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Instrumental Methods of Evaluation in Orthopedic Support for Patients with Diabetes Mellitus

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ABSTRACT: To solve the problems of rehabilitation of the lower extremities, an important role is given to the examination of the functional state of the feet. When recommending orthopedic shoes, using a computer podography, you can see the real picture of the pressure distribution over the surface of the track and identify areas of foot overload.

KEY WORDS: measuring insoles, risk of recurrence of trophic ulcers, irrational shoes, podograph, decreased sensitivity, treatment and prophylactic effects, internal form of shoes.

I.INTRODUCTION

One of the indicators of the quality of the shoe is its convenience, determined by the correct ratio of the shape and size of the foot and the inner space of the shoe. The shape and dimensions of the internal shape of the shoe depend mainly on the shape and size of the shoe on which the shoe is made. Therefore, the shoe block is the main device on which the molding, assembly and finishing of shoes is carried out. And already, proceeding from the parameters of the shoe, they design the working bodies of many shoe machines, design the details of the top and bottom of the shoe [1,2].

Shoes are designed to protect the foot and, therefore, the entire human body from environmental influences; it facilitates movement and provides a normal environment for work and leisure.

In conditions of increasing requirements for the quality of shoes, constant updating of the assortment of materials, their reasonable choice is of particular importance, as well as the study of methods for evaluating the most important properties of materials, which determine their ability to satisfy human needs for products.

A shoe block is not an exact copy of the foot, but represents its stylized display of a certain aesthetic orientation, manifested in the man-shoes-art form system. The main task of the designer of the internal form of shoes is to comply with the anatomical and physiological requirements or to find compromise solutions with the requirements of fashion, but with the indispensable advantage of rationality.

The technical side of designing the internal form of shoes is diverse and complex. Anthropometric data on the shape and size of the foot, taking into account its physiology and biomechanics, must be converted into the parameters of the block and based on them to determine the outlines of the curved faces of its surface.

Due to the lack of information and control of the spatial form of shoes, the subjectivity of solving the shape of individual sections of the surface and their conjugation are random, irregular. All this complicates the use of automatic or semi-automatic equipment, exact methods for the production of shoes, and makes it necessary to use technology that provides for irrational allowances of parts for processing.

II. SIGNIFICANCE OF THE SYSTEM

Biomechanical properties due to the function of the foot include: mass, cushioning properties, flexibility, rolling, stability and retention.

During operation, a person interacts with shoes. In the process of wearing shoes, the foot from the inside acts in a certain way on it and, over time (along with environmental factors), deforms and destroys it. In turn, shoes also affect the human body. At the same time, the negative effect of the irrational design of shoes on human health and work

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capacity is possible. It is also important to consider that a person interacts with shoes when carrying out auxiliary processes - putting on, removing, leaving, etc [3].

The magnitude, direction and place of application of forces acting on the shoes change sharply during walking and running, three main types of resistance of the shoe to deformations arising from the force of the foot are distinguished:

-bending stiffness characterizing the resistance of the shoe to bending;

- spacer stiffness, characterizing the resistance of the cross sections of shoes in the bundle and forefoot to a change in its geometric shape;

- supporting stiffness, characterizing the resistance of the bottom of the shoe to a change in geometric shape in the direction of increasing the contact surface with the support under the action of compressive forces normal to the supporting surface.

№	Period	Walking		Running	
		Time shares seconds	% duration of the reference period	Time, fractions seconds	% duration of the reference period
1.	Double step	59/60 - 82/60	-	34/60-51/60	-
2.	Support on both legs (total)	10/60-27/60	3/12-57,1	-	-
3.	Being in the air of both legs	-	-	14/60	-
4.	Supports of one leg	31/60-60/60	-	12/60-29/60	-
5.	From the moment of separation of the beams from the support to the moment of separation from the support of the fore part	6/60-36/60	13,6-67,4	5/60-18/60	26,5-79,6

III. LITERATURE SURVEY

Creating a database for the scientific justification of medical footwear designs, taking into account the location of reflex zones on the feet, will allow not only correcting and unloading the deformed areas of the feet, but also providing therapeutic and preventive effects through them on individual organs.

