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AUTOMATED DIAGNOSIS OF PATHOLOGY OF THE HUMAN MUSCLE-MOTOR SYSTEM ON THE BASIS OF STATOGRAPHIC RESEARCH

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Abstract
The analysis of efficiency of a method of the automated differential diagnostics of pathology of the person's musculoskeletal system with a possibility of the analysis of multicomponent data of the human statogram is carried out. By means of the device of neural networks the method of a functional estimation of a condition of musculoskeletal system of the person according to statographic researches, namely geometrical and power parameters of statograms at two-support and one-support standing is offered.
Keywords: automated diagnosis, musculoskeletal system, statographic studies.

Despite the rich choice of research methods and constant improvement of technical means, as noted by many researchers, objective and differentiated diagnosis of the musculoskeletal system (ORS) is hampered by the presence of a wide range of compensatory-adaptive reactions [1, 2]. To provide vertical support when standing and walking, the patient seeks to intuitively adapt to changes in his ORS [1, 3]. A large number of methods of compensatory processes eliminate the deformation and make it difficult to quantify [4, 5, 6]. Therefore, there is a need to create devices that not only allow to detect pathology and the degree of its compensation, but also to quantify it [7].

The aim of the study was to substantiate the method of automated differentiated diagnosis of human ORS pathology with the possibility of analyzing multicomponent data of the human statogram.

The data of statographic research of 15 patients with osteochondrosis of the lumbar spine were analyzed; 15 patients with bilateral coxarthrosis stage II-III and 10 healthy volunteers. The parameters of the statograms were analyzed: energy strength of the statogram at two-support and one-support standing, the area of spots in these positions, the ratio of spots of single-support standing to the area of two-support standing, the ratio of spots of the statogram to the total area of the statogram.

More than 10 geometric parameters of statograms were developed for the study of statograms, which describe the parameters of the area of statogram spots, the magnitude of the scatter of the centers of statogram spots and their boundaries in the frontal and sagittal planes, asymmetry coefficients of geometric and angular spots. Particular attention is paid to the spectral characteristics of statograms. In the course of statistical researches the big dispersion of parameters of statograms which can testify to existence of this or that pathology is revealed. Based on the obtained data, it was found that in the diagnosis of a possible pathological condition, the parameters of statograms should be analyzed not separately, but in combination, using multidimensional classification algorithms.

The strongest method of statistical classification is discriminant analysis, but it requires the presence of dichotomous quantities as a classification argument, and if there are more than 3 levels, the results of the analysis are very difficult to interpret the verification of classification equations.

Therefore, we chose modern methods of classification analysis, namely neural networks.

20 parameters of spectral and geometric characteristics of the statogram were selected as input arguments of the neural network. Several models of neural networks were analyzed and the one with the highest probability of predicting the correct result was selected. The neural network has 2 hidden layers, the neurons of which activate the function of the hyperbolic tangent, ie the nonlinear dependence of the pairs of neurons. The network has 3 output neurons by the number of levels of the classification argument. The work of the neural network consists of three stages: training of the network on a special sample with the established diagnosis (training sample), checking the network model on the control sample and the stage of checking the model on a random sample. During the learning phase, the neural network learns to return a specific output signal for a specific input signal, this is done through continuous learning on a set of learning data. During the execution phase, the neural network returns the output signals based on the input data.

The algorithm for performing direct propagation functions is as follows: the input data is fed to the input layer of the network and distributed throughout all layers of the network until it reaches the output layer, where the result is returned. During training, the neural model on the input and output data set is configured to obtain the same values at the outputs as in the training sample. When determining the size of the neural model, it is necessary to take into account the size of the training sample. The number of scales to be adjusted must be less than the number of input images, otherwise the network will "remember" the images and lose the ability to classify, on the other hand, the more scales of the network to be adjusted, the more accurate the adjustment. The sample used was relatively small, and each image contains the results of energy analysis of the statogram and 17 parameters of the geometric data of the statogram (a total of 20 input parameters).

In some cases, the neural network gave ambiguous results. This can be explained by the fact that, as a rule, diseases of the hip joint develop first on one side and are accompanied by lameness, pain, shortening of the limb. Constant asymmetric load on the hip joints leads to an increase and change in the load on the lumbar spine, over time it leads to the development of degenerative diseases - osteochondrosis, spondyloarthritis and others. In the future, even greater asymmetry of the load on the joints, exacerbated by degenerative diseases of the spine, leads to the symmetrical development of the disease of the second hip joint. These circumstances explain the low differentiation of diseases in patients, especially the elderly. The highest probability of correctly predicted results occurred in the group of patients with coxarthrosis (96.5%), less in the group of patients with osteochondrosis (67.3%) and in the control group (69.7%).

The constructed neural network showed a fairly high result in the diagnosis. The neural network has the highest sensitivity and specificity for the detection of coxarthrosis, less sensitivity and specificity - for the detection of osteochondrosis.

Modern instrumental research methods give the researcher a large number of parameters that require modern processing methods. The automated process of building neural networks allows the researcher without special knowledge in the field of programming to create sufficiently effective classification models. The created neural model allowed to identify with rather high probability in orthopedic patients the prevailing orthopedic pathology.

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АВТОМАТИЗОВАНА ДІАГНОСТИКА ПАТОЛОГІЇ ОПОРНО-РУХОВОЇ СИСТЕМИ ЛЮДИНИ НА ОСНОВІ СТАТОГРАФІЧНИХ ДОСЛІДЖЕНЬ

Анотація
Проведено аналіз ефективності методу автоматизованої диференційної діагностики патології опорно-рухової системи людини з можливістю аналізу багатокомпонентних даних статограми людини. За допомогою апарату нейронних мереж запропонований метод функціональної оцінки стану опорно-рухової системи людини за даними статографічних досліджень, а саме геометричних і енергетичних параметрів статограм при двохопорному й одноопорному стоянні.
Ключові слова: автоматизована діагностика, опорно-руховий апарат, статографічні дослідження.

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