot facilitate the formation of the transverse arch. However, at the same time, the supporter applies a force tightening the metatarsal ligaments in the direction from the instep part to the sole part and this force is likely to cause the collapse of the transverse arch. Especially when user's weight is not on the foot, the effect of the above-mentioned pad decreases and the arch formation becomes unsatisfactory. Further, the use of this supporter is accompanied by the danger of edema and paralysis caused by especially strong tightening of the instep.

[0007] Patent Document 4 discloses a supporter having toe-receiving parts and an adjuster belt, wherein a big toe and a little toe of a foot are respectively fitted into the toe-receiving parts, and the degrees of outward spreading of the big toe and the little toe are adjusted by the adjuster belt based on the individual symptoms of hallux valgus and digitus minimus varus. This supporter is intended for use in combination with fashionable shoes, such as pumps. Accordingly, for achieving a design suitable for this purpose, the instep part of this supporter is designed as a thin line extending along the base portions of the toes. The supporter of Patent Document 4 does not cause the transverse arch to collapse since this supporter does not tighten the metatarsal ligaments in the direction from the instep part to the sole part, but this supporter does not have a structure capable of applying the tightening force from the lateral and medial sides of the metatarsal ligaments in the direction towards the middle of the foot, which force is necessary for the formation of the transverse arch. Therefore, this supporter is not suitable for ameliorating splayfoot.

[0008] Patent Document 5 discloses a pair of functional socks for restoring a collapsed transverse arch. The sock has a structure such that a sole part covering the metatarsal ligaments of the sole of a foot and parts adjacent to the lateral and medial sides of the sole part are made of a high-elasticity material, whereas an instep part of the sock covering the metatarsal ligaments of the instep of the foot is made of a low-elasticity material having a lower elasticity than the above-mentioned high-elasticity material. Patent Document 5 describes that, when the functional sock is fitted on a foot, the foot is tightened in the widthwise direction thereof such that the lateral and medial ends of each metatarsal ligament are drawn closer to each other, whereas the foot is free from the tightening in the thicknesswise direction thereof from the instep to the sole of the foot, thereby effectively restoring the metatarsal ligaments into a desired transverse arch form. According to the specific examples of the functional socks disclosed in Patent Document 5, the low-elasticity material is cotton for producing conventional socks, and the high-elasticity material is a cotton material containing a urethane rub-

ber woven thereinto. The urethane rubber-containing cotton material is incapable of exerting a tightening force necessary for supporting the power point of the elastic region, and the cotton for socks used as the low-elasticity material stretches together with the high-elasticity region of the socks. Therefore, when the present inventor reproduced and tested the socks of Patent Document 5, the socks exhibited a slight effect of forming a small transverse arch before putting weight on the foot, but the transverse arch formation effect was lost when the weight was put on the foot.

[0009] In addition, as a treatment brace for the above-mentioned “PTTD”, there is known a shoe insert (the so-called “UCBL shoe insert”) developed by UCBL (University of California Biomechanics Laboratory). The UCBL shoe insert is made of a hard plastic material (such as polyurethane) and comprises lateral and medial longitudinal arch support parts, and a heel part having a depression for maintaining the calcaneus bone at an appropriate height. The shoe insert is used by securing it to the foot with a belt or the like. The UCBL shoe insert inflicts constrain and discomfort on the user because it is made of a hard material and covers a large area of the foot. In general, the UCBL shoe insert is custom made by molding using a mold with a cavity having a negative image of the foot of each patient and, therefore, is disadvantageous in that the production is laborious and costly.

[0010] Braces, such as those manufactured and sold under the trade name “Aircast” (one of specific examples of which is “AirLift” (registered trademark)), are also known, which cover not only the sole, but also the entire ankle portion. At the sole part of this brace is provided a metatarsal bone pad in the form of an air pump into which air can be blown. However, such a brace compresses the entire ankle portion of the foot and causes problems such as bad blood circulation, and pain and discomfort for the user.

[0011] Also known is “Richie Brace” (registered trademark) manufactured and sold by Richie Brace, Inc., U.S.A. This brace has a structure which strongly restricts the movements of the foot joints exclusive of the dorsal flexion and plantar flexion. In other words, with the exception of the dorsal flexion and plantar flexion, this brace functions like a plaster cast strongly fixing the foot. Since the size of this brace is large and is custom made, this brace is accompanied by problems, such as high cost and difficulty in obtaining the brace.

[0012] Further, all of the above-mentioned conventional braces for treating PTTD have almost no effect for prevention or correction of splayfoot.

[0013] As apparent from the above, there has been no socks or a supporter which can be used daily and enables comprehensive and effective prophylaxis and treatment of various disorders accompanying foot deformation, such as splayfoot, hallux valgus, falling of foot arch (flattening of a sole) due to PTTD, and heel valgus.

[0014] [Patent Document 1] Unexamined Japanese Patent Application Laid-Open Specification No. 2006-225833

[0015] [Patent Document 2] Unexamined Japanese Patent Application Laid-Open Specification No. 2008-31615

[0016] [Patent Document 3] Unexamined Japanese Patent Application Laid-Open Specification No. 2005-305085

[0017] [Patent Document 4] Unexamined Japanese Patent Application Laid-Open Specification No. 2007-330743

[0018] [Patent Document 5] Unexamined Japanese Patent Application Laid-Open Specification No. 2005-42213

DISCLOSURE OF THE INVENTION

Problems to Be Solved by the Invention

[0019] As described hereinabove, there has been a demand for a supporter or a pair of socks which not only maintains even under the load of the user's weight the transverse arch formed by fitting the supporter or the like on a foot, but also enables comprehensive and effective prophylaxis and treatment of various disorders accompanying foot deformation (such as splayfoot, hallux valgus, falling of the foot arch (flattening of a sole) due to PTTD, and heel valgus) without inflicting discomfort or pain on the user.