Diagnosis of the human musculoskeletal system is especially important, which is explained by a direct relationship between the condition of the human feet and the condition of the human spine, as well as the maxillofacial system of a person. The development of foot pathologies leads not only to an incorrect distribution of pressure on the supporting surface, but also to joint pathologies, which in turn can disrupt a person's usual way of life.

Diabetic foot problems are currently of great interest to all leading orthopedic firms in the world. Diabetes mellitus is a chronic disease that at the present stage of development of medicine cannot be cured. According to the WHO International Committee the number of patients with diabetes has increased significantly and makes up more than 3% of the world's population, and in the age group over 60 years old - 7-9%. However, many experts believe that the true incidence of diabetes is 2 times higher than detected. Every third patient is hospitalized due to foot damage, diabetic gangrene is the cause of 70% of all amputations [4].

Especially important is the timely detection of pathologies associated with diabetic foot syndrome. Diabetic foot syndrome is characterized by purulent-necrotic processes and, in advanced cases, can lead to amputation of the affected lower limb. The relevance in the timely detection of this pathology is due to the number of people with diabetes. This number is increasing annually. Moreover, from the number of 5 million, about a quarter is susceptible to the manifestation of diabetic foot syndrome. Untimely detection of this pathology leads to amputations, and then to an increase in the number of people with disabilities.

The idea of computer podography comes from optical methods for diagnosing feet. Known systems that contain a glass plate where a person is placed, and a scanner that takes pictures of the feet of the subject. According to the images obtained, having previously performed certain analytical calculations, they are diagnosed. The method has

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proven itself and is still used today. This diagnosis has a drawback - a person is standing during the study, i.e. is in statics. However, a person's lifestyle also includes a dynamic component or the commission of various locomotor acts: walking, running and other physical activities.

Given the above, we can conclude that when using optical methods for diagnosing the musculoskeletal system of a person, it is not possible to obtain data on the distribution of pressure on the supporting surface of the human foot during physical exertion[5].

To solve this issue, it is proposed to use the method of computer podography. The method itself is based on determining the distribution of pressure on the supporting surface of a person's feet using a computer podograph. A computer podograph is an information-measuring system, which includes a data acquisition unit, a data processing unit, and a personal computer.

The device is a measuring insole with sensors mounted in them, which are embedded in the shoes of the subject. After processing the received data, they are sent to a personal computer, where they are interpreted in a special software package and diagnosed.

The prospects for such information-measuring systems are quite extensive. The use of research results can be applied in sports medicine, the production of orthopedic shoes and other fields.

When designing the internal form of shoes (pads), it must be taken into account that even slight pressure on the surface of the foot leads to squeezing of the capillaries and squeezing out of them blood. Prolonged circulatory disturbances in the capillaries can lead to traumatic injuries.

Comfortable shoes should be considered one that does not cause disturbances in the circulatory system of the skin and bone structure of the feet, i.e. ensures its normal functioning. It is known that the foot of the shoe, especially in shoes and low shoes, is compressed in the transverse direction. Already when putting on the shoes and the position of the legs on weight, compression of the foot and stretching of the upper material in the transverse direction are noted. To determine the pressure of the shoe on the foot, it is necessary to proceed from an objective assessment. Such an assessment can serve as a change in blood supply during compression of the foot.

People with diabetes should pay special attention to their legs and feet. To protect against injuries while reducing sensitivity, to prevent ulcers, orthopedists are advised to wear preventive orthopedic shoes.

In people with diabetes, blood vessels and nerves are affected. As a result, the sensitivity of the legs decreases, the risk of foot injuries, the development of foot ulcers increases.

Diabetic shoes are one of the preventive measures aimed at preventing the development of foot injuries. If the patient wears orthopedic shoes suitable for him, then this reduces the likelihood of ulcers on the foot by 2-3 times.

