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Development of the Design of Footwear and Insoles for the Prevention of Flat-Valgus Deformity of the Foot

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ABSTRACT: The article is devoted to the design of children's shoes, for the prevention of the most common foot pathology in children - flat-valgus deformity. Comfort when walking orthopedic shoes is the most important, which depends on the shape and elasticity of the projections, as well as on the material used. The article compares the characteristics of polymeric materials that have a stable and predetermined elasticity. This shoe uses a new design of removable prophylactic insoles to improve the preventive properties of the shoe, bring the inner shape of the shoe closer to the natural surface of the soil, provide a reflex therapeutic effect on the foot, and create conditions for taking it easy off the shoe.

In addition, the shoe design is different from the analogs in that the design of the heel part of the shoe is proposed for tight fixation of the ankle joint, in which a certain stiffness is created due to the technological parameters. In the heel part, an additional fragment is used in which the intermediate part of the batting is attached by parallel seams at a certain distance. This creates the necessary stiffness of the heel part of the ankle.

Thus, in the new shoe design, preventive properties can be achieved due to the removable insole and stiffness of the ankle joint.

Keywords:flat-valgus deformation, children's shoes, removable preventive insole, additional node, heel stiffness, basic comfort, arch supports.

I.INTRODUCTION

According to statistics, one of the most common abnormalities in the anthropometry of children's feet is flat feet and X-shape legs (pes-valgus deformity), which manifests itself as a decrease in the height of the arches of the foot and a curvature of its axis: in standing position the child's legs become X shaped.It was found that 42% of children between 3 and 6 years which normal weight develop pes valgus. Age, gender, obesity, cerebral palsy, etc,- are known risk factors for the development of growth and musculoskeletal changes.[1]

II. METHODOLOGY

Often a shoe will suffice as therapy. Therapeutic, preventive shoes perform diagnostic, prophylactic and therapeutic functions. In the process of wearing such shoes, you can independently check for the presence or absence of defects in the development of the feet of a child by examining which areas have been rubbed off on the sole. In the case of proper development of the feet of a child, such shoes can be worn as a prophylactic for the correct formation of the

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joints of children's legs. In the case of detection of any deformity of the foot, it is recommended that prophylactic shoes be worn constantly using orthopedic insoles.

The main objective of this shoe is to prevent pathology and correct formation of the arch of the foot. The most important advantage of this shoe is the presence of a glued orthopedic insole - an arch support, the purpose of which is to prevent the occurrence of flat-footedness and relieve pain when walking. By production of this footwear only natural high-quality materials are used: leather and nubuck, allowing a foot to "breathe". Models characterized by the presence of a high rigid backdrop. The design of fasteners allows you to fix the foot of the child in the correct position. There is an optimum heel, the flexible not sliding sole. Thanks to this, the footwear ensures the correct development of the baby's feet, both as prophylactic footwear and as a medical footwear.

Improving the design of children's shoes is usually associated with a change in the elastic-geometric and dissipative parameters of the bottom support system, as evidenced by the emergence in the last decade of a stream of inventions, publications, and industrial developments carried out by leading shoe companies.

In foreign scientific and technical literature, publications on this issue are purely descriptive in nature. This makes it possible to assume that the effect of increasing the reference comfort achieved empirically. If computational methods are used, they are the property of the company and not published. Given the high importance of the problem raised to maintain and preserve the health of the population, it is advisable to concentrate the efforts of researchers on its resolution. At the same time, the existing general methods for determining the parameters of the structural elements of the shoe bottom system [2] can be very useful for solving particular problems of increasing the comfort.

The reference comfort as a component of the integral concept of shoe comfort reflects the conditions of the most favorable interaction of the plantar part of the foot with the shoe bottom system, which determined by an array of optimal indicators obtained when the human foot contacts the normal mass with the middle ground.

In the full range of criteria for assessing the reference comfort, there are three main, in accordance with which design changes should be introduced, the characteristics calculated and the materials of the bottom shoe system should be selected. These include:

Pressure distribution over the foot bearing surface (the criterion is pressure distribution);

Reaction to the heel part of the base in the phase of transfer of body weight to depreciation;

Tension arising in the plantar muscles and ligaments during loading of the foot (the criterion is the thrust force).

From the hierarchy of criteria, rather significant ones highlighted, since they are responsible for the multi-cyclical impact on the human musculoskeletal system, prevention of flatfoot and integral 30% reduction of contact pressure on the plantar part of the foot.