Means to Solve the Problems

[0020] In this situation, the present inventor has made extensive and intensive studies with a view toward solving the above-mentioned problems. As a result, he has unexpectedly found that the above-mentioned problems can be solved by a support structure comprising an instep part for covering an instep of a forefoot, a sole part for covering a sole of the forefoot, and at least a pair of slip-proof means for gripping the lateral and medial sides of the forefoot, wherein: the instep part and the sole part are connected together to form a cylindrical structure such that, when the support structure is fitted on a foot, the borders between the instep part and the sole part are aligned with the lateral and medial sides of the forefoot; the slip-proof means for gripping the lateral and medial sides of the forefoot are attached to the inner surface of the cylindrical structure at respective portions thereof to be contacted with the lateral and medial sides of the forefoot; and the instep part exhibits a larger elongation than the sole part as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. Further, with his attention directed to the fact that there are correlations between various disorders accompanying foot deformation (such as splayfoot, hallux valgus, falling of the foot arch (flattening of a sole) due to PTTD, and heel valgus), the present inventor has found that the addition of an ankle support band to be fitted around an ankle in a manner such that an anterior of the ankle and a heel are encircled by the ankle support band to the above-mentioned support structure enhances the prophylaxis and treatment effects of the support structure by enabling the correction of the three-dimensional structure of the entire foot from the forefoot to the rearfoot. The above-mentioned ankle support band comprises an anterior ankle part for covering the anterior of the ankle and a heel part for covering the heel, wherein the anterior ankle part and the heel part are connected together in a manner such that, when the ankle support band is fitted around the ankle, the borders between the anterior ankle part and the heel part are aligned with the lateral and medial sides of the ankle; and further comprises at least a pair of slip-proof means for gripping the ankle which is attached to the inner surface of the ankle support band, wherein one of the slip-proof means is attached to a portion of the ankle support band to be contacted with medial malleolus of the foot and another slip-proof means is attached to a portion of the ankle support band to be contacted with the foot at an intermediate position between the lateral malleolus and the heel. In addition, the present inventor has found that, when the support structure comprises a hallux valgus correcting flexible plate attached to the inner

surface of the sole part, wherein the hallux valgus correcting flexible plate extends along a portion of the support structure to be contacted with an edge of a medial side of the forefoot and has a wedge-shaped cross-section continuously tapering in thickness from the top to the bottom, it becomes possible to effectively prevent and correct the rotation of hallux phalanges which is a cause of hallux valgus. The present invention has been completed, based on these findings.

[0021] The foregoing and other objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings, and the appended claims.

EFFECTS OF THE INVENTION

[0022] By the use of the support structure of the present invention, it becomes possible to not only maintain even under the load of the user's weight the transverse arch formed by fitting the support structure on a foot, but also suppress the clothing pressure applied by the support structure against the instep to a relatively low level so that the occurrence of edema and paralysis can be prevented. Accordingly, the present invention enables comprehensive and effective prophylaxis and treatment of various disorders accompanying foot deformation (such as splayfoot, hallux valgus, falling of the foot arch (flattening of a sole) due to PTTD, and heel valgus) without inflicting discomfort or pain on the user. In addition, the above-mentioned excellent effects of the present invention can be accomplished by the use of thin materials and a simple structure, whereby the support structure of the present invention can be easily fitted on a foot and can be used in combination with outdoor or indoor footwear. This means that the daily use of the support structure is easy so that the above-mentioned excellent prophylactic and curative effects of the present invention can be easily enhanced to a larger extent by daily use of the support structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1a is a cross-sectional view of a foot having a normal transverse arch (shown with broken lines), which is taken along metatarsal bone caputs.

[0024] FIG. 1b is a cross-sectional view of a foot suffering from splayfoot and having a collapsed transverse arch (shown with broken lines), which is taken along metatarsal bone caputs.

[0025] FIG. 2 is a perspective view of an embodiment of the support structure of the present invention which is fitted on a foot with splayfoot.

[0026] FIG. 3 is a cross-sectional view of the foot of FIG. 2, which is taken along line I-I of FIG. 2.

[0027] FIG. 4 is a perspective view of an embodiment of the support structure of the present invention in the form of a sock before being fitted on a foot.

[0028] FIG. 5 is a perspective view of the support structure of FIG. 4, which is fitted on a foot.

[0029] FIG. 6 is a perspective view of another embodiment of the support structure of the present invention in the form of a sock, which is showing the side of medial malleolus.

[0030] FIG. 7 is a perspective view of the support structure of FIG. 6, which is showing the side of lateral malleolus.

[0031] FIG. 8 is a perspective view of still another embodiment of the support structure of the present invention.

[0032] FIG. 9 is a perspective view of an example of a hallux valgus correcting flexible plate used with the support structure of FIG. 8.

[0033] FIG. 10 is an explanatory diagram showing the method for attaching the hallux valgus correcting flexible plate to a foot.

DESCRIPTION OF REFERENCE NUMERALS

- [0034] 1 First metatarsal bone
- [0035] 2 Second metatarsal bone
- [0036] 3 Third metatarsal bone
- [0037] 4 Fourth metatarsal bone
- [0038] 5 Fifth metatarsal bone
- [0039] 6 Supporter
- [0040] 6' Support structure in the form of a sock
- [0041] 7 Instep part
- [0042] 8 Sole part
- [0043] 9 Slip-proof means for gripping the lateral and medial sides of the forefoot
- [0044] 10 Bunion opening
- [0045] 11a Toe part
- [0046] 11b Heel part
- [0047] 11c Metatarsus part
- [0048] 11d Lower leg part
- [0049] 12 Anterior ankle part of the ankle support band
- [0050] 13 Heel part of the ankle support band
- [0051] 14 Slip-proof means for gripping the ankle
- [0052] 15 Metatarsal bone pad
- [0053] 16 Hallux valgus correcting flexible plate
- [0054] 17 Shape-memory alloy plate

BEST MODE FOR CARRYING OUT THE INVENTION

[0055] For easier understanding of the present invention, the essential features and various preferred embodiments of the present invention are enumerated below.

[0056] 1. A support structure for prophylaxis or treatment of a disorder accompanying a foot deformation, which comprises:

[0057] an instep part for covering an instep of a forefoot,
 [0058] a sole part for covering a sole of the forefoot, and
 [0059] at least a pair of slip-proof means for gripping the lateral and medial sides of the forefoot,
 wherein:

[0060] the instep part and the sole part are connected together to form a cylindrical structure such that, when the support structure is fitted on a foot, the borders between the instep part and the sole part are aligned with the lateral and medial sides of the forefoot;

[0061] the at least a pair of slip-proof means for gripping the lateral and medial sides of the forefoot are attached to the inner surface of the cylindrical structure at respective portions thereof to be contacted with the lateral and medial sides of the forefoot; and

[0062] the instep part exhibits a larger elongation than the sole part as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted.

