

**The purpose** of the study is to investigate the influence of metabolic syndrome indicators on X-ray manifestations of OA and to develop a mathematical model for determining the severity of X-ray changes, depending on metabolic manifestations.

**Methods.** 63 patients with OA (14 males, mean age  $58.0 \pm 0.82$ ) with different phenotypes were examined in the Kharkiv Regional Hospital. The plan of examination included the following data: history of the disease, waist circumference (WC), fasting plasma glucose (FPG), glycosylated hemoglobin (HbA1c), immunoreactive insulin (IRI), HOMA-IR, total cholesterol (TC), low-density lipoprotein cholesterol (LDL). The knee X-ray was performed for all patients. The first stage of X-ray changes was determined in 8% of the patients, the second stage – in 58.7% and the third stage – in 33.3% of the patients respectively. Patients were divided into 2 groups: 1<sup>st</sup> - patients with stages I and II by Kellgren and 2<sup>nd</sup> - patients with stage III by Kellgren. The following indicators were selected as the most statistically significant: the level of FPG (mmol/l), HbA1C (%), LDL (mmol/l), WC (cm) and duration of type 2 diabetes mellitus (T2DM). The calculation of the criteria was carried out at 95% of confidence probability. To find the importance of each of the describing elementary rules in determining the various degrees of severity of X-ray changes, a metric approach to the map of interconnections between them was applied. The map was obtained by the method of multiple correspondent analysis. The classifier model was formed as a weighted sum of binary characteristic functions describing elementary rules.

**Results.** The values of the selected indicators of metabolic syndrome in two groups of patients with radiological changes of different severity were the following: FPG 1<sup>st</sup> group - 8.85 [7.8, 9.6], 2<sup>nd</sup> group - 10.7 [11.4, 10.1]; HbA1C: 1<sup>st</sup> group - 8.75 [7.7, 9.7], 2<sup>nd</sup> group - 10.2 [9.3, 11.4]; LDL: 1<sup>st</sup> group - 4.04 [3.26; 4.66], 2<sup>nd</sup> group - 5.24 [4.59; 5.77]; WC: 1<sup>st</sup> group - 94.5 [88.0; 99.0], 2<sup>nd</sup> group - 110.0 [96.0; 119.0]; duration of T2DM: 1<sup>st</sup> group - 8.0 [4.0; 10.0], 2<sup>nd</sup> group - 11.0 [8.0, 13.0]. The ranges of values that were characteristic of X-ray changes of varying severity were estimated for each of the selected indicators. Thus, each group of patients received its description in the form of elementary rules, representing a comparison of individual indicators to some threshold values.

The next step of model construction was to determine the importance of each of the selected elementary rules in determining one or another degree of X-ray changes. For this purpose, the spatial representation of the interrelationships between the stages of the X-ray changes with the elementary rules that describe them was obtained by the method of multiple correspondent analysis. Significance coefficients were calculated for clarifying the effect of metabolic indicators on the severity of X-ray changes and its quantitative characteristics. The values of the

coefficients allow us to rank the indicators by their validity to determine one or another degree of X-ray changes (tabl.1)

№ (i)	Indicator	Value range	№ (j)	group		The coefficient in the model ( $\alpha_{i,j}$ )
				1 <sup>st</sup> group	2 <sup>nd</sup> group	
1	Duration of T2DM (years)	<8	1	7,47	6,22	<b>-12,53</b>
		8-10	2	6,13	6,98	<b>8,49</b>
		>10	3	5,62	9,56	<b>39,43</b>
2	WC (cm)	<100	1	16,67	7,36	<b>-93,07</b>
		≥100	2	5,62	13,41	<b>77,89</b>
3	FPG (mmol/l)	<10	1	17,87	7,29	<b>-105,81</b>
		≥10	2	5,33	13,97	<b>86,36</b>
4	HbA1C (%)	<9,7	1	11,02	8,14	<b>-28,75</b>
		≥9,7	2	6,35	9,18	<b>28,29</b>
5	LDL (mmol/l)	≤4,6	1	11,76	7,65	<b>-41,11</b>
		>4,6	2	6,15	10,23	<b>40,80</b>

Significance coefficients are used in the mathematical model for determining the degree of X-ray changes based on the values of the five metabolic syndrome indicators. The model proposes to calculate the so-called index of X-ray changes expressiveness  $I_{expres}$  by the formula (fig.1):

$$I_{expres} = \sum_i \sum_j \alpha_{i,j}$$

the coefficients  $\alpha_{i,j}$  are given in the last columns of the table,  $i = 1, \dots, 5$  - the number of the indicator,  $j = 1, 2, 3$  - the number of the range of its values. According to the constructed model, if  $I_{expres} > 0$  - the level of X-ray changes is defined as expressed (stage 3), if  $I_{expres} < 0$  - as less expressed (stage 1 and 2).

With the proposed mathematical model, the degree of X-ray changes by Kellgren was correctly determined in 55 patients out of 63, that is, the overall accuracy of the model was 87.30%. X-ray changes of the third stage were diagnosed correctly in 18 patients out of 21, that is, the sensitivity of the model was 85.71%. Less distinct X-ray changes (stage 1 and 2) were correctly diagnosed in 37 patients out of 42, i.e the specificity of the model was 88.10%.

**Conclusion.** An in-depth analysis of the relationships between metabolic parameters and X-ray changes of joints allowed to develop the mathematical model for determining the severity of X-ray changes with the use of certain metabolism indicators. The obtained model demonstrates high accuracy, specificity and sensitivity.