To improve the footwear comfort, various structural solutions used, including supplementary insoles. In many cases, in addition to insoles, other attachments used in shoes. These are various silicone elements (under the heel area - with shortening of the limb, incorrect installation of the ankle joints), under the anterior sections of the feet (with painful corns, curvature of the fingers, and in other cases) [3, 4].

The considered designs can provide the reference comfort according to the established criteria if the geometry of the elements and the footprint planimetry are justified by metric synthesis, elastic and dissipative characteristics of the materials used, dynamic calculation and clearly conducted experiment.

The introduction of structural elements into the bottom system without proper substantiation of their characteristics may not only fail to improve the comfort conditions, but also lead to the opposite result. Thus, the installation of a protrusion of too rigid material in the beam part will lead to the loss of its spring functions by the foot,

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since the metatarsal support cannot move in the horizontal direction; if the protrusion material is soft, it will not be able to create the proper resistance to the thrust force and the effect of installing the protrusion will be minimal.

Low-profile bearing surface due to insufficient contact will not be able to bring the pressure distribution to the optimum; if the profile parameters are overestimated, there may be conditions for the unloading of the supporting skeletal elements of the foot and the loading of soft tissue ligaments.

When using rigid materials for the heel part of the bottom of the shoe, the shock load on the skeleton increases significantly, while excessive material compliance leads to disruption of the step rhythm by increasing the phase of indentation of the heel part into the bearing surface.

III.PATENTS SURVEY

An analysis of the trends in the development of comfort shoes has shown that the variety of technical solutions to the problem of increasing support comfort suggests that this question is in a state of search for the optimal option.

The introduction of structural changes without calculating the characteristics and selection of materials corresponding to these characteristics may lead to negative results.

Support comfort in shoes can be achieved by jointly solving a constructional problem, based on introducing rational elements into the bottom shoe system [5], and the problem of mechanics of a deformable body, which allows establishing the optimal values of elastic geometric and dissipative characteristics of structural elements.

One of the types of preventive and curative care for flattening the longitudinal and transverse arches of the feet is the use of insteps [6].

In [7], the results of comprehensive studies on the search for polymeric materials with stable and predetermined elasticity presented.

Most fully, meet the medical requirements of the instep of PU and a copolymer of ethylene with vinyl acetate (EVA). PU has a stable elasticity, as the plasticizer is a high molecular weight product. The material is non-toxic; the technology of manufacturing orthopedic products from it is simple and available to prosthetic and orthopedic enterprises. Products can be obtained by injection molding.

Another new thermoplastic material is EVA. This material is also non-toxic and has a stable elasticity. The material is relatively easy to process by injection molding at 100°C -110°C. By their nature, both of these materials characterized by high chemical resistance and water resistance. Materials can be painted in body color and other colors. Finished products do not have a harmful effect on the body.

IV. MAIN PART

In order to improve the prophylactic properties of shoes, approximate the internal shape of the footprint to the natural surface of the soil, provide a reflex-therapeutic action on the foot, create conditions for the convenience of removing it from the shoes, a new design of a removable preventive insole has been developed.

From the prior art known insoles designs for children's prophylactic shoes [8], which contains the upper, intermediate and lower layers. The upper layer is made of leather, the intermediate layer of preformed in the process of wearing foamed thermoplastic material, and the lower frame layer of dense thermoplastic material, while the intermediate layer is made with a recess in the heel part under the tubercle of the calcaneus.

Another construction of aninsole for children’s prophylactic [9,10] footwear containing upper, intermediate and lower layers has an additional intermediate layer, which, covered with various diameterssilica gel grains.

The disadvantages of this design is that the diameter of the silica gel grains in the instep part does not provide sufficient preventive properties with the tendency of the pillars to flat-valgus deformation.

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To improve the preventive properties of footwear, to bring the inner shape of the footprint closer to the natural surface of the soil, to provide a reflex-therapeutic action on the foot, to create conditions for the convenience of removing it from the shoe, a new design of a removable preventive insole has been developed. In Fig 1,a) general shape of preventive removable insole.