[0063] 2. The support structure according to item 1 above, wherein the ratio (A)/(B) of the elongation (A) of the instep part to the elongation (B) of the sole part is 1.2 or more, each

elongation being measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted.

[0064] 3. The support structure according to item 1 or 2 above, wherein each of the slip-proof means for gripping the lateral and medial sides of the forefoot is made of an adhesive material.

[0065] 4. The support structure according to any one of items 1 to 3 above which further comprises a pad attached to the inner surface of the sole part, the pad being attached to a portion of the support structure which is to face a metatarsal bone of the foot on which the support structure is fitted.

[0066] 5. The support structure according to any one of items 1 to 4 above, which is in the form of a sock.

[0067] 6. The support structure according to any one of items 1 to 4 above, which is in the form of a stocking.

[0068] 7. The support structure according to any one of items 1 to 6 above, which further comprises an ankle support band to be fitted around an ankle in a manner such that an anterior of the ankle and a heel are encircled by the ankle support band, wherein the ankle support band comprises:

[0069] an anterior ankle part for covering the anterior of the ankle,

[0070] a heel part for covering the heel, and

[0071] at least a pair of slip-proof means for gripping the ankle,
 wherein:

[0072] the anterior ankle part and the heel part are connected together in a manner such that, when the ankle support band is fitted around the ankle, the borders between the anterior ankle part and the heel part are aligned with the lateral and medial sides of the ankle;

[0073] the at least a pair of slip-proof means for the ankle being attached to the inner surface of the ankle support band, one of the slip-proof means being attached to a portion of the ankle support band to be contacted with medial malleolus of the foot and another slip-proof means being attached to a portion of the ankle support band to be contacted with the foot at an intermediate position between the lateral malleolus and the heel; and

[0074] the anterior ankle part exhibits a larger elongation than the heel part as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted.

[0075] 8. The support structure according to item 7 above, wherein the ratio (A')/(B') of the elongation (A') of the anterior ankle part to the elongation (B') of the heel part is 1.2 or more, each elongation being measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted.

[0076] 9. The support structure according to item 7 or 8 above, wherein each of the slip-proof means for gripping the ankle is made of an adhesive material.

[0077] 10. The support structure according to any one of items 1 to 9 above, which further comprises a hallux valgus correcting flexible plate, wherein the hallux valgus correcting flexible plate is attached to the inner surface of the sole part and extends along a portion of the support structure to be contacted with an edge of a medial side of the forefoot, the flexible plate having a wedge-shaped cross-section which continuously tapers in thickness from the top to the bottom.

[0078] 11. The support structure according to item 10 above, wherein the hallux valgus correcting flexible plate comprises a shape-memory alloy plate extending in a longi-

tudinal direction of the flexible plate, the shape-memory alloy plate being embedded in the hallux valgus correcting flexible plate or attached to the surface of the hallux valgus correcting flexible plate.

[0079] Hereinbelow, the present invention is described in detail.

[0080] A normal foot as shown in FIG. 1a has a transverse arch (shown with broken lines) connecting the base of the first toe (first metatarsal bone caput) and the base of the fifth toe (fifth metatarsal bone caput). On the other hand, a foot as shown in FIG. 1b which is suffering from splayfoot shows a symptom of collapsed and flattened transverse arch.

[0081] The support structure of the present invention is used for correcting the splayfoot by restoring the collapsed transverse arch as shown in FIG. 1b to the normal transverse arch as shown in FIG. 1a.

[0082] In the present invention, the term “support structure” means a foot orthosis comprising a structure of a supporter and encompasses not only a supporter as such, but also other foot orthoses, such as those in the form of a sock or stocking, as long as they comprise a structure as defined in the present invention. Further, in the present invention, the term “side” of a foot is not used to exclusively mean the lateral and medial sides of the foot, but is used to encompass the opposite sides of the instep as well.

[0083] FIG. 2 is a perspective view of an embodiment of the support structure of the present invention which is fitted on a foot with splayfoot. Further, FIG. 3 is a cross-sectional view of the foot of FIG. 2, which is taken along line I-I of FIG. 2.

[0084] The support structure of the present invention as shown in FIG. 2 has a shape of a supporter. The supporter 6 of FIG. 2 has instep part 7 for covering an instep of a forefoot (i.e., top of the forefoot) and sole part 8 for covering the sole of the forefoot (i.e., bottom of the forefoot), and the instep part 7 and the sole part 8 are connected together to form a cylindrical structure such that, when the support structure is fitted on a foot, the borders between the instep part 7 and the sole part 8 are aligned with the lateral and medial sides of the forefoot. The instep part 7 exhibits a larger elongation than the sole part 8 as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. Further, at least a pair of slip-proof means 9,9 (shown with broken lines) for gripping the lateral and medial sides of the forefoot are attached to the inner surface of the cylindrical structure at respective portions thereof to be contacted with the lateral and medial sides of the forefoot. When the supporter 6 is fitted on a foot, the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot perform a function of fixing the supporter 6 to the foot at the lateral and medial sides thereof with the sole part 7 tightening the foot in the widthwise direction thereof (see FIG. 3). In the support structure of the present invention, as explained above, the elongation of the instep part 7 is made to be larger than the elongation of the sole part 8 as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. By virtue of such a structure, the clothing pressure applied to the instep of a foot becomes reduced, whereas the tightening force in the widthwise direction of a foot for forming a transverse arch is effectively applied to the foot. Further, by the use of the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot, it becomes possible to not only obtain effectively the above-mentioned tightening force, but also maintain the tightening force while the weight is on the foot. On the other hand, a

supporter, such as that disclosed in Patent Document 5 which has no slip-proof means for gripping the lateral and medial sides of the forefoot, will slip off from the lateral and medial sides of the foot even when the elongation of the instep part 7 is made larger than that of the sole part 8 as measured in a widthwise direction of the foot. As a result, the tightening force applied from the sole part becomes equalized with that applied from the instep part so that desired transverse arch correction is not achieved.

[0085] There is no particular limitation with respect to the materials for the instep part 7 and the sole part 8 as long as the above-mentioned relationship between the elongations of these parts can be satisfied, and the materials can be appropriately selected from the materials conventionally used for producing supporters, stockings and socks. For improving the comfort during the use of the support structure of the present invention, it is preferred to use materials which are air permeable, hygroscopic and quick drying. Specific examples of materials for the instep part 7 and the sole part 8 include materials described in the above-mentioned Patent Documents 1 and 2. These documents also describe methods for producing regions of socks and the like which have different elongations, and such methods can be applied to the present invention for adjusting the elongation. Typical examples of materials used include a mixed fabric of polyurethane and nylon. Since the sole part 8 may be made of a material having substantially no elasticity, a nonwoven fabric of polypropylene or the like can be also used in the present invention.

