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Correlation Analysis of the Complex Indicators of the Health of Patients at the Physical Rehabilitation Clinic

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Keywords: health, musculoskeletal system, pain, rehabilitation, survey, physical activity, correlation, body mass index, polymorbidity.

Abstract : The aim of the work is to create a digital model of the state of "healthy life" of patients of the physical rehabilitation clinic with diseases of the musculoskeletal system (MSS). Based on the data of the electronic questionnaire, a multivariate correlation analysis of the health characteristics of 211 patients with an average age of 46 years was carried out. In 32% of patients, the body mass index (BMI) is within the normal range, in 34% – pre-obesity, in 22% – obesity. Duration of physical activity (DFA) for 41% of patients is less than 0.5 hours a day, for 28% from 0.5 to 1.5 hours, for 31% more than 1.5 hours. The correlation between BMI and DFA, in general, is 0.1. With an increase in DFA from 45 to 75 minutes, a decrease in the average BMI from 27.6 to 23.3 kg / m ^{2} is observed, which corresponds to the transition from pre-obesity to normal BMI. The distribution of patients by the level of perceived pain (LPF) is bell-shaped, except for 20% who do not feel pain. The mathematical expectation of BMI for patients with mild pain (scores 0–3) is 23 kg/m ^{2}, with moderate pain – 27.3, and with severe pain – 27.8. The correlation between LPF and BMI is weak and is – 0.39**.** 42% of patients assess their general health status (GHS) as satisfactory or good, and 12% as poor. Paired GHS correlation with parameters health negative : with LPF – 0.35, with BMI – 0.32, with the number of sick parts of the MSS – 0.28, with the number of concomitant diseases and conditions – 0.38. Correlation of GHS with a complex health predictor is 0.47.

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1 INTRODUCTION

Currently, one of the key goals of healthcare is the accelerated growth of the indicators of expected duration of "healthy" life. According to estimates (Ivanova, 2024) about 13% of life expectancy of men and 19% of life expectancy of women in Russia will live with low quality of health. The criteria for low quality of life are: the presence of disability of groups I or II , significant limitation of mobility or self-assessment of health as poor or very poor.

The ambiguity of the health self-assessment criterion poses the task of defining the problems associated with the possibility of assessing health as "poor". To understand the problems of patients regarding their health (Orlov, 2022), it is important to have a systemic digital model of their socio-medical characteristics (Dusakaeva, 2022). The first stage of obtaining such data (anamnesis) provides enough information to form a statistically significant characteristic of patients' health, as well as the relationships between various health indicators (Pogodina, 2018).

Modern technologies make it possible to form anamnesis in digital form (Korotaevsky, 2022), which allows systematizing the data obtained for a significant number of patients, as well as determining not only the proportion of various indicators, but also their interdependence (correlation).

These characteristics and relationships may vary significantly across patient samples. This paper examines the characteristics of patients who first presented to a physical therapy rehabilitation (MPR) clinic (Kryuchkova, 2023) due to musculoskeletal disorders (MSS).

As the main health characteristics, two indicators from the quality of life indicators were taken, according to the non-specific questionnaire SF-36 (Ware, 1994), in particular, "General health" and "Pain intensity". Two indicators concerned the number of body parts that bother patients and concomitant (in relation to MSS) diseases. The latter is associated with the need to take into account contraindications for MPR and assess the impact of polymorbidity (Rukodaynyy, 2023) on health. Two more questions concerned the physical activity and constitution of patients.

To register the specified data, patients were asked to fill out an electronic questionnaire using a tablet. Based on the results of the survey of 211 patients, a database of patient health indicators was formed, statistical processing was carried out, including the distribution of patients by measured indicators, regression dependencies and correlation coefficients between indicators were determined.

At this stage of the work, it was important to identify the possibilities of forming a sufficiently complete digital model of the state of “healthy life” and determining key statistical indicators of the health of patients with MSS diseases .

2 RESEARCH METHODOLOGY

The aim of the work is to form a digital model of the state of “healthy life” of patients of the clinic of therapeutic and physical rehabilitation with diseases of the musculoskeletal system.

The study used the electronic questionnaire method, statistical processing methods of survey results, and a systems approach. Statistical processing of the research results was carried out using Excel spreadsheets.