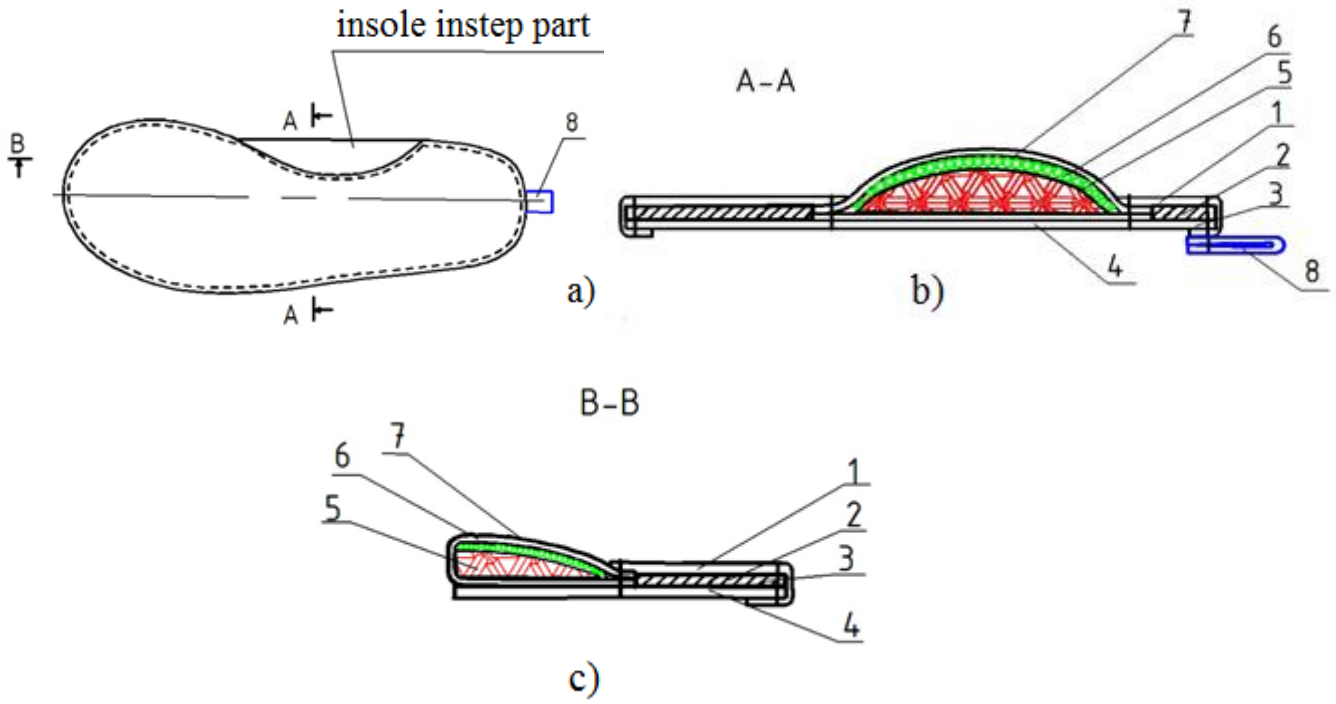

Figure 1–Removable preventive insole
a) general view, b)cross section along A-A line,c) cross section along B-B line

Removable insolesis a multilayer structure consist an upper layer 1, intermediate layer -2 of textile material, the which surface parts are glued silicagrains. This layer is located above the other - intermediate elastic layer 3 and the bottom layer of the insole board 4. Instep inner side portion sewn in the form of additional item correction pad - 5, which is glued silica grains 6. Correction pad-fitted by a textile material or leather lining 7 and pasted on the bottom layer of the insole board 4. All layers stitched around the perimeter at a distance of 2-5 mm from the edge. In order to easy remove insole from footwear. In the prominent part of the heel part stitched textile tape loop -8 (Fig.1 a,b,c)

The top layer can be made of textile material or leather lining. Figure 2 shows the experimental models developed removable insoles.

In addition, shoes for a child with a flat-valgus foot should have a rigid heel part well fixing ankle joint with laces, straps, etc.

Figure 2 - The pattern design upper of children's shoes
a) Constructive basis of the upper part of the shoe, b) fragment of upper heel part

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For fixing the ankle, the design of the heel part of the shoe is proposed, in which a certain stiffness is created due to the technological parameters, namely, in the heel part an additional unit is used consisting of the outer part, the intermediate part and the lining, Fig.2 a)

Intermediate piece of batting, which is attached to the details of the top of the parallel lines at a certain distance Fig.2 b) creates the necessary rigidity of the heel part

V. CONCLUSION

Thus, prophylactic properties can be achieved thanks to the dual use of removable prophylactic insoles and the structural rigidity of the heel part of the shoe. Multifunctional preventive insole with corrective pads has an ergonomic design, can effectively reduce pressure on the foot, silica gel can absorb moisture and sweat, so children's feet remain dry and feel comfortable

Stiffness fragment of the design of the heel part of the shoe, fixing the ankle joint, helps prevent the formation of X-shaped children's legs

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