[0086] With respect to the material used for forming the slip-proof means 9 for gripping the lateral and medial sides of the forefoot, there is no particular limitation as long as the material is capable of fixing the support structure of the present invention to the forefoot at the lateral and medial sides thereof when the support structure is fitted on the foot. Materials having high friction coefficient and adhesive materials can be used for forming the slip-proof means 9 for gripping the lateral and medial sides of the forefoot. Specific examples of the materials having high friction coefficient include synthetic rubbers, such as an ethylene-propylene-diene rubber (EPDM), a chloroprene rubber (CR) and a silicon rubber; and natural rubbers (NR). U.S. Pat. No. 5,948,707 describes materials (e.g., water-resistant and vapor-permeable material having a non-continuous elastomer layer formed on a polytetrafluoroethylene film) used for preventing the slippage of casts (supporters) for legs and arms, and such materials can be also used in the present invention. With respect to the adhesive materials, there is no particular limitation as long as the materials exhibit adhesiveness such as would be suitable for simultaneously realizing satisfactory adhesion to the skin of a foot and easy removal therefrom at the detachment of the support structure from the foot, and various conventional adhesive materials can be used. For example, a conventional double-sided adhesive tape can be used as the slip-proof means for gripping the lateral and medial sides of the forefoot, while changing the adhesive tape each time the support structure is removed and then refitted on the foot of the user. However, it is preferred to use an adhesive material which recovers its adhesiveness by washing. The adhesive material which recovers its adhesiveness by washing is a material which can be washed with water or a neutral detergent for recovering its adhesiveness when the adhesiveness becomes lowered by the attachment of dusts and oils during the use thereof. Examples of such materials include a silicone gel adhesive layer described in Unexamined Japanese Patent

Application Laid-Open Specification No. Hei 11-323616, and a urethane adhesive layer described in Unexamined Japanese Patent Application Laid-Open Specification No. 2000-247061. Conventional adhesive elastic bandages can be also used.

[0087] The suitable size of each of the instep part **7** and the sole part **8** of the support structure of the present invention varies depending on the size of the foot. It is preferred to select an appropriate size such that a satisfactory tightening force can be applied in the widthwise direction of the foot and that the clothing pressure applied to the instep of the foot can be reduced. For example, as to the width of the support structure, the width of the sole part may be about 1.0 to 1.5 times the width of the foot, whereas the width of the instep part may be about 0.2 to 1.0 times the width of the foot because the instep part is made of a material having a relatively high elasticity.

[0088] In the present invention, it is preferred that the support structure has an opening formed at a portion to be contacted with a boundary between the metatarsal bones and the phalanges at the side (especially the medial side) of the foot. The reason is as follows. In a foot suffering from splayfoot, the joints at the base of the first toe and the joint at the base of the fifth toe protrude outwardly at the medial and lateral sides of the foot, and even a slight increase in the thickness of a supporter or socks may increase friction and cause pain. Further, in a foot suffering from hallux valgus, a swollen bursa or bunion may be formed around the joint at the base of the first toe. In these cases, it is especially preferred to form bunion openings **10,10** as shown in FIG. 2 at portions to be contacted with the above-mentioned joints to thereby decrease the friction between the support structure and the joints. With respect to the size and shape of the bunion openings **10,10**, there is no particular limitation. For example, the bunion opening may be a circular or oval hole having a diameter or major axis of about 1.5 to 4 cm.

[0089] In the present invention, for obtaining satisfactory tightening force in the widthwise direction of the foot and also for satisfactorily reducing the clothing pressure applied against the instep of the foot, it is necessary that the elongation (A) of the instep part **7** is larger than the elongation (B) of the sole part **8** (i.e., (A)>(B)), wherein each elongation is measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. The ratio (A)/(B) of the elongation (A) of the instep part **7** to the elongation (B) of the sole part **8** is preferably 1.2 or more, more preferably 2 to 200, and most preferably 2.5 to 100. The elongation (B) of the sole part **8** may be 0%, but in such a case, it is preferred that the elongation (A) of the instep part **7** falls within the below-mentioned ranges.

[0090] In the present invention, the elongation (A) of the instep part **7** as measured under a load of 4.9 N (500 gf) is generally in the range of from 5 to 200%, preferably 35 to 180%, and more preferably 75 to 155%, and the elongation (A) as measured under a load of 17.7 N (1800 gf) is generally in the range of from 10 to 300%, preferably 115 to 250%, and more preferably 160 to 210%, the elongation being measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. When the elongation (A) of the instep part **7** is smaller than the above-mentioned range, the tightening of the instep may become too strong (i.e., the clothing pressure may become too high) and may cause problems, such as swelling, paralysis, pain, redness and the like of the instep. The elongation (B) of the sole part **8** as

measured under a load of 4.9 N (500 gf) is generally in the range of from 0 to 150%, preferably 1 to 100%, more preferably 5 to 75%, and the elongation (B) measured under a load of 17.7 N (1800 gf) is generally in the range of from 0 to 180%, preferably 5 to 150%, more preferably 10 to 120%, the elongation being measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. When the elongation (B) of the sole part **8** is larger than the above-mentioned range, the tightening force in the widthwise direction of the foot may become unsatisfactory. The elongations (A) and (B) are measured with respect to a region having a length of 3 cm and a width of 2 cm.

[0091] In addition, for forming the instep part **7** and the sole part **8** of the support structure of the present invention, a combination of different materials having different elongations can be used as long as it is possible to achieve a satisfactory tightening force in the widthwise direction of the foot and a satisfactory decrease in the clothing pressure applied against the instep of the foot. Especially with respect to the sole part **8**, for reducing the burden on the foot of the user, a material having a large elongation can be used for portions (e.g., portions distant from the boundary between metatarsal bones and phalanges) where a strong tightening force is not required. Even in such cases, it is preferred that the elongations (A) and (B) and the ratio (A)/(B) all fall within the above-mentioned ranges, wherein an average of the elongation values for all portions of the instep part **7** is used as the above-mentioned elongation (A), and an average of the elongation values for all portions of the sole part **8** is used as the above-mentioned elongation (B). It is preferred that the elongations (A) and (B) and the ratio (A)/(B) of at least the region around the border between the metatarsal bones and the phalanges fall within the above-mentioned ranges. Herein, the "region around the border between the metatarsal bones and the phalanges" is the region from 1 cm above to 1 cm below the border between the metatarsal bones and the phalanges, preferably the region from 2 cm above to 2 cm below the border, and more preferably the region from 3 cm above to 3 cm below the border.

