RESULTS OF THE FULL-FACTOR EXPERIMENTS OF PROPHYLACTIC FOOTWEAR CONSTRUCTION RECOMMENDED FOR PATIENTS WITH INSULAR DIABETES

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Annotation: *The article covers the results of full-factor experiments of prophylactic footwear recommended for patients with diabetes. Comparative results of production determined the optimal parameters of prophylactic footwear are given.*

INTRODUCTION

Timely selected prophylactic footwear prevent foot gangrene and reduce the risk of disability. Therefore, it is important to study the physiological and biomechanical characteristics of foot pathology in diabetic patients, the method of designing the optimal design of prophylactic footwear based on medical and technical requirements.

An effective prophylactic footwear includes an inner insole; each zone of the insole has a certain stiffness and is made of elastic EVA material. The insole zones are selected based on the actual pressure of the patient's foot zones. To prevent pressure on the inflamed part of the patient's foot, we suggest a load-bearing portion of the insole based on the deformation of the foot surface. In this case, the toes are protected from any inflammation, even at amputation.

Effectiveness of prophylactic footwear for patients with insular diabetes is determined by the degree to which it prevents the appearance and development of trophic wounds and the extent to which pre-existing changes in the foot are prevented. The main parameters for evaluating the effectiveness of prophylactic footwear are: reduction of tissue area in the pre-wound condition; reducing the number of foci of trophic wounds when wearing individually manufactured prophylactic footwear only depending on the condition of the foot; pedography (measuring the distribution of pressure on the sole of the foot in a footwear) of the feet.

Special prophylactic footwear with inner insole have been studied and applied and have been proven to relieve toenail pain in diabetes, thereby reducing the maximum pressure of the toe.

The basis for the creation of modern techniques and technologies is to conduct experiments on new developments and determine their optimal technological performance based on the results obtained. Mathematical and statistical methods are used in the planning of operations to increase the efficiency of operations. In practice, these methods reduce the time to solve the set tasks, reduce the cost of practice and improve the quality of the results obtained [1].

Conducting full-factor experiments is one of the most common methods is the full-factor experiment method. When practicing this method, all the input factors determined are varied, the output factors are obtained, and their reliability is checked based on mathematical-statistical methods [2].

It is possible to vary the factors infinitely during the practice period, but it is sufficient to change the factors to two, three, or five levels to obtain clear practice results [3].

The experimental data were processed according to the program "regression analysis" developed in the laboratory of experimental planning of Bukhara Engineering-Technological Institute. Cochrane criterion was used to assess the homogeneity of the variance, Student criterion was used to assess the value of the regression coefficients, and the Fisher criterion was used to assess the adequacy of the regression models.

Factors influencing the technological performance of prophylactic footwear for patients with insular diabetes are the thickness of the special insole of the footwear (mm), the ratio of the specific insole surface (%); weight (kg) of patients with diabetes, so we define these indicators as undesirable factors (Table 3.5).

Table 3.5

Name of the factor	Coded icon	The real value of the factor			Change interval
		-1	0	+1	
Thickness of the insole (mm);	x1	5	10	15	5
Ratio of insole surface (%);	x2	20	30	40	10
Patient weight (kg)	x3	70	90	110	20

First, we substantiate the accepted values of these input factors:

A) x1 is the thickness of the insole (mm);

Patients with insular diabetes are provided with a special insole design designed for prophylactic footwear to provide the required load to the required pain points of the foot. In the construction of the insole, special attention was paid to its thickness, because it is the thickness of the inner insole and the material chosen for the insole that has the ability to absorb wounds when walking. Therefore, in order to study the optimal dimensions of a special insole made for prophylactic footwear, experiments used pad thicknesses ranging from 5 mm to 15 mm.

B) x2 is the ratio of the surface of the insole;

In studies, the essence of a special inner insole construction designed for prophylactic footwear of patients is that the rhombus elements, which have different hardness properties, are connected to each other. Depending on the painful zones of the patient's foot claw, rhomboid elements that are less pronounced in the corresponding zones of the insole are selected. Based on these studies, it is possible to vary the ratio of insole surface to 20% to 40%.

C) Weight (kg) of a patient with diabetes.

Scientific research has been conducted mainly in middleweight patients. The results of experimental tests of patients with a lightweight of 70 kg to a maximum weight of 110 kg were obtained. On this basis, the deformation of the proposed prophylactic footwear special insole depending on the patient's weight was studied. The weight of patient varied from 70 kg to 110 kg were taken as input factor in the study

As output factors, we determine the overall average deformation index of the special footwear insole for patients with insular diabetes (Table 2).

Table 2

Output factors	Name	Unit of measurement
Y	The general average deformation of the special insole of prophylactic footwear	mm

"Equatorial Footwear" LLC, "Gijduvon Poyabzali" PE footwear factories produced prophylactic footwear and special insole in practice, and conducted experiments on patients listed in the Republican specialized scientific-practical medical center of endocrinology named after Academician E.H. Turakulov.

The operation-planning matrix is shown in Table 3.

According to this matrix, three repetitive experiments were performed in each condition, and total for 24 experiments.

Table 3

Experiment number	Factors		
	x1	x2	x3
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	-	-	+
6	+	-	+
7	-	+	+
8	+	+	+

The results and variances of the output factors obtained because of the operation are given in Table 3.7.

The arithmetic mean of the output factors $\bar{Y}$ was determined and the variance of the results $S_i^2\{Y\}$ was calculated (Table 4).

$$\bar{Y} = \frac{Y_{i1} + Y_{i2} + Y_{i3}}{3} \quad (1)$$

$$S_i^2\{Y\} = \frac{\sum_{i=1}^{3}\left(Y_i - \bar{Y}\right)}{m-1} \quad (2)$$

where m is the number of repetitions of the experiments under the same conditions.