Diabetic foot syndrome is an independent complication of diabetes mellitus, which is dangerous due to the severe clinical, psychological, social, economic consequences.

In order to prevent the development of complications, you need to know the causes of their occurrence. Quite a few factors have been identified with which the development of diabetic foot syndrome is associated. Of particular interest is the determination of the significance of social and hygienic risk factors in the occurrence and course of diabetes [6,7,8].

IV. METHODOLOGY

The main purpose of the confection of materials for the product is the production of high-quality goods, competitive in market conditions. This provides a comprehensive solution to the problem of rational and proper selection of materials in product packages, based on in-depth knowledge of the assortment, material properties and requirements for the product as a whole and its individual parts.

The causes of deformities of the feet can be conditionally divided into external and internal. External causes include overload, depending on the nature of work and irrational shoes, internal - hereditary-constitutional predispositions, as well as primary weakness of the muscular system. In the classification of pathological conditions of the feet due to excessive static load, static deformations and functional failure are usually distinguished. Static deformations include: longitudinal and transverse flat feet, deviation of the thumb outward, hammer-shaped fingers, callosity, corns and scuffs. Functional failure of the feet is characterized by rapid fatigability of the lower extremities, soreness of the feet and lower leg, swelling of the soft tissues of the feet, instability of the joints under exertion (tucking of the foot when walking and running), increased sweating.

According to a randomized clinical trial, for 1 year of wearing "shoes on a finished block" there was a 45% decrease in the risk of recurrence of trophic ulcers.

High-quality orthopedic shoes significantly (2-3 times) reduce the risk of cider for diabetic foot - that is, it has a more effective preventive effect than most drugs prescribed for this purpose.

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When developing the design of shoes, it is necessary to take into account the specifics of the foot as an organ of motion support. These features are studied by biomechanics and physiology of the motor apparatus. So, with the help of biomechanical analysis, a rational form of the stealth surface of shoes can be revealed. The task of biological mechanics is to describe the movement, identify the forces acting in this case, their nature, conditions of action and effectiveness. When standing, relatively few muscles work. The immobility of most joints is achieved thanks to the simple tension of the ligaments, with almost no muscle involvement. With a symmetrical standing, the severity of the human body is evenly distributed on both feet. When designing shoes, possible deviations with the structure and functions of the foot are taken into account [9,10].

The development of a scientifically based methodology for assessing the force interaction of the foot and shoes according to the indicators of the physicomechanical properties of the material packages is verified and predicting these properties according to the parameters of the force interaction of the foot and shoes.

As a type of movement, ordinary walking forward along a straight path was chosen. The speed and stereotype of walking were familiar to each subject.

The properties of the supporting surface remained unchanged throughout the experiment: carpet with a small pile. The length of the path of movement of the subjects - 6 meters - a sufficient distance to stabilize walking.

Using the “DiaSled” measuring complex, the following characteristics were recorded:

-the distribution on the plane of the measuring insoles of the specific pressure Pij maximum during the experiment:

Ppm = fin); Pu = f (t)

where Pij is the maximum pressure at the sensor ij, n is the number of the read cycle, 1 is the current experiment time, i, j is the column and row in which the sensor is located;

trajectory of the center of foot pressure on the measuring insole:

Ppm = f (n); ys= fin); Pu= F (t); yz = f (f)

where xy, yy are the coordinates of the center of pressure along the xyy axis located in parallel, respectively, with the rows and columns of the sensor matrix in the measuring element.

The following measurements were carried out under conditions when the right foot of the subjects was compressed with the help of insoles first half full, which corresponds to compression by 4 and 8 mm, respectively. The left foot, as already noted , remained uncompressed and served as a "standard" for assessing changes in the pressure distribution under the right foot. For each of the two degrees of compression for each foot, the pressure distribution on the plantar surface was obtained. Thus, as a result of the experiment, it became possible assess the impact of the completeness of shoes on the biomechanical characteristics of the walk for ten surveyed.