[0092] The ratio (A)/(B) used in the present invention may be either a ratio of elongations measured under the load of 4.9 N (500 gf) or the ratio of the elongations measured under the load of 17.7 N (1800 gf), and one of the ratios should fall within the above mentioned range. It is more preferred that both ratios fall within the above-mentioned respective ranges.

[0093] When the support structure of the present invention is fitted on a foot, it is preferred that the clothing pressure at the instep becomes 0 to 25.0 kPa.

[0094] With respect to the shape and size of the slip-proof means **9,9** for gripping the lateral and medial sides of the forefoot, there is no particular limitation as long as the slip-proof means are capable of fixing the support structure of the present invention to the forefoot at the lateral and medial sides thereof. For example, there can be mentioned a rectangular or quasi-rectangular shaped slip-proof means having a length of 3 to 10 cm and a width of 0.5 to 3 cm. In addition, when the bunion openings **10,10** are formed as shown in FIG. 2, the slip-proof means may have a cut-out portion conforming to the opening. Further, a plurality of the slip-proof means **9** can be attached to each of the respective portions of the support structure to be contacted with the lateral and medial sides of the forefoot. For example, to each or one of the respective portions of the support structure to be contacted with the lateral and medial sides of the forefoot may be attached: two

strips of the slip-proof means 9,9 each extending in a longitudinal direction of the foot; or a plurality of square, circular or oval slip-proof means 9 which are arranged side by side in the direction corresponding to the longitudinal direction of the foot.

[0095] In the support structure of the present invention, the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot are fixed at respective portions of the support structure to be contacted with either the lateral- and medial-side edges of the foot and/or the lateral- and medial-side edges of the instep, and the slip-proof means may extend to the portions to be contacted with the lateral- and medial-side edges of the sole.

[0096] In the present invention, the instep part 7, the sole part 8 and the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot may be combined together before fitting the support structure to the foot, for example, by stitching the above-mentioned components into a form of a support structure as shown in FIG. 2. Alternatively, the above-mentioned components can be combined together at the time of fitting the support structure to the foot. For example, the support structure of the present invention can be formed by a method comprising the following steps (1) to (3) by using the instep part 7 and sole part 8 which are combinable with each other by means of loop and hook fasteners, and by using a double-sided tape as the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot:

[0097] (1) a piece of double-sided tape is attached to each edge of the lateral and medial sides of the foot as the slip-proof means for gripping the lateral and medial sides of the forefoot;

[0098] (2) a sole part provided with hook fasteners (attached to an outer surface of the sole part at the edges of the opposing side portions thereof) is fixed to the foot by using the double-sided tapes attached to edges of the lateral and medial sides of the foot, wherein the sole part is fixed in a manner such that the foot is tightened in a widthwise direction of the foot; and

[0099] (3) an instep part provided with loop fasteners (attached to an inner surface of the instep part at the edges of the opposing side portions thereof) is attached to the sole part by mating the loop fasteners to the corresponding hook fasteners of the sole part. (Needless to say, the loop fasteners can be used with the sole part, and the hook fasteners can be used with the instep part.)

[0100] The support structure having two or more bag parts for placing the toes therein, which bag parts are as described in the above-mentioned Patent Document 5, is one of the preferred embodiments of the present invention. The presence of such bag parts enables the first toe and the fifth toe to be pulled towards the central axis of the sole when the user inserts the toes into the respective bag parts for fixing the support structure to the foot, thereby forming a transverse arch. Therefore, the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot can be easily fixed at desired positions of the lateral and medial sides of the foot while maintaining the transverse arch formed.

[0101] Further, in the present invention, a pad may be attached to the inner surface of the sole part 8 at a portion which is facing a metatarsal bone of the foot. This pad is capable of improving the effect of the support structure to correct the transverse arch, especially when the weight is on the foot. With respect to the materials and production of the

metatarsal bone pad, reference can be made to, for example, the above-mentioned Patent Document 3.

[0102] The embodiment shown in FIG. 2 is a supporter as such, but the support structure of the present invention may be in the form of a sock or stocking. When the support structure of the present invention is in the form of a sock or stocking, the parts other than the instep part 7, the sole part 8 and the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot can be produced by any conventional materials and methods generally used for producing socks and stockings.

[0103] FIG. 4 is a perspective view of an embodiment of the support structure of the present invention in the form of a sock before being fitted on a foot, and FIG. 5 is a perspective view of the support structure of FIG. 4, which is fitted on a foot. In the support structure 6' of the present invention which is in the form of a sock, the parts other than the instep part 7, the sole part 8 and the slip-proof means 9,9 for gripping the lateral and medial sides of the forefoot are as explained above, and additional parts 11a and 11b can be formed by conventional methods using materials which are generally used for producing conventional socks or stockings.

[0104] FIG. 6 is a perspective view of another embodiment of the support structure of the present invention in the form of a sock, which is showing the side of medial malleolus, and FIG. 7 is a perspective view of the support structure of FIG. 6, which is showing the side of lateral malleolus. The support structure 6' of the embodiment shown in FIGS. 6 and 7 further comprises an ankle support band to be fitted around an ankle in a manner such that an anterior of the ankle and a heel are encircled by the ankle support band. The ankle support band has anterior ankle part 12 for covering the anterior of the ankle and heel part 13 for covering the heel. The anterior ankle part 12 and the heel part 13 are connected together in a manner such that, when the ankle support band is fitted around the ankle, the borders between the anterior ankle part and the heel part are aligned with the lateral and medial sides of the ankle. Further, slip-proof means 14,14 for gripping the ankle (shown with broken lines) is attached to the inner surface of the ankle support band, wherein one of the slip-proof means is attached to a portion of the ankle support band to be contacted with the medial malleolus of the foot while another slip-proof means is attached to a portion of the ankle support band to be contacted with the foot at an intermediate position between the lateral malleolus and the heel. Further, the anterior ankle part 12 exhibits a larger elongation than the heel part 13 as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. By virtue of such structure, the ankle support band is effective for prophylaxis and treatment of PTTD while preventing unnecessary oppression of blood vessels and nerves at the ankle and without excessively disturbing the movements of muscles and ligaments around the ankle. As explained above, there are correlations between various disorders accompanying foot deformation (such as splayfoot, hallux valgus and PTTD), and the addition of the ankle support band to the support structure of the present invention enables more comprehensive and effective prophylaxis and correction of foot deformations. Further, as shown in FIG. 7, metatarsal bone pad 15 may be attached to the inner surface of the sole part 8 at a portion which is to face a metatarsal bone of the foot. The prophylactic and corrective effects of the present invention will be remarkably enhanced by the attachment of the meta-

tarsal bone pad **15**. The materials and methods for producing the metatarsal bone pad **15** have been explained above.

