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DEVELOPMENT AND SCIENTIFIC JUSTIFICATION OF THE DESIGN OF ORTHOPEDICAL FOOTWEAR FOR PATIENTS WITH INJURIES TO THE SOUL-FOOT JOINT

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Abstract: This article discusses modifications made to the State Standard 3927-88 footwear template for creating orthopedic footwear for patients with ankle joint injuries. Based on these modifications, an orthopedic footwear design was developed and scientifically substantiated. A special shape was given to the sole of the footwear. The article presents a scheme for assembling the upper part based on the developed orthopedic footwear design, as well as a scheme for assembling the entire footwear.

Keywords: ankle joint, supporting motor system, metric numbering, construction, comfort, foot, shoe mold, heel, shoe assembly circuit, pedometry, dynamometry, supporting system, angle of inclination, biomechanics.

Introduction. Currently, orthopedic footwear is one of the most sought-after products supporting the musculoskeletal system. In addition to protecting the feet, it has several additional features, and wearing it not only provides comfort but also positively impacts human health. At present, there are various orthoses and orthopedic footwear for the ankle joint, designed to support the musculoskeletal system after injury and prevent sprains and twists of the ankle joint. Studies show that users of ankle orthoses rarely experience ankle joint injuries. However, orthoses do not reduce the degree of injury to the ankle joint or other parts of the leg. Rehabilitation plays a crucial role in recovery. In cases of injury, weakness, or instability of the ankle joint, rehabilitation is a key part of the treatment plan. Often, people experience persistent ankle pain or fail to return to full walking activity because they haven't allowed sufficient time for proper recovery. The main factors for recovery are balance, range of motion, strength, and stability.

It is important to maintain stable positive treatment outcomes. If patients return to their normal lifestyle without orthopedic correction, their problems may recur. To prevent this, it is necessary to ensure the following for the foot:

- pain relief;
- restoration of musculoskeletal system functions;
- increased heel sensitivity;
- balance and musculoskeletal equilibrium;
- development of optimal gait.

The process includes assessing the function of the foot and the entire musculoskeletal system before and after the preparation of orthopedic footwear, conducting a functional examination, and subsequent specific shaping under load. The goal of orthopedic shoe correction is to prevent and treat foot flattening and ankle joint injuries, eliminate discomfort, and reduce painful symptoms associated with functional stress in the upper parts of the musculoskeletal system.

Patient foot measurements are taken based on functional diagnostics, considering the patient's weight, daily physical activity, existing foot deformities, presence or absence of discomfort and pain signs, as well as the seasonality of footwear, types of leather and materials used, and foot size. The shoe last shape is determined individually based on the patient's foot, with the foot placed in a neutral position during molding.

The internal shape of the footwear needs to be modified to create an optimal fit. The GOST (State Standard) is based on a metric numbering system for lasts. The shoe last number is determined by the foot length expressed in centimeters. The direct correlation between the last number and foot length ensures the correct design of all last parameters in accordance with foot dimensions. This system allows for the application of a unified metric numbering system for individual consumer goods - leather and rubber footwear, and other products. Despite the varying additions to foot length used in designing these products, each specific number corresponds to the same foot length across all these items.

The formation of optimal walking. It includes an assessment of the function of the foot and the entire musculoskeletal system before and after the preparation of orthopedic footwear, a functional examination, and subsequent specific training under load. The goal of orthopedic shoe correction is to prevent and treat flattening of the foot and foot joint, eliminate discomfort, and reduce pain associated with functional stress in the upper extremities of the musculoskeletal system.

Patient foot measurement is performed based on functional diagnostics, i.e., taking into account the patient's weight, daily physical activity, existing foot deformities, presence or absence of signs of discomfort and pain, as well as the seasonality of footwear, the type of leather and materials used in it, and foot size. The shape of the shoe preparation is determined individually depending on the patient's foot, while the foot is neutral during molding.