In order to be able to correctly perform multivariate correlation and regression analysis, it is necessary to collect data on health indicators of a sufficiently large number of patients under comparable conditions. Therefore, it was decided at this stage to form a model based on the results of a patient survey using the most common indicators. There are studies (Talykova, 2017) showing that patients' subjective assessment of their MSS is quite objective.

The study was based on the clinic for therapeutic and physical rehabilitation of patients with MSS diseases of the DEMA network in the village of Kratovo, Moscow Region. During 2023–2024, 211 patients were surveyed during their initial visit to the clinic. The average age of patients was 45.9 years, the standard deviation was 18.4 years, the proportion of men and women was 50% each.

The first question from the SF-36 questionnaire concerning the patient's overall health status was used as the main assessment of quality of life. Its disadvantage, as applied to this work, is the scale biased toward positive assessments (excellent, very good, good, mediocre, and poor), which reduces sensitivity to negative levels of health. Therefore, a symmetrical scale was used: excellent, good, mediocre, unsatisfactory, poor.

The second question asked about the pain experienced by the patient. The SF-36 uses a 5-point pain scale: very mild, mild, moderate, severe, and very severe, as well as the starting position of no pain at all. Since “the average amount of pain reduction with available treatments is about 30–40%, and this occurs in less than half of patients”

(Morozov, 2020), a 20% pain measurement step is insufficient for MPR practice. Therefore, a 10-point "Verbal Rating Scale" (VRS) was used, in which the ratings are descriptive pain terms numbered from 0 to 10 (Jensen, 2018).

The body mass index (BMI) was calculated based on the obtained data on a person's body weight (M) in kg and his height (H) in meters

$$BMI\ (kg/m^2) = M / H^2. \quad (1)$$

To measure the duration of physical activity (DPA), patients were asked to choose the duration of their physical activity time in 0.5 hour increments. DPA 1 included patients with very little physical activity, DPA 2 – less than 0.5 hour, DPA 3 – from 0.5 to 1 hour, etc., DPA 6 – 2 or more hours per day.

Patients were also asked to indicate the body parts that bothered them and the associated diseases in relation to the MSS (Moroga, 2023).

The following designations of health parameters were used in the work:

1. General health status – GHS
2. Body mass index – BMI
3. Duration of physical activity – DPA
4. The level of pain felt – LPF
5. Number of sick parts of the MSS – NSP
6. The number of concomitant diseases and conditions – NCD.

The simplest statistical characteristics of the patient sample were the mean values (mathematical expectation – M) and median, as well as the standard deviation – S. For a more detailed description of the sample, graphs of the distribution of characteristics were used, including the construction of trends and the determination of the coefficients of determination R^2 for them. The correlation between two sequences of indicators was determined using the CORREL Excel function.

To determine the combined influence of various indicators on the health status of patients, a procedure for optimizing the contribution coefficients of indicators to the health predictor was used.

3 RESULTS

3.1. Body mass index of patients

One of the most important socio-medical characteristics of patients is the level of body weight in relation to the normal. Various indicators can be used to determine this characteristic, but one of the most common indicators is the body mass index (BMI), developed by the Belgian mathematician Adolphe Quetelet (Quetelet, 1911) in 1835, which can be determined according to formula (1).

The distribution of patients according to BMI value is shown in Fig. 1. Each BMI group included patients with a BMI value in the range from X to X+2, with the value X+1 corresponding to this point on the graph. As can be seen from Fig. 1, the distribution is bell-shaped and is approximated by a 4th-degree polynomial with a high determination coefficient $R^2 = 0.91$. The mathematical expectation (M) of BMI values is 25.7, and the median is 25.6.

The closeness of these indicators indicates that there were no points significantly different from the general pattern among the data obtained. The standard deviation of the sample is S = 6.5. 97% of the points fall within the 2S range. This means that the distribution is close to normal, according to which the probability of finding points in the 2S range is 95.5%.