[0105] The above-mentioned ankle support band is explained in detail below. The ankle support band can be produced in a form integrated with the support structure in the form of a sock. Alternatively, a separately prepared ankle support band may be attached to the main body of the support structure. With respect to the shape and size of the ankle support band, there is no particular limitation as long as the ankle support band is capable of encircling the anterior of the ankle and the heel, and remaining at a desired portion of the foot without slipping off when the support structure is fixed on the foot. For example, a strip having a width (length in the longitudinal direction of the foot) of 1 to 8 cm, preferably 2 to 5 cm can be used as the anterior ankle part **12**. It is preferred that the heel part **13** has a width (length in the longitudinal direction of the foot) which is sufficient for the part to be firmly fixed to the heel. For example, the width of the heel part **13** is preferably 5 to 12 cm, more preferably 6 to 10 cm. As shown in FIGS. 6 and 7, it is preferred that the heel part **13** has a circular or oval opening formed at a portion thereof which is to be contacted with the center of the heel and the portions around the center.

[0106] The anterior ankle part **12** and the heel part **13** can be individually formed by the materials and methods which are the same as those used for forming the above-mentioned instep part and the sole part. As in the case of the instep part and the sole part, it is necessary that the anterior ankle part **12** exhibits a larger elongation (A') than the elongation (B') of the heel part **13** (i.e., (A') > (B')), as measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. It is preferred that the ratio (A')/(B') of the elongation (A') of the anterior ankle part to the elongation (B') of the heel part is 1.2 or more, preferably 2 to 200, and most preferably 2.5 to 100. Further, it is preferred that the elongation (A') and the elongation (B') both fall within the ranges explained above in connection with the elongations (A) and (B) described above. The elongation (B') of the heel part **13** may be 0%, but in such case, it is preferred that the elongation (A') is within the above-mentioned range.

[0107] The slip-proof means **14,14** for gripping the ankle can be formed by the materials and methods which are the same as those used for forming the above-mentioned slip-proof means for gripping the lateral and medial sides of the forefoot. As explained above, the slip-proof means **14** for gripping the ankle at the side of the medial malleolus is attached to a portion of the support structure which is to be contacted with medial malleolus of the foot. It is preferred that the position and size of the slip-proof means **14** for gripping the ankle at the side of the medial malleolus are such that the slip-proof means **14** can cover the medial malleolus entirely when the support structure of the present invention is fitted on a foot. On the other hand, the slip-proof means **14** for gripping the ankle at the side of the lateral malleolus is attached to a portion of the support structure which is to be contacted with an intermediate position between the lateral malleolus and the heel. By positioning the slip-proof means **14,14** for gripping the ankle in the above-mentioned manner, it becomes possible to easily suppress the occurrence of valgus (outward angulation of foot), while preventing excess suppression of varus (inward angulation of foot). Therefore, effective prophylaxis and treatment of PTTD becomes possible without excessively restricting the foot movements. Further, it is preferred that the slip-proof means **14** (for gripping

the ankle) is attached to a portion in which the entire slip-proof means **14** is positioned below the bottom (shown in FIG. 7 with dotted lines) of the lateral malleolus. Alternatively, the slip-proof means **14** for gripping the ankle can be attached to a portion such that a part of the slip-proof means **14** covers the lower portion of the lateral malleolus. In this case, the area of the slip-proof means **14** at a portion thereof which covers the lower portion of the lateral malleolus is preferably 50% or less, more preferably 30% or less, most preferably 20% or less of the total area of the slip-proof means **14** for gripping the ankle.

[0108] With respect to the specific shape and size of the slip-proof means **14,14** for gripping the ankle, there is no particular limitation as long as the desired effects of the present invention can be achieved. For example, the shape of the slip-proof means can be appropriately selected from the group consisting of a square, a rectangle, a circle and an oval. With respect to the size, it is preferred that the length of the side of the square, the long side of the rectangle, the diameter of the circle or the long axis of the oval is 2 to 10 cm, preferably 2.5 to 7 cm, and more preferably 3 to 5 cm.

[0109] As in the case of the slip-proof means for gripping the forefoot, it is preferred that the slip-proof means **14,14** for gripping the ankle are made of an adhesive material. Specific examples of the adhesive materials are as explained above in connection with the slip-proof means for gripping the forefoot.

[0110] In one of the preferred embodiments of the support structure of the present invention, the above-mentioned sole part and heel part are connected through a bridging part made of a low elongation material which is the same as or similar to the material(s) used for forming the sole part and the heel part (hereinafter, this bridging part is referred to as "metatarsus-sole connection band"). The use of the metatarsus-sole connection band is preferred because it further enhances the effects of the present invention to prevent or correct the valgus of hallux and heel. With respect to the material, elongation and the like of the metatarsus-sole connection band, reference can be made to the explanations made above in connection with the sole part and the heel part.

[0111] FIG. 8 is a perspective view of still another embodiment of the support structure of the present invention. This support structure has a toe opening which is separated into an opening for the first toe and another opening for the remaining toes. In the embodiment depicted in FIG. 8, a hallux valgus correcting flexible plate **16** extending along a portion of the support structure to be contacted with an edge of a medial side of the forefoot is attached to the inner surface of the sole part. As shown in FIG. 9, the hallux valgus correcting flexible plate **16** has a wedge-shaped cross-section which continuously tapers in thickness from the top to the bottom.