The shape of the shoe's interior will need to be changed to a mold for an alternative design. The GOST is based on a metric numbering system for molds. The foot length, expressed in centimeters, was adopted as the shoe pattern number. The direct dependence of the mold number on the foot length ensures the correct design of all mold parameters in accordance with the foot size. This system allows for the application of a unified metric numbering system for individual consumer goods - leather, rubber shoes, and other products. Despite the fact that the foot length additions used in the design of these products vary, in all of these products, each specific number corresponds to the same foot length.

Methodology & empirical analysis. In order to better provide footwear that matches human foot dimensions, GOST standards have adopted modifications to the dimensions of adjacent sizes of lasts with the same width, as well as the intervals between adjacent widths of lasts with the same size number. As a result, the length interval was reduced from 6.67 mm to 5.0 mm, while the interval between adjacent widths was increased from 5.0 mm to 6.0 and 8.0 mm. By reducing the length interval, the number of last (shoe) sizes in the series for age groups has increased. Increasing the width interval, while considering the required range of shoe widths for production, expanded the total

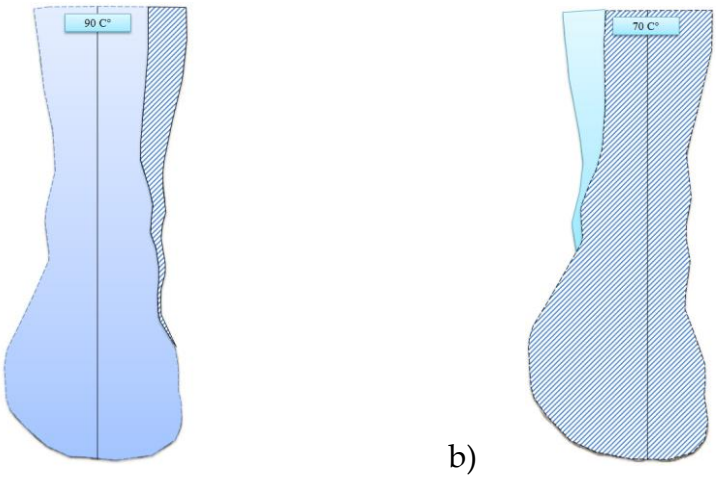
width range from 15 to 24 mm. This allows for a 20% increase in providing the population with footwear that fully corresponds to foot sizes in width.

To facilitate the selection of average, initial last fullness, intermediate levels (half-fullness) of 3 and 4 mm have been introduced between adjacent fullness levels. This is due to the fact that the average typical foot sizes, which were used as the basis for designing lasts for some regions, are not uniform (deviating towards larger or smaller sizes). However, when choosing the initial fullness, it is necessary to adhere to the gap of 6 or 8 mm between adjacent fullness levels, as established by GOST.

II. Results. Before creating an orthopedic footwear design for patients with ankle joint injuries, a last based on GOST 3927-88 was selected, and a modification was made to the average copy of the last to increase the level of comfort inside the shoe[1].

Figure 1. Mold based on State Standard №. 3927-88

Mold modifications are classified according to the types of deformations: for static deformations, for flat feet, for shortened legs, for paralyzed legs (tubular), for orthopedic devices, for the elderly, and for the feet of diabetic patients. Molds designed for static deformations are categorized by footwear type, gender and age groups, and heel height similar to mass-produced footwear. Such molds are used for flat feet, unilateral and bilateral lymphedema (in the presence of additional conditions, such as flat feet), for adapting the mold to the foot volume, as well as for other types of static deformities[2].



a) b)

Figure 2. The angles of inclination of the supporting bone

When designing lasts and footwear, it is important to understand how the foot functions both in a stationary position and during movement in order to make informed design decisions. Rational shoe design can be achieved by determining the distribution of foot pressure while standing, foot function during walking and running, changes in foot dimensions, and similar data through biomechanical studies.

Orthopedic lasts can be divided into individual and adaptable types depending on their method of use in production. Individual lasts are made of plaster or wood for specific patients with very complex foot deformities. According to research findings, adaptable lasts are used in 89% of orthopedic footwear manufacturing cases. To optimize the technological process for the production of orthopedic footwear, it is necessary to carefully study the assortment of available lasts. Adaptable lasts require adjustment to the patient's foot. It is necessary to choose the last depending on the type of deformity, the type of shoe, age and gender characteristics, and to make the necessary additions. An addition is a special part made primarily of leather, cardboard, or other material that is placed on the body of the last to modify the inside of the shoe in accordance with medical requirements and foot deformities. For example, in cases where the pathological condition of the foot is assessed in patients with pronounced displacement of the second and third toes and a lowering of the metatarsal heads or damage to the ankle joint, an addition is made to the shoe last that corresponds to the shape of the specified pathology[3].

