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# **Operational and Technological Requirements for Rational Shoes for Patients with Diabetes**

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**ABSTRACT:** This article describes the hygienic and anthropometric requirements for creating rational shoes for patients with diabetes, since diabetic footwear should provide the maximum comfortable foot position with optimal load distribution, which significantly reduces fatigue and pain, and shoes should also be hygienic. to protect the body from external influences and a favorable microclimate of the footwear space.

**KEY WORDS:** Operational and technological requirements, diabetic pathology, pathological changes, diabetic foot syndrome, orthopedic and prophylactic products, prophylactic shoes, foot deformities, orthopedic shoes,

## **I. INTRODUCTION**

Diabetic pathology of the feet has been the subject of much research, but almost all of these works concerned the already developed severe manifestations of angiopathy and neuropathy, that is, the diabetic foot syndrome complex. Pathological changes in the feet in patients with initial manifestations of this pathology have not been adequately studied, especially from the point of view of orthopedic provision. Moreover, such patients make up the majority of the total number of patients with diabetes mellitus and subsequently replenish the group with developed complications on the feet. The range of orthopedic products for such patients in our country is very limited, and orthopedic provision is reduced to recommendations on the selection of shoes. Incorrectly selected orthopedic and prophylactic products together with the acquired stereotype of walking can eventually increase the risk of foot deformity, which can adversely affect the patient's condition.

To date, there is no classification based on the parallel of clinical and biomechanical manifestations of diabetic foot pathology, which allows the timely appointment of rational orthopedic shoes and insoles.

The human foot is experiencing tremendous stress throughout life. The foot consists of 19 muscles, 26 bones, 33 joints and 107 ligaments, tendons and nerves.

To understand how leg problems arise, we need to consider the mechanics of movement. Most of the problems with the legs, with the exception of those caused by injuries, and a number of complaints of pain in the knee and hip joints, as well as in the spine, occur in violation of the biomechanics of the foot. Many of these diseases can be cured using orthopedic shoes. As you will see below, today computer technology has made possible excellent diagnosis and treatment of almost all abnormalities

In individuals with various types of foot deformities, both with diabetes mellitus and without it, the pressure distribution on the sole of the foot has the character of local overloads, which coincide with the location of the bumps. With flat feet, the heads of I, II and III metatarsal bones are often overloaded, as well as the distal phalanx of the first finger. With the flattening of the forefoot - the head of the I - V metatarsal bones, the distal phalanx of the first finger and the base of the V metatarsal bone, and with an increase in the longitudinal arches of the foot - the head of the I - V metatarsal bones, the calcaneal tuber. Toes are practically out of load. When walking, the nature of the pressure distribution is maintained.

A comparative analysis of the pressure distribution under the feet in the standing and walking position showed that patients with various deformations of the feet and patients with diabetes mellitus with preserved pain sensitivity or with a slight decrease in static unload the painful areas due to load transfer to other areas of the foot.

In patients with diabetes mellitus with a marked decrease in sensitivity on the foot, the overload zones do not change their standing or walking position.

It is known that with any kind of locomotion, the foot experiences the greatest loads from the plantar surface. Therefore, increasing the supporting comfort of shoes is the most important task for shoe industry specialists.



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One of the most significant criteria for supporting comfort is the distribution of dynamic loads (pressure) over the plantar surface of the foot.

As a result of scientific and practical studies of diabetic feet, the need for orthopedic support has been substantiated already in the early stages of development of diabetic foot pathology. A new shoe design has been developed that allows rational preventive care for patients based on indications for the use of orthopedic shoes and orthopedic shoe products, as well as medical and technical requirements for orthopedic shoes, shoes and insoles for patients with initial manifestations of diabetic foot pathology. In the manufacture of prototypes, male and female blocks of the initial sizes with the corresponding heel heights and parameters close to those being developed were chosen. Pads have been modified in accordance with manually constructed sections. After making the mock samples of the shoes, the pads were adjusted, which consisted in increasing the elevation of the toe of the men's pads and changing the shape of the toe of the women's pads, as well as insoles with an air gap.