[0112] In many cases, hallux valgus is accompanied by rotations of the first metatarsal bone and the first toe (hallux). For example, in the case of a right foot, hallux is often rotated clockwise as seen from the tip of the toes. The hallux valgus correcting flexible plate **16** is capable of preventing or correcting the rotation of the hallux by exhibiting a wedge effect to the hallux. More detailed explanation on this point is given below. In the present invention, by virtue of the above-mentioned construction of the support structure, prophylaxis or correction of splayfoot is effected by maintaining or correcting the position of the metatarsophalangeal (MTP) joint of the hallux to a middle position (normal position). However, when the MTP joint is fixed to the middle position, adductor muscle

of the hallux becomes relaxed. In this situation, when the hallux valgus correcting flexible plate **16** is positioned in a manner as depicted in FIGS. **8** and **10**, an inversive force is effectively applied against the hallux by the wedge effect of the hallux valgus correcting flexible plate **16**, thereby enabling the prevention and correction of the internal rotation of the hallux phalanges (i.e., a state where the hallux phalanges are twisted such that the nails face the medial side).

[0113] With respect to the size of the hallux valgus correcting flexible plate **16**, it is preferred that the flexible plate **16** has a dimension as depicted in FIG. **10**, namely a length such that the plate extends from phalanx proximalis caput to the middle of the metatarsal bones, and a width sufficient for exhibiting the wedge effect. Specifically, the size of the flexible plate **16** varies depending on the size and the like of the foot, but for example, the length may be 3 to 15 cm and the width may be 1.5 to 5 cm. Further, it is preferred that the thickness at the top of the flexible plate is 1 to 8 mm, more preferably 2 to 6 mm.

[0114] As shown in FIGS. **9** and **10**, for preventing the oppression of the MTP joint portion of the first toe, it is preferred that the hallux valgus correcting flexible plate **16** has a cut-out portion conforming to the shape of the joint. With respect to the shape of the cut-out portion, there is no particular limitation as long as the oppression of the MTP joint portion of the first toe can be avoided. For example, as shown in FIG. **10**, it is preferred that the width of the hallux valgus correcting flexible plate **16** is narrowed at a portion which is to be contacted with the MTP joint so that this portion of the flexible plate **16** only contacts a narrow region at the boundary between the sole part and the side of the foot. With respect to the width of the hallux valgus correcting flexible plate **16** at this cut-out portion (the minimum width of the flexible plate when the cut-out portion is curved like that shown in FIG. **9** or **10**), there is no particular limitation. However, it is preferred that the width of the hallux valgus correcting flexible plate **16** at this cut-out portion is 0.2 to 1.5 cm, more preferably 0.3 to 1.3 cm.

[0115] As shown in FIG. **9**, it is preferred that the hallux valgus correcting flexible plate **16** comprises a shape-memory alloy plate **17** extending in a longitudinal direction of the flexible plate. The shape-memory alloy plate **17** reinforces the effect of prophylaxis and correction of the foot deformation while weight is on the foot. The shape-memory alloy plate **17** can be embedded in the hallux valgus correcting flexible plate or attached to the surface of the hallux valgus correcting flexible plate.

[0116] When the hallux valgus correcting flexible plate **16** is used, it is preferred that the flexible plate **16** is attached to the inner surface of the sole part of the support structure at a position to be contacted with a foot in such a manner as depicted in FIG. **10**. Specifically, it is preferred that the flexible plate extends along the border between the sole and the side of the foot and contacts the region from the phalanx proximalis caput to the middle of the metatarsal bones.

[0117] The hallux valgus correcting flexible plate **16** may be made of a conventional flexible resin. For example, at least one resin selected from the group consisting of vinyl chloride, polyethylene, polypropylene, polyethylene terephthalate, a fluorocarbon resin, an acryl resin, an ABS resin and a urethane resin can be used.

[0118] Hereinbelow, the present invention will be described in more detail with reference to the following

Example and Comparative Example, but they should not be construed as limiting the scope of the present invention.

Example 1

[0119] Correction of splayfoot was performed using supporter **6** shown in FIG. **2**. The patient was a female of age 53 suffering from symptoms including the fallen longitudinal arch and transverse arch, formation of tylosis at the second and third MTP joint portions, and swelling (bunion formation), redness and pain of the hallux MTP joint. The HV angle (hallux valgus angle) was 25° (wherein the HV angle is the angle between the bone axis of the hallux proximal phalanx and the bone axis of the first metatarsal bone, which is an index of valgus deformation of hallux), and M1M2 angle was 15° (wherein the M1M2 angle is the angle between the bone axis of the first metatarsal bone and the bone axis of the second metatarsal bone, which is an index of the first metatarsal bone varus).

[0120] Hereinbelow, the supporter **6** is explained in detail. An elastic synthetic fiber cloth (73% polyurethane, 27% nylon) having a shape of an isosceles trapezoid (shorter parallel side: 2 cm, longer parallel side: 4 cm, and each of the remaining two sides: 8 cm) was used as the instep part **7**, and a rectangular polypropylene nonwoven fabric (width: 16 cm, length: 8 cm) was used as the sole part **8**. The elongation (A) of the elastic synthetic fiber cloth used as the instep part **7** was 75% as measured under the load of 4.9 N (500 gf) and 160% as measured under the load of 17.7 N (1800 gf), wherein the elongations were measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. The elongation (B) of the polypropylene nonwoven fabric used as the sole part **8** was 5% as measured under the load of 4.9 N (500 gf) and 10% as measured under the load of 17.7 N (1800 gf), wherein the elongations were measured in a direction corresponding to the widthwise direction of the foot on which the support structure is fitted. Accordingly, the ratio (A)/(B) of the elongation (A) of the instep part **7** to the elongation (B) of the sole part **8** was 15 as measured under the load of 4.9 N (500 gf), and was 16 as measured under the load of 17.7 N (1800 gf).

[0121] The opposite 8 cm-sides of the elastic synthetic fiber cloth used as instep part **7** were respectively sewn to the corresponding 8 cm-sides of the polypropylene nonwoven fabric to form a cylindrical support structure. The rectangular polypropylene nonwoven fabric used as the sole part **8** had two oval openings (bunion openings **10,10**) each having a major axis of 3 cm. The oval openings were formed at respective portions of the sole part which are to be contacted with the border between the metatarsal bones and the phalanges at the lateral and medial sides of the forefoot.

[0122] Strips of a conventional double-sided tape were cut out into the shape as shown in FIG. **2** and used as a pair of slip-proof means **9,9** for gripping the lateral and medial sides of the forefoot.