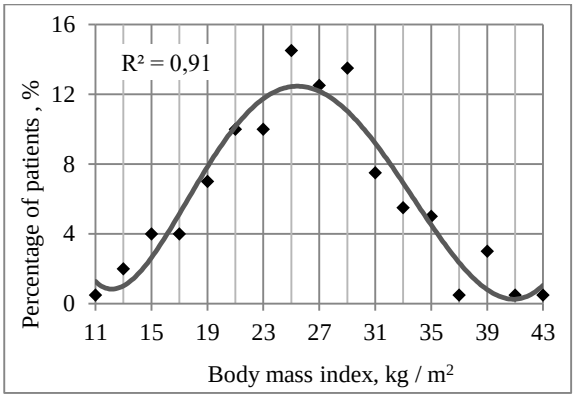

Figure 1: Distribution of patients by BMI.

Based on the WHO recommended interpretation of body mass index (BMI), the clinic's patients can be characterized as shown in Table 1.

Table 1: Distribution of clinic patients by BMI.

The relationship between height and body weight	BMI , kg / m²	Percentage, %
Marked weight deficiency	Less than 16	6.5
Body weight deficiency	16—18.5	5.5
The normal ratio	18.5—25	32
Overweight is pre-obesity	25-30	34
1st degree obesity	30-35	16.5
2nd degree obesity	35-40	5.0
Obesity of the 3rd degree	40 or more	1.0

Rounding off the obtained values, we can summarize that 1/3 of patients belong to the groups with normal weight and pre-obesity, 1/4 are patients

with obesity, mainly grade 1, and 1/8 are patients with underweight.

According to the Russian Academy of Medical Sciences, in 2023 in Russia, 50% of men and 60% of women over 30 years of age are overweight and 30% are obese (Obesity). Considering that about 50% of patients are women and men, the average rate of people with excess weight is 55%. As can be seen from Table 1, excess weight (pre-obesity and obesity) is observed in 56.5% of patients at the MPR clinic , which is close to the results of the Russian Academy of Medical Sciences. However, the proportion of patients with obesity is significantly lower than in Russia as a whole. This may be due to the fact that people who pay attention to their physical fitness come to MPR clinics .

3.2. Physical activity of patients

A person's physical fitness can depend on a number of factors, including physical activity, caloric intake, and genetics. To determine the impact of duration of physical activity (DPA) on health status, patients were surveyed about their average daily DPA , the results of which are presented in Table 2.

Table 2: Duration of physical activity of patients .

Duration of physical activity of patients, hours	Percentage of patients , %
Very small	23.4
Less than 0.5	17.1
From 0.5 to 1.0	16.1
From 1.0 to 1.5	12.2
From 1.5 to 2.0	10.7
2.0 and more	20.5

It is seen that 40.5% of patients have very short-term physical activity, less than 0.5 hours. 31.2% of patients have relatively high DPA – more than 1.5 hours per day. Another 28.3% of patients have moderate DPA – from 0.5 to 1.5 hours per day. Determining the correlation between patients' DPA and their BMI showed that it is very small (– 0.086).

To study the interdependence of these two health indicators in more detail, the values of the mathematical expectation (M) and standard deviation (S) of BMI were determined in groups of patients with different DPA. The corresponding results are given in Table 3.

The most significant difference in the mathematical expectation of BMI (4.3 kg/m^2) is observed between the DPA ranges of 0.5 to 1.0 hours and 1.0 to 1.5 hours.

Table 3: Statistical characteristics of BMI for samples of DPA .

Duration of physical activity, hours	M	S
Very small	26.2	6
Less than 0.5	26	5.7
From 0.5 to 1.0	27.6	5.1
From 1.0 to 1.5	23.3	6.7
From 1.5 to 2.0	24.5	6.3
2.0 and more	25.5	7.4
All DFA	25.7	6.3

This means that with an increase in the duration of physical activity from approximately 45 minutes to 75 minutes, the greatest decrease in the patient's body mass index occurs (by about 17%). This approximately corresponds to the patient's transition from the pre-obese to normal BMI (Table 1). The standard deviation values (Table 3) are in the range of 5.1–7.4 (6.25±1.15 kg/m^2).

3.3 Diseases of the musculoskeletal system of patients

Using a questionnaire, it was determined which parts of the musculoskeletal system (MSS) are troubling patients. Results survey are given in Table 4.

Table 4: Parts of the MSS that worry patients.