The conducted studies allowed us to formulate medical and technical requirements for the design of the orthopedic insole and shoes for patients with initial manifestations of diabetic foot pathology:

- make orthopedic shoes according to a specially developed block;
- the design of the orthopedic insole should provide a rational redistribution of the load on the plantar surface of the foot, taking into account the degree of development of the disease.

During the use of individual orthopedic insoles, none of the patients suffered damage to the skin of the feet. Almost all patients noted a decrease in pain and an increase in comfort when standing and walking. However, as a remark, in some patients with pronounced deformities of the feet, difficulties appeared in the selection of standard shoes, which once again confirms the need to use orthopedic shoes in this category of patients made using a special unified block.

Orthopedic shoes are shoes designed for people who have problems with the ligamentous apparatus of the foot or other diseases of the lower extremities. The use of correctly selected orthopedic shoes helps to correct deformations at an early stage of development, and also prevents the further progression of the disease. The correct selection of such shoes is carried out only by a specialist who is directly involved in your disease or problems associated with your legs. Prophylactic orthopedic shoes may be needed not for all patients with diabetes, but for those who have various deformities of their feet.

Properly selected shoes can reduce the risk of diabetic foot syndrome by 2–3 times. It should be noted that such shoes have a special structure. It is due to this that a medical effect is achieved. Orthopedic shoes are made from natural materials. No substitutes are acceptable here. It absorbs moisture perfectly and allows the foot to breathe. Unlike everyday shoes, it has a tight and rigid back that provides reliable fixation of the foot. In high-quality shoes, the back should not shrink and deform. Additional tabs fix the ankle joint well and do not allow the calcaneus to deviate from the axis of the lower leg. Another difference is the presence of a special insole, which has a slightly curved shape and arch support. An orthopedic insole secures the foot in a suitable position, and also allows you to evenly distribute the load throughout the foot.

Diabetic footwear provides the most comfortable foot position with optimal load distribution, which significantly reduces fatigue and pain. These products have:

- a wide sole providing good stability on any road surface;
- comfort and ease when dressing or taking off without involving assistants;
- soft top and bottom, preventing injury to deformed sections of the lower extremities;
- a special forefoot, in which the fingers are completely free and placed as comfortably as possible;
- a small heel with a beveled front edge or a solid platform without a heel.

We have everything necessary to ensure ergonomic requirements related to the comfort of shoes to wear. It is known that diabetic shoes can be irrational in terms of nasal comfort. Therefore, when developing a rational design of diabetic shoes, it is necessary to ensure the conditions of its operation..

There are four groups of ergonomic indicators:

1. Hygienic.
2. Anthropometric.
3. Physiological.
4. Psychophysiological.

Shoes from a hygienic point of view should provide protection for the body from external influences and a favorable microclimate of the footwear space. Anthropometric indicators are determined by the conformity of the product to the size and shape of the human body.



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In general, the hygienic and anthropometric requirements for shoes for patients with diabetes are made up of the requirements for the design of shoes, due to the peculiarities of the structure of the foot, and the materials from which the shoes are made. Size and style affect its flexibility, as the bending arm lengthens with increasing size and the corresponding bending load decreases.

Physiological and psychophysiological indicators are determined by the conformity of the product design with power, energy, physiological, visual, auditory and other human capabilities.

Thus, ergonomic indicators are closely related to various factors of shoes: design, materials, the shape of the details of the top and bottom, the shape of the toe and heel parts, the shape of the footprint of the shoe.

The specific requirements for the internal form (block) of diabetic footwear intended for use by patients with diabetes include the following:

- the shape of the front of the shoe should be designed in such a way that the inner surface of the shoe promotes the free arrangement of the fingers and the location of the orthoses in the toe-beam part of the foot;
- the shape and dimensions of the pads should be designed taking into account the coverage sizes of diabetic shoes.