[0123] The width of the patient's foot, as measured under the load of the patient's weight, at the border between the metatarsal bones and the phalanges was 10.5 cm before fitting the supporter on the foot, but this value decreased to 9.5 cm after fitting the supporter on the foot. Further, after fitting the supporter on the foot, the HV angle of the foot decreased from 25° to 18° and the M1M2 angle of the foot decreased from 15° to 9° (both the HV angle and M1M2 angle were measured while the weight is on the foot). When the patient's foot was observed 8 hours after fitting the supporter on the foot, all of

the width, HV angle and M1M2 angle of the foot were respectively maintained at the above-mentioned values obtained by the measurements immediately after fitting the supporter on the foot, and the foot with the supporter did not show any disorders, such as swelling, paralysis, pain and redness.

Comparative Example 1

[0124] A supporter was produced in substantially the same manner as in Example 1, except that a pair of slip-proof means 9 for gripping the lateral and medial sides of the forefoot were not used. Using the produced supporter, the correction of the splayfoot was performed in the same manner as in Example 1. When the width of the foot with the supporter fitted thereon was measured without putting weight on the foot (i.e., while the foot was held in the air), the width decreased from 10.5 cm to 10.0 cm. However, the width of the foot returned to 10.5 cm under the load of patient's weight.

[0125] Further, when the HV angle and the M1M2 angle of the foot were measured under the load of patient's weight, almost no change was observed in the HV angle and M1M2 angle of the foot before and after fitting the supporter on the foot (the HV angle and the M1M2 angle of the foot having the supporter fitted thereon were about 24° and about 14°, respectively).

INDUSTRIAL APPLICABILITY

[0126] By the use of the support structure of the present invention, it becomes possible to not only maintain even under the load of user's weight the transverse arch formed by fitting the support structure on a foot, but also suppress the clothing pressure applied by the support structure against the instep to a relatively low level so that the occurrence of edema and paralysis can be prevented. Accordingly, the present invention enables comprehensive and effective prophylaxis and treatment of various disorders accompanying foot deformation (such as splayfoot, hallux valgus, falling of the foot arch (flattening of a sole) due to PTTD, and heel valgus) without inflicting discomfort and pain on the user. In addition, the above-mentioned excellent effects of the present invention can be accomplished by the use of thin materials and a simple structure, whereby the support structure of the present invention can be easily fitted on a foot and can be used in combination with outdoor or indoor footwear. This means that the daily use of the support structure is easy so that the above-mentioned excellent prophylactic and curative effects of the present invention can be easily enhanced to a larger extent by daily use of the support structure.

1. A support structure for prophylaxis or treatment of a disorder accompanying a foot deformation, which comprises: an instep part for covering an instep of a forefoot, a sole part for covering a sole of the forefoot, and at least a pair of slip-proof means for gripping the lateral and medial sides of the forefoot, wherein:

said instep part and said sole part are connected together to form a cylindrical structure such that, when the support structure is fitted on a foot, the borders between the instep part and the sole part are aligned with the lateral and medial sides of the forefoot;

said at least a pair of slip-proof means for gripping the lateral and medial sides of the forefoot are attached to the inner surface of said cylindrical structure at respective

portions thereof to be contacted with the lateral and medial sides of the forefoot; and

said instep part exhibits a larger elongation than said sole part as measured in a direction corresponding to the widthwise direction of the foot on which said support structure is fitted.

2. The support structure according to claim 1, wherein the ratio (A)/(B) of the elongation (A) of said instep part to the elongation (B) of said sole part is 1.2 or more, each elongation being measured in a direction corresponding to the widthwise direction of the foot on which said support structure is fitted.

3. The support structure according to claim 1, wherein each of said slip-proof means for gripping the lateral and medial sides of the forefoot is made of an adhesive material.

4. The support structure according to claim 1 which further comprises a pad attached to the inner surface of said sole part, said pad being attached to a portion of the support structure which is to face a metatarsal bone of the foot on which the support structure is fitted.

5. The support structure according to claim 1 which is in the form of a sock.

6. The support structure according to claim 1 which is in the form of a stocking.

7. The support structure according to claim 1, which further comprises an ankle support band to be fitted around an ankle in a manner such that an anterior of the ankle and a heel are encircled by said ankle support band, wherein said ankle support band comprises:

an anterior ankle part for covering the anterior of the ankle, a heel part for covering the heel, and

at least a pair of slip-proof means for gripping the ankle, wherein:

said anterior ankle part and said heel part are connected together in a manner such that, when the ankle support band is fitted around the ankle, the borders between said anterior ankle part and said heel part are aligned with the lateral and medial sides of the ankle;

said at least a pair of slip-proof means for the ankle being attached to the inner surface of said ankle support band, one of the slip-proof means being attached to a portion of the ankle support band to be contacted with medial malleolus of the foot and another slip-proof means being attached to a portion of the ankle support band to be contacted with the foot at an intermediate position between the lateral malleolus and the heel; and

said anterior ankle part exhibits a larger elongation than said heel part as measured in a direction corresponding to the widthwise direction of the foot on which said support structure is fitted.

8. The support structure according to claim 7, wherein the ratio (A')/(B') of the elongation (A') of said anterior ankle part to the elongation (B') of said heel part is 1.2 or more, each elongation being measured in a direction corresponding to the widthwise direction of the foot on which said support structure is fitted.

9. The support structure according to claim 7, wherein each of said slip-proof means for gripping the ankle is made of an adhesive material.

10. The support structure according to claim 1 or 7 which further comprises a hallux valgus correcting flexible plate, wherein said hallux valgus correcting flexible plate is attached to the inner surface of said sole part and extends along a portion of the support structure to be contacted with an edge of a medial side of the forefoot, said flexible plate having a wedge-shaped cross-section which continuously tapers in thickness from the top to the bottom.

11. The support structure according to claim **10**, wherein said hallux valgus correcting flexible plate comprises a shape-memory alloy plate extending in a longitudinal direction of said flexible plate, said shape-memory alloy plate being embedded in said hallux valgus correcting flexible plate or attached to the surface of said hallux valgus correcting flexible plate.

12. The support structure according to claim **7** which further comprises a pad attached to the inner surface of said sole part, said pad being attached to a portion of the support structure which is to face a metatarsal bone of the foot on which the support structure is fitted.

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