Parts of the MSS that worry patients	Percentage of patients, %
None of them bother	6.2
Upper limbs	14.2
Shoulder belt	18
Shins and feet	19.9
Hip joints	23.7
Lower extremities, knees	36
Neck and collar zone	36
Spine	45

The greatest number of patients are concerned about problems with the spine and cervical-collar zone – 81% in total. Almost as often, patients note problems with the lower extremities, including the hip and knee joints, shins and feet – 80% in total. In third place are the upper extremities and shoulder girdle – 32% in total. The proportion of patients who are not bothered by any part of the body is 6.2%. Each patient could indicate from one to seven parts of the body that bother him. The proportions of patients who indicated a different number of problem parts of the MSS are shown in Fig . 2.

The largest proportion of patients report having only one problematic body part (38.1%). Two body parts bother 31.4% of patients. Studies of the frequency of comorbidity in elderly patients (77.6±8.2 years) (Khovasova, 2022) showed that approximately the same number of patients (56%) had two or more MSS diseases and a larger number (35%) had three or more.

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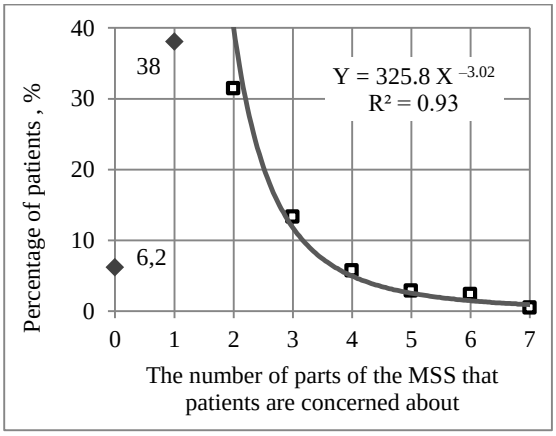

Figure 2: The number of parts of the musculoskeletal system that patients are concerned about.

The dependence of the proportion of patients in % on the number of problematic parts of the MSS from 2 to 7 is approximated with a high coefficient of determination $R^2 = 0.93$ by a power trend

$$Y = 325.8 \bullet X^{-3.02}. \quad (2)$$

Previously, the authors conducted studies of polymorbidity (Rukodaynyy , 2023) of 212 patients with MSS diseases , which took into account not only MSS problems , but also other diseases. In this case, the dependence of the proportion of patients on the number of diseases has approximately the same character as in Fig. 5, but with the number of diseases increased by one. In these studies, the maximum proportion of patients (29.4%) had two diseases, not one. In second place were patients with three diseases (27.8%), not two.

The trend for diseases from 3 to 10 is

$$Y = 1051 \bullet X^{-3.31}. \quad (3)$$

Thus, the approximately cubic power-law dependence of the proportion of patients with different numbers of diseases is quite universal.

3.4 Level of pain felt by patients

The presence of problems in the MSS is usually associated with the pain felt by patients. To assess the level of pain felt by patients, a scale close to the 10-point Verbal Pain Rating Scale and the Verbal-Descriptive Scale (Gaston – Johansson , 1990) was used in the questionnaire. The average pain corresponds to the average digital rating - 5. Each patient indicated one of the proposed pain levels. As the results of the study showed, the distribution of patients by the level of pain felt (Fig . 3) is bell-shaped, with the exception of those who do not feel pain (20.5%).

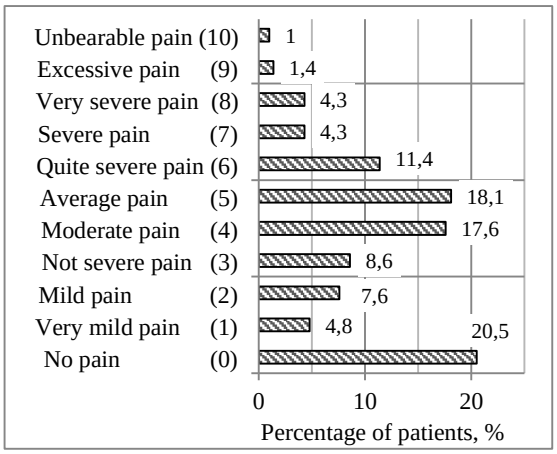

Figure 3: Level of pain felt by patients.

About half of patients (47% of all patients or 59% of those who experience any pain) experience moderate, average or quite severe pain. Unbearable, excessive, very severe or severe pain is felt by 11% of patients. Mild or weak pain is felt by 21% of patients, and 20.5% do not feel pain.