For example, consider the construction of a section of 0.68D. The coordinates of point 1c are entered first, then the points 1n, since arcs of this type are always constructed counterclockwise. Then enter the value of the radius of curvature, in this case it will be the radius Rsl.

Further arcs are constructed in the following order:

- from point 2c to point 1c, radius P1c ;
- from point 1n to point 2n, radius Pn ;
- from point 2c to point Sv, radius P2v;
- from point Zn to point 2n, radius P2n .

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Points Zn and Sv are connected by a segment or an arc, depending on the section. In this case, the points Zn and Sv are connected by an arc with a radius of P3 (Fig. 2.).

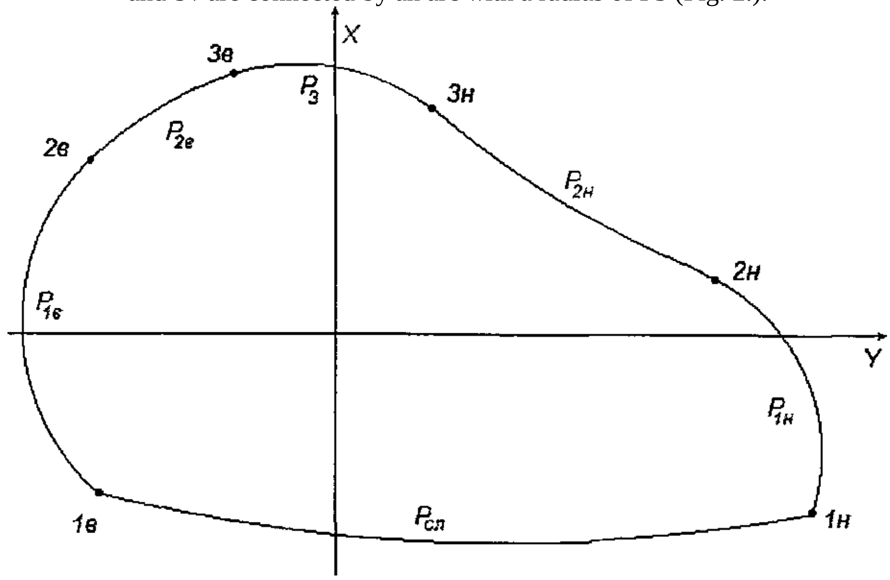

Fig. 1. Section 0.68D

As a result, all arcs are interconnected, forming a contour of the section of the block. In order for all these actions to be performed automatically, we wrote the "last" subroutine. The connection is made by means of spline modeling, due to which the smoothness of the composite curve at the interface points is ensured.

The total error in the assessment of supporting comfort by the proposed method includes the following components:

1. The error in measuring pressure in each sensor, due to the fact that the measuring insoles of any systems are capable of fixing only the force perpendicular to the plane of the sensors. The horizontal forces arising during locomotion can be measured only by the platform, but its use in the proposed experiment is impractical.

In addition, the sensors of the measuring insole embedded in the shoes are not located in the same plane, since the shoe trace has a complex profile. Therefore, as a result of the inspection, only a part of the vertical force is measured, and with a significant profiling of the track, there is a danger of recording pressures arising from the bending of the measuring insole.