The last defines the internal volume and shape of the shoe and is the primary means of its manufacture. Unlike mass production, orthopedic footwear is manufactured individually, taking into account the existing defects of each consumer. Therefore, in each case, it is necessary to make required modifications to the shape of the last.

Activities to be explored:

- human gait;
- the main standing position;
- static positions.

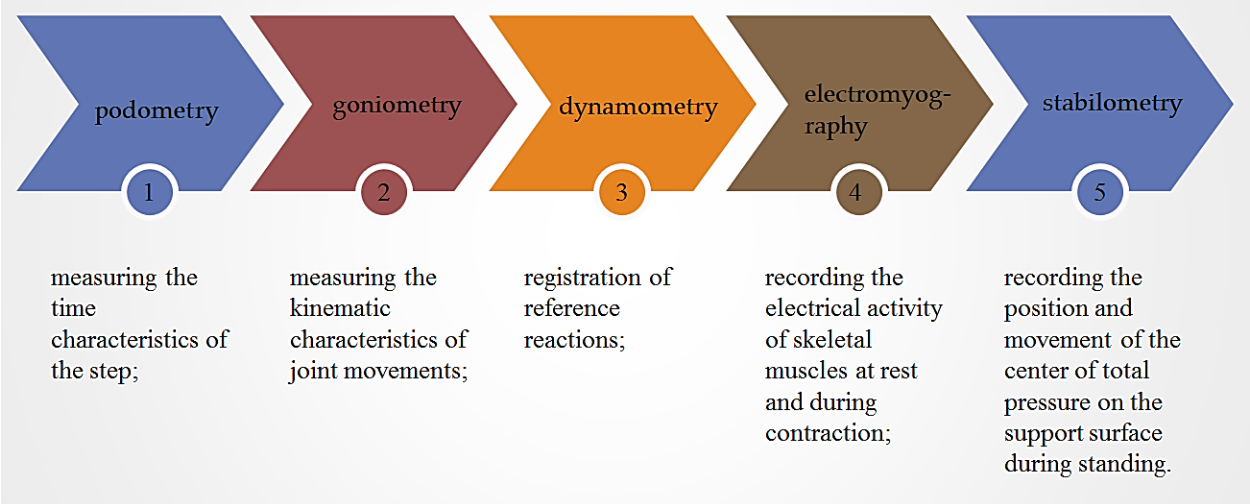


Figure 3. The main research methods

In more than 50% of people, the greatest strength occurs in the early stages of the basic period. The pressure depends on the speed of the movement: the faster a person moves, the higher the inertia force and the pressure on the support.