Table 4

No.	x1	x2	x3	У1	У2	У3	$\bar{Y}$	S2{Y}
1	-	-	-	4.5	4.6	4.8	4.63	0.02333
2	+	-	-	5.0	5.2	4.9	5.03	0.02333
3	-	+	-	5.4	5.6	5.5	5.50	0.01000
4	+	+	-	6.8	6.85	6.75	6.80	0.00250
5	-	-	+	5.6	5.8	5.5	5.63	0.02333
6	+	-	+	7.2	7.0	7.3	7.17	0.02333

7	-	+	+	7.6	7.5	7.2	7.43	0.04333
8	+	+	+	8.2	8.4	8.0	8.20	0.04000
Total							6.300	0.18917

We check the homogeneity of the variance values using the Cochrane criterion. The value of the Cochrane criterion is determined by the following formula:

$$G_x = \frac{S_i^2\{Y\}_{\max}}{\sum_{i=1}^{N} S_i^2\{Y\}} \qquad (3)$$

where:

G_x is the calculated value of the Cochrane criterion;

$S_i^{\,2}\{Y\}$ is the largest variance value of the test results;

$\sum_{i=1}^{N} S_i^{\,2}\{Y\}$ is the sum of the variance values;

$$G_x = \frac{S_i^2\{Y\}_{\max}}{\sum_{i=1}^{N} S_i^2\{Y\}} = \frac{0{,}04333}{0{,}18917} = 0{,}229$$

The calculated value of the Cochrane criterion is compared with the value selected from the table. In this case, the condition $G_x \prec G_{жад}$ must be met.

When there is a tabular value of the Cochrane criterion is $P_D = 0{,}95$

$$G_{жад} = \{f_1 = N = 8,\ f_2 = m-1 = 3-1 = 2\} = 0{,}5137 . \qquad (4)$$

Therefore, in our case the variances are homogeneous. Because the set condition $0{,}229 \prec 0{,}5137$ was met. Once these conditions are met, the regression coefficients are calculated and the regression equation is constructed.

The regression equation is as follows:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{123}x_1x_2x_3 . \qquad (5)$$

Regression coefficients are calculated using the following formula:

$$b_0 = \frac{1}{N}\sum_{i=1}^{N}\overline{Y_i} \qquad (6)$$

where:

N is number of experiments.

$$b_i = \frac{1}{N}\sum_{i=1}^{N} x_{ji} x_{ij} \overline{Y_i}$$

$$b_{ji} = \frac{1}{N}\sum_{i=j=1}^{N} x_{ij} \overline{Y_i} \quad , \qquad (7)$$

where:

i is order of tests;

j is order of factors.

$$b_0 = \frac{1}{8} \cdot 50{,}4 = 6{,}3$$

$$b_1 = \frac{1}{8} \cdot (-4{,}63 + 5{,}03 - 5{,}5 + 6{,}8 - 5{,}63 + 7{,}17 - 7{,}43 + 8{,}2) = 0{,}5 \quad ;$$

$$b_2 = \frac{1}{8} \cdot (-4{,}63 - 5{,}03 + 5{,}5 + 6{,}8 - 5{,}63 - 7{,}17 + 7{,}43 + 8{,}2) = 0{,}68 \quad ;$$

$$b_3 = \frac{1}{8} \cdot (-4{,}63 - 5{,}03 - 5{,}5 - 6{,}8 + 5{,}63 + 7{,}17 + 7{,}43 + 8{,}2) = 0{,}81 \quad ;$$

$$b_{12} = \frac{1}{8} \cdot (4{,}63 - 5{,}03 - 5{,}5 + 6{,}8 + 5{,}63 - 7{,}17 - 7{,}43 + 8{,}2) = 0{,}017 \quad ;$$

$$b_{13} = \frac{1}{8} \cdot (4{,}63 - 5{,}03 + 5{,}5 - 6{,}8 - 5{,}63 + 7{,}17 - 7{,}43 + 8{,}2) = 0{,}075 \quad ;$$

$$b_{23} = \frac{1}{8} \cdot (4{,}63 + 5{,}03 - 5{,}5 - 6{,}8 - 5{,}63 - 7{,}17 + 7{,}43 + 8{,}2) = 0{,}025 \quad ;$$

$$b_{123} = \frac{1}{8} \cdot (-4{,}63 + 5{,}03 + 5{,}5 - 6{,}8 + 5{,}63 - 7{,}17 - 7{,}43 + 8{,}2) = -0{,}21 \quad .$$

Based on the calculations, the regression equation is as follows

$$Y = 6{,}3 + 0{,}5x_1 + 0{,}68x_2 + 0{,}81x_3 + 0{,}017x_1x_2 + 0{,}075x_1x_3 + 0{,}025x_2x_3 - 0{,}21x_1x_2x_3 \qquad (8)$$

The significance of the regression coefficients was examined by calculating the calculated value of Student criterion

The calculated value of the student criterion was compared with the value selected from the table. In this case, the following condition must be met.

$$t_x \succ t_{жад} \quad , \quad t_{жад} = [P_D = 0{,}95;\ f_2 = 16] = 2{,}12$$

If a given condition is met, the calculated regression coefficients are considered significant, but if the condition is not met, this regression coefficient is considered insignificant and is excluded from subsequent calculations. Based on the results of the calculations, since the values of $t_R(b_{12})$, $t_R(b_{13})$ are smaller than the values selected from the table, and the subsequent calculation of the coefficients b_{12}, b_{13} is excluded as insignificant.

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