The expected BMI for the mild pain group (levels 0–3) is 23 kg /m^2 , and for moderate and severe pain it is 27.3–27.8 kg /m^2 · This means that patients with a lower BMI tend to experience less pain.

The correlation between the level of level of pain felt (LPF) and BMI is statistically significant – 0.39. The correlation between the level of perceived pain and DPA is small and equals 0.14. The correlation between LPF and the number of parts of MSS that bother patients is equal to 0. 18.

3.5 General health

Patient survey about The general health status (GHS) showed that the majority of them consider themselves to have good (41.5%) or satisfactory (42%) health status. Unsatisfactory or very poor GHS in 12% of patients and excellent GHS in 4.3% of patients .

The analysis of the correlation between the health indicators considered above is presented in Table 5. The highest value (0.39) is the correlation between the body mass index and the level of perceived pain. The least significant is the correlation between the general state of health and the duration of physical activity.

Table 5: Correlation between health indicators.

Health indicators		Correlation
1	2	
GHS	Body mass index	–0.32
	Level of pain felt	–0.35
	Duration of physical activity	+ 0.05
	Number of sick parts of the MSS	–0.28
BMI	Level of pain felt	+ 0.39
	Duration of physical activity	–0.09
	Number of sick parts of the MSS	+ 0.31

3.6 Concomitant diseases

Table 6 presents the proportion of patients with various MSS comorbidities and conditions (NCD).

According to their reviews, the most common concomitant diseases and painful conditions observed in patients of this clinic are the consequences of injuries and surgeries (41%), cardiovascular diseases (19%), allergic reactions (17%), gastrointestinal diseases and ulcers. These are the same diseases that were noted in the previously completed work on the study of polymorbidity (Rukodaynyy, 2023) (more than 2 chronic diseases in one patient), but the results obtained also have some differences, since different samples are considered here.

It can be seen that the highest correlation (–0. 38) is observed with general health status , which is quite natural. Body mass index also significant correlates (0. 33) with Number of sick parts of the MSS.

Table 6: Proportion of patients with concomitant diseases and conditions.

Concomitant diseases of MSS diseases and conditions	%
Injuries, operations	41. 2
Cardiovascular	19. 4
Allergic reaction	16. 6
Gastrointestinal, ulcerative	14. 2
Varicose veins, thrombophlebitis	10. 4
Brain diseases	10. 0
Eye diseases	9. 5
Thyroid disease	8. 5
Gynecological or urological	7. 1
Urolithiasis, cholelithiasis	5. 7
Diseases of the endocrine system	5. 7
Bronchial diseases, asthma	4. 7
Diabetes mellitus	3. 3
Oncological diseases	2. 8

Table 7 also shows the values of the correlation coefficients between the number of sick parts of the MSS (NSD) and other health indicators.

Table 7: Correlation of NCD with other health indicators.

Health indicators		Correla-tion
1	2	
NCD	General health status	–0. 38
	Number of sick parts of the MSS	0. 34
	Body mass index	0. 33
	Level of pain felt	0. 19
	Duration of physical activity	–0. 08

It can be seen that the highest correlation (–0. 38) is observed with general health status , which is quite natural. Body mass index also significant correlates (0. 33) with Number of sick parts of the MSS.

There is also a correlation (0. 34) between NCD and number of sick parts of the MSS , which is difficult to consider obvious. Probably, the growth of both diseases is equally influenced by such factors as high BMI , etc.

3.7 The combined influence of various factors on general health

Of all the indicators that affect General health status , only the duration of physical activity (DPA) has a positive effect , although weakly. To bring this indicator into a unified form, the lack of physical activity indicator LPA = 7 – DPA was formed , the

growth of which negatively affects GHS , and from the point of view of correlation it is equivalent to DPA , since the constant does not affect the correlation.

To determine the combined effect of various health indicators on the General health status (GHS) indicator, a comprehensive health predictor was formed.

$$I_H = BMI \bullet K_1 + LPF \bullet K_2 + LPA \bullet K_3 + NSP \bullet K_4 + NCD \bullet K_5, \quad (4)$$

where K_N – coefficients whose sum is equal to 1.