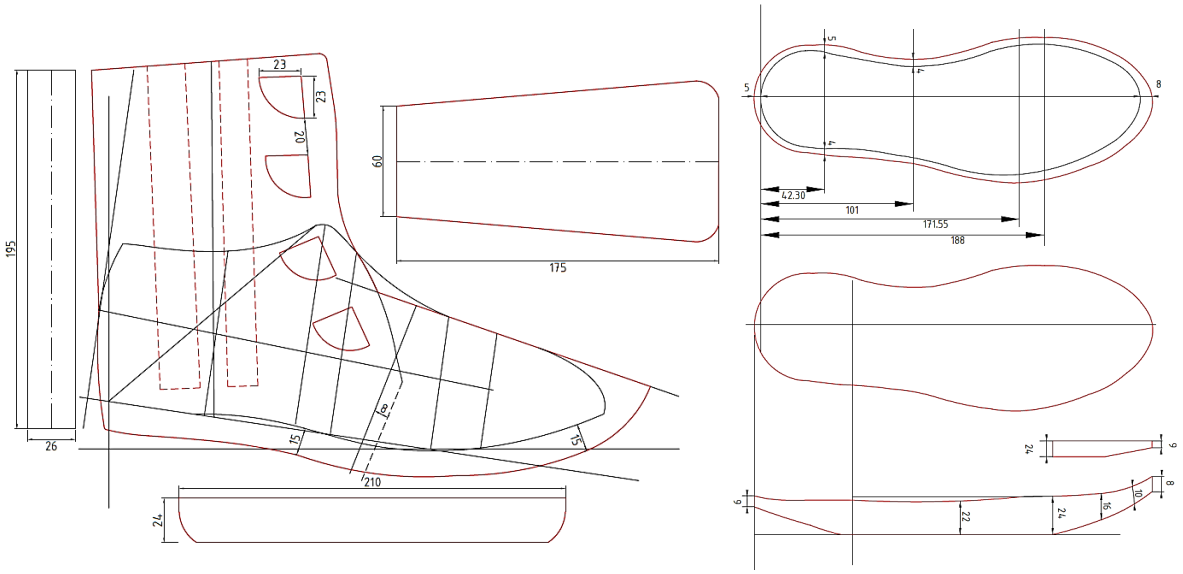


Figure 2. The structural foundation of the base and sole of orthopedic footwear

There are several methods for creating a shoe design, and this research paper uses the graphical copying method. To correctly draw the contours of the outer parts of the upper part of the LPO, it is necessary to use a grid of base and auxiliary lines.

III. Conclusions. The initial parts determine the position of the lower extremities relative to individual anatomical points and locations. The distance from the most convex point of rounding the foot to the support lines is calculated using the equation X=ARV (The average relative value of the residue is the length of the average copy of the mold).

Table 1. Model passport

№	Details name	Number per pair	Materials name	Thickness of details	State Standard of Materials
1	**2**	**3**	**4**	**5**	**6**
1	Vamp	2	Large cattle hide tanned with chromium	1,1-1,3	939-2021
2	Inner handle	2	Large cattle hide tanned with chromium	1,1-1,3	939-2021
3	Handle outer	2	Large cattle hide tanned with chromium	1,1-1,3	939-2021
4	Outer Rear Belt	2	Large cattle hide tanned with chromium	1,1-1,3	939-2021

5	Toe-cap	2	Large cattle hide tanned with chromium	1,1-1,3	939-2021
6	Tongue	2	Chrome-tanned calfskin leather	1,9-1,0	939-2021
7	Vamp lining Underwear Leather	2	Underwear textile material	0,9-1,1	19196-93
8	Vamp Underwear Leather	4	Underwear textile material	0,9-1,1	19196-93
9	Tongue Underwear Leather	2	Underwear textile material	0,9-1,1	940-81
10	Quarter material	4	Jeans Material	0,6	21790-93
11	Quarter material Underwear Leather	8	Thermoplastic		27319-87
12	Underwear Leather	4	Porous structured intermediate material		19196-93
13	Velcro tape	2	Velcro tape	+	NX
14	Leather Underwear Vamp	2	Porolon	+	TU 17-958-73
15	Cardboard	4	Porolon	+	TU 17-958-73
16	Midsole	2	Underwear leather	0,9 mm	940-81
17	Insole	2	Cardboard	2,3-2,4	9245-84
18	Heel breast	2	Porous rubber	8-10	12365-84

The processes of cutting leather for shoe, lining leather, textile materials, processing the materials of the leather parts of the lining and lining are carried out in the preparation department.

Currently, the sequence of operations for processing and assembling shoe overhead parts is being compiled using a standard method based on the experience of leading enterprises. The design of technological processes is primarily carried out based on a product diagram. In this case, after a comprehensive study of the initial data necessary for design (standard, previously used technological process methods, etc.), the technological process is carried out in three stages.

Women's orthopedic shoes are made with denim uppers, and a special intermediate component is used to aid in the healing of the damaged ankle joint. The shoes are secured to the foot using straps made of Velcro material. The sole consists of three layers, with the first and second layers being flat. The third layer, which is the part that comes into contact with the support surface, has its toe and heel areas rounded off. This shape helps stabilize the movement of the affected foot while walking.

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