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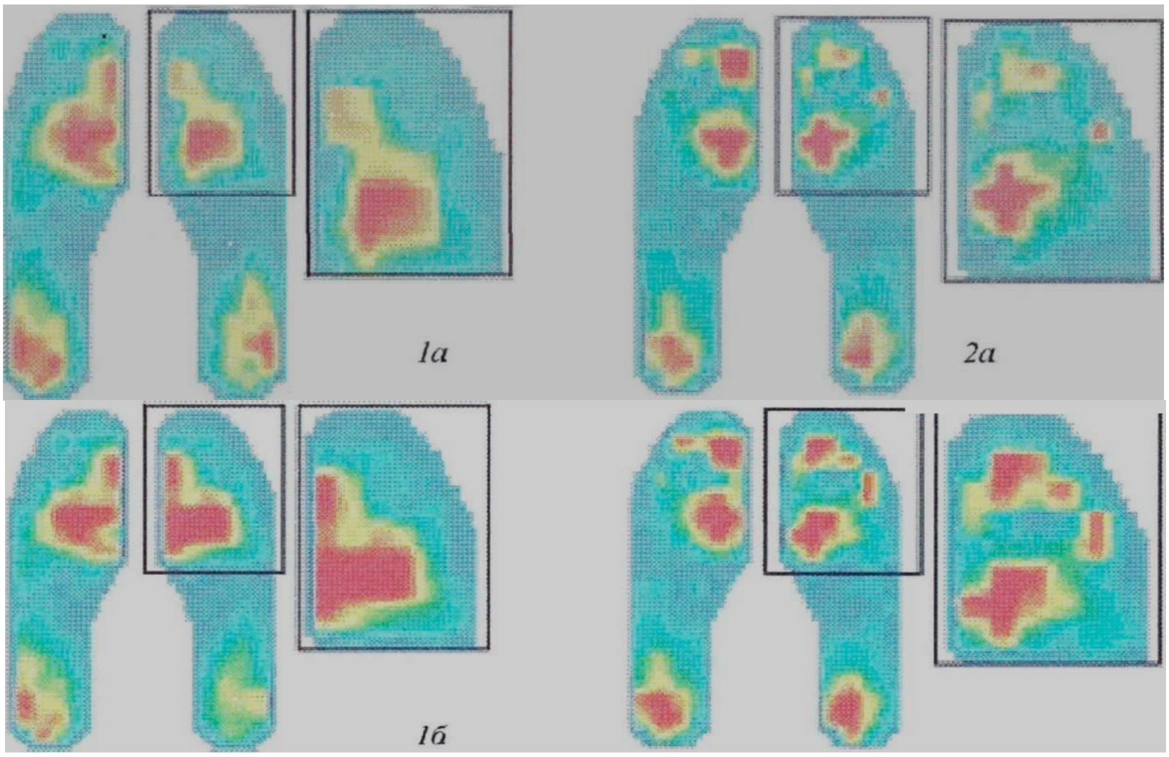

Fig. 2. Pressure distribution under the feet of the subjects P-th (1) and N-th (2)
a - walking under normal conditions (without compression); b - walking with compression of the right foot by one full