To determine the influence of various indicators on GHS , the coefficients K_N were varied and the correlation between GHS and the complex predictor I_H was determined. In this case, the values of K_N were searched for, at which the correlation is maximum (optimization). As the optimization results showed, the highest correlation between GHS and I_N is observed with two variants of K_N, which are given in Table 8.

Table 8: Coefficients K_N of the contribution of health indicators to the predictor I_H

Indicators	K_N	
Number of concomitant diseases and conditions	0. 37	0. 33
The number of sick parts of the MSS	0. 37	0, 33
The level of pain felt	0. 26	0. 25
Duration of physical activity	0	0. 09
Correlation	0. 47	0. 47

The maximum correlation coefficient is minus 0.47. This level of correlation is considered weak. An increase in each of the indicators considered makes a negative contribution to the overall health.

The results obtained indicate that the greatest (but weak) impact on the "healthy life state" (GHS) of patients is exerted by the number of comorbidities and conditions and the number of diseased parts of the MSS . A significant contribution to the General health status contribute to the level of perceived pain. Very little effect on General health status duration of physical activity, however, as shown above in a certain range Duration of physical activity this influence can be significant.

4 DISCUSSION

High levels of good and satisfactory The general health status against the background of low other conditions indicates the need to identify more detailed gradations of health in subsequent studies. This will allow us to identify the proportion of patients with moderately poor health. However, the number of gradations The general health status should not be very high (7–8), as it will be difficult for patients to assess the differences between them.

It is also important to include age and gender of patients in the key health indicators, although this is met with reluctance by some patients to voluntarily indicate their age.

5 CONCLUSIONS

1. A study of health indicators of 211 primary patients of the clinic of therapeutic and physical rehabilitation with diseases of the musculoskeletal system (MSS) using an electronic questionnaire made it possible to create a digital model of the state of healthy life of a sample of patients.
2. In the sample of patients, 32% have a body mass index (BMI) within the normal range, 34% are pre-obese, 22.5% are obese, and 12% are underweight. The distribution of BMI of patients is close to normal and has a mathematical expectation of BMI = 25.7 and a standard deviation of S = 6.5.
3. Duration of physical activity (DPA) is: less than half an hour a day for 41% of patients, from 0.5 to 1.5 hours for 28% and more than 1.5 hours for 31% of respondents.
4. Overall, the correlation between BMI and DPA is insignificant (–0.09). However, with an increase in DPA from 45 to 75 minutes, a significant decrease in the average BMI value is observed from 27.6 to 23.3 kg /m^2, which approximately corresponds to the patient's transition from the pre-obese to normal Body mass index.
5. The greatest number of patients are concerned about problems with the spine and the cervical-collar zone – 81% in total. In 80% of cases, patients note problems with the lower extremities, including the hip and knee joints, shins and feet. The upper extremities and shoulder girdle bother 32% of patients.
6. The presence of only one problematic part of MSS is noted by 38.1% of patients. Two parts of the body bother 31.4% of patients. The dependence of the proportion of patients on the number of problematic parts of MSS (more than 2) is approximated by a power trend $Y = 325.8 \bullet X^{-3.02}$, with a high determination coefficient (0.93).

7. The distribution of patients according to the level of pain felt according to the 10-point scale is bell-shaped, except for the 20% who do not feel pain. Moderate, moderate or quite severe pain (scores 4–6) is experienced by 47% of patients. Unbearable, excessive, very severe or severe pain (scores 7–10) is felt by 11% of patients. Mild or weak pain (scores 1–3) is felt by 21% of patients.
8. The mathematical expectation of BMI for the group of patients with mild pain (scores 0–3) is 23 kg / m^2, and for moderate and severe pain – 27.3–27.8 kg /m^2 , respectively. Correlation between The level of pain felt and Body mass index high and is – 0.39.
9. According to a 5-point scale, 42% of patients assess their General health status as satisfactory and the same number as good. 12% of patients consider their health to be unsatisfactory or poor. Correlation General health status with The level of pain felt minus 0.35, and with Body mass index – minus 0.32.
10. The number of concomitant diseases and conditions most closely correlates with the General health status (–0.38), Number of sick parts of the MSS (0.34) and Body mass index (0.33).
11. Grade joint influences various indicators General health status shows that the greatest contribution in optimal forecast indicator health contributes The number of concomitant diseases and conditions (37%), The number of sick parts of the MSS (37%), and The level of pain felt (26%).

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