The following requirements are imposed on orthopedic shoes for patients with diabetes mellitus: the materials used must be environmentally friendly and subjected to hygienic treatment; the top of the shoe - to provide freedom in the forefoot and reliable support for the heel, the work piece of the upper - to have a minimum number of seams and to be covered with soft material from the inside; all seams, parts and decorative elements should not exert pressure on the foot; if possible, it is necessary to abandon the toe cap, or it is performed in a shorter form; the sole should correspond to the size of the foot and the weight of the patient, as well as the specifics of the environment.

It is proved that the use of specialized orthopedic shoes is reduced by 2 times.

The most important factor contributing to the development of diabetic foot ulcers is high plantar pressure. This factor affects only in combination with neuropathy. That is why any treatment must necessarily take into account the need for partial or complete unloading of certain zones or the entire foot.

The lack of measures for unloading the foot, high plantar pressures can cause the formation of ulcers on the foot, which has lost sensitivity. There are three ways of damage. The first is the effect of the load on a very small area, for example, on fingers with high heels, even insignificant in time.

To date, there is no classification based on the parallel of clinical and biomechanical manifestations of diabetic foot pathology, which allows the timely appointment of rational orthopedic shoes and insoles.

Requirements for the rational shape of the draw pads:

- the shape and geometric dimensions of the pads should provide the necessary footwear for the toe, to take into account the thickness of the interstitial layer, to correspond to the optimal height of the heel of the heel of the foot;
- in case of edema growing at the end of the day, it is advisable to recommend shoe designs with parts that regulate volume parameters, while pads should ensure the use of the maximum (possibly non-standard) volume;
- it is necessary to take into account the case of the use of replaceable inset soft devices in one shoe design, which can be used as edema increases (decreases);
- this option pads must be made individually and take into account the full, long and high increments depending on the deformations of the feet.

Requirements for the construction of the shoe upper. When designing designs for special shoes for patients with diabetes, it is advisable to consider the following:

- the design of the top blank for special orthopedic shoes for patients with diabetes mellitus should be devoid of traumatic seams, folds of any thickness, thickenings (in various connecting nodes);
- the design of the shoe has an allowance taking into account the thickness of the insert orthopedic insoles;
- have a minimum number of cutting parts in the area of the sock beam part; the lining is built with a minimum number of parts and lines;
- in the designs of shoes and low shoes to use for fastening shoes on the foot (depending on the deformations of the diabetic foot), laces, belts with buckles, belts with Velcro tape;
- in the designs of boots and low shoes to design a soft tongue that prevents rubbing with edema of the foot or bandaging;
- the design of summer shoes for holding on the foot must be secured with a lifting belt;
- limit the use of elastic braid; use it in cases minor deformations of the feet;
- high aesthetic characteristics of shoes, including design and colors are one of the components of psychological

patient comfort.