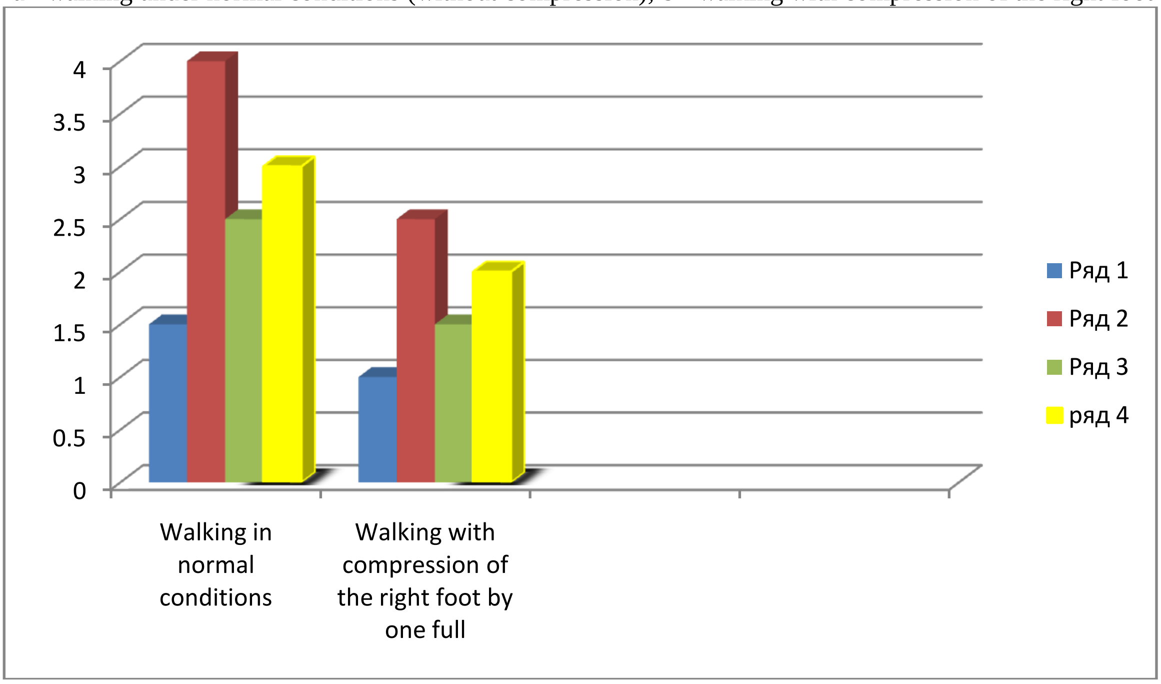

Fig. 3 Diagram of the pressure distribution under the feet of the subjects P-th (1) and N-th (2)a - walking under normal conditions (without compression); b - walking with compression of the right foot by one full

When analyzing the results of the experiment, the influence of the completeness of the shoe on the pressure distribution over the plantar surface of the foot was initially investigated. In fig. Figure 11 shows the pressure distribution patterns for two examined under different walking conditions: without additional compression of the feet and under compression of the right foot to fullness (8 mm). The maximum pressure is shown in red, the minimum - in blue. For informational purposes, the area corresponding to the forefoot of the right foot, where the greatest changes in pressure were observed, is presented on a larger scale. Under compression of the foot, an increase in plantar pressure was observed under the heads of the metatarsal bones, in the toe region, in the region of the external and internal arches. In the calcaneal region, pressure, on the contrary, decreased. Moreover, the pressure distribution under the uncompressed left foot “standard” in the same experiment remained almost unchanged.

VI.CONCLUSION AND FUTURE WORK

Thus, the spatial shape of the inner trace of the heel shoes, firstly, ensured the turn of the calcaneus in the sagittal plane, bringing the mutual position of the foot bones closer to the natural one and reducing the overload of the forefoot, as well as the area of the inner arch due to supination of the foot. Secondly, in the conditions of use of shoes with the experimentally obtained new spatial form of the inner trace, the conjugation of the plantar surface of the heel of the foot and the surface of the trace in the heel part is improved, which allows the heel bone to be fixed in the frontal plane.Therefore, the proposed design and technological solution improves the supporting comfort of the heel shoes in patients with diabetes.

Supporting shoe comfort is one of the most important ergonomic requirements, since it experiences the greatest loads when interacting with the footwear space in the footprint area of the toe on the plantar surface.

The redistribution of dynamic loads along the plantar surface of the foot is ensured by changing the spatial shape of the inner footprint of the shoe. Improving the supporting comfort of shoes in the case of optimizing the distribution of pressure on the plantar surface of the foot by changing the spatial shape of the shoe in the heel to achieve better matching of the inner trace of the finished shoe with the heel of the plantar surface of the foot. An increase in the supporting comfort of a shoe of greater completeness can be achieved by the use of add-on preventive insoles in it. The nature of the pressure distribution in the forefoot on the plantar surface of the foot varies significantly between different carriers. Moreover, in the posterior part of the plantar surface of the foot in people with undeformed feet, a uniform pattern of pressure distribution is observed. Improving the supporting comfort of the heel shoes is possible if the pressure distribution on the plantar surface of the foot is optimized by changing the spatial shape of the shoe in the heel and gel parts to achieve better matching of the inner trace of the finished shoe with the heel of the plantar surface of the foot.

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