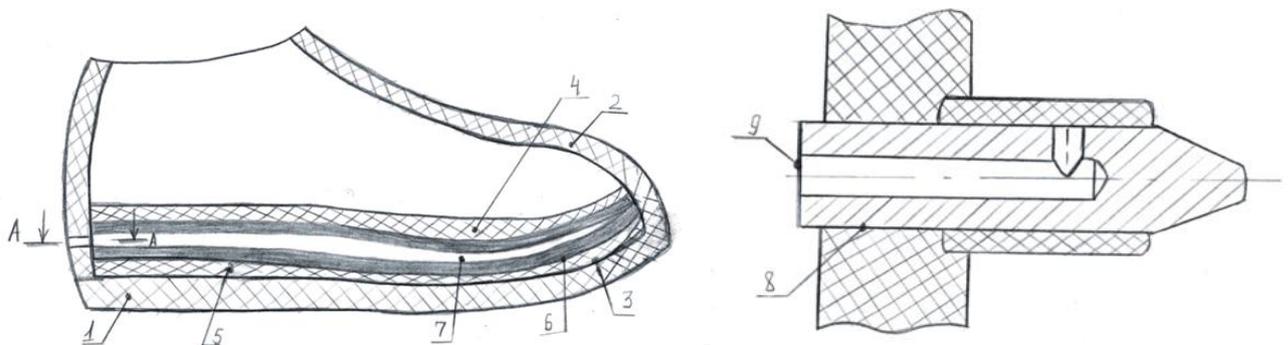
The essence of the invention lies in the fact that orthopedic shoes for patients with diabetes mellitus, consists of a sole fastened to the sole and interconnected whole-cut top and lining, provided with a tongue, a multi-layered volumetric insole made with the possibility of removing it from shoes, fastening elements, In this case, the insole is a three-layer insole with a three-layer insole from the lower and upper elasto-elastic coatings, the method of which is sealed with a certain pressure, an elastic-elastic material having an opening with a nipple device for changing the pressure in the airtight zone of the main composite insole.

The proposed design of orthopedic shoes for patients with diabetes mellitus allows you to relieve pressure on individual parts of the foot, while ensuring an even distribution of the load on the entire surface of the foot. At the same time, it is possible to achieve maximum unloading of the foot due to the combination of materials of the inset volume insole.

The upper cover of the insole is made of ortholux material with perforation. The material contributes to the creation of an optimal microclimate in shoes, has elastic properties, reduces the "shear force" and friction when walking and running. The intermediate layer located under the top coating due to tightness, elastic properties and air under pressure in it reduces typical loads from pressure zones, takes the form of the foot during wear and the load will be uniform throughout the foot area. The lower pad of the inline volumetric insole also allows unloading of the foot due to its high shock-absorbing function.

Orthopedic shoes (Drawing number 1) for patients with diabetes consists of a sole 1, attached with the sole of the top and lining, made of one-piece with a soft tongue of shoes.

Inside the shoe, there is an insert volume insole 3, consisting of upper 4 and lower 5, coatings of elastic materials, and between them there is an intermediate hermetically made and partially filled with air 7 with a certain pressure gasket 6 made of elastic material.



**Drawing number 1. The proposed design of orthopedic shoes for patients with diabetes**

The gasket 7 has an opening with a drip device 9 for changing the air pressure in the sealed zone of the gasket.

The design works as follows, when moving and walking a patient with diabetes mellitus, the inset volume insole 3 is affected by concentrated loads in various parts of the surface of the foot. In this case, the corresponding parts of the upper gasket 4 are deformed, and then the load falls on the intermediate gasket 6. Due to the air 7 being under pressure in the sealed zone of the gasket 6, the load is instantly redistributed and the upper part of the gasket 6 presses the shape of the foot, and the pressure over its entire surface distributed evenly. In this case, the lower pad 5 also performs uniform distribution of the load over the entire surface of the foot. If necessary, through the nipple device 9, you can adjust the air pressure in the 7 tight zone of the gasket 6. The design allows uniform load on the entire surface of the foot. The design can be used for all types of shoes.

Orthopedic shoes are individually customized for the patient. If necessary, the master makes changes to the design of the heel, the sole, as well as the upper of the shoe, which helps to unload the foot, cushioning and makes rolling easier when walking.

In addition, the diabetic footwear produced on these pads should be suitable in size and shape for the vast majority of consumers, and the quantitative ratios of the shoes of various sizes should not differ from the ratios of the sizes of the feet of consumers.



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It is known that one of the reasons for the occurrence of foot defects is a mismatch in the ratio of the type-size of the feet of patients and the size-full assortment of shoes. As a result of this, an individual selection to the foot is carried out by a certain group of the population or working incorrectly. They are forced to use shoes of larger or smaller sizes, which negatively affects the work of the foot.

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