BULGARIAN ACADEMY OF SCIENCES

Institute of Information and Communication Technologies

INTELLIGENT METHODS OF ANALYSIS OF REHABILITATION PROCESSES

PHD ABSTRACT

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INTRODUCTION

The development of new, highly effective intelligent methods of analysis of rehabilitation processes possessing optimal statistical characteristics is a topical scientific problem. This topicality is determined by the modern tendencies of widely using technical and technological methods in medicine and the growing importance of rehabilitation techniques for the improvement of the life quality of patients having neurological problems, in particular. These tendencies are expressed by the researchers' striving for using the latest achievements in the field of designing highly effective, but rather complex algorithms for data processing based on patients' observation in hospitals. Modern intelligent methods require processing of great data amounts using all the available information about the observed clinical situation.

In the last years more and more widely-applied are the intelligent methods of analysis and modelling of biological and medical processes which give useful information through using mathematical approaches as well as methods from the sphere of the 'artificial intellect'. Each real process is in fact a combination of separate sub-processes taking place in parallel through time. This, to great extent, makes it difficult to find out the regularities in the functioning of a certain biological system. The usage of mathematical means of modelling, including the generalized net model GMs) is practically proved as being an adequate and correct method of solving complex and important problems connected with rehabilitation processes.

Another approach which is a subject of this dissertation- the inter criteria analysis, uses two mathematical formalisms, defined in Krassimir Atanassov's doctrine, namely the algebraic apparatus of index matrices (IMs), when it is necessary to apply algebraic operations upon matrices with different dimensionalities, as well as the internationally recognized (intuitionistic fuzzy sets (IFSs) as a mathematical tool for treating uncertainty. Its aim is to use the matrix containing the data for the evaluations or the assessments of m in number evaluated objects multiplied by n in number assessment criteria in order to form a new matrix sized [m *x* n] which sets the correlations between every two criteria as intuitionistic fuzzy pairs, thus leading to the name inter criteria analysis. This dissertation work shows original results based on

research of the contemporary paradigms in the field of the intelligent systems, using analytical and experimental models.

The main accent in the dissertation work was the analysis of the great diversity of researches and already existing methods whose aim was to define the appropriate approaches, methods and algorithms to be tested on definite groups of objects. In order to achieve the desired results efforts were made aimed at different elements of the whole procedure of diagnostics of the rehabilitation processes- comparative analysis, choice and justification of their parts, evaluation of their strong points and restrictions, the perspectives of realisation in the spirit of world trends.

This dissertation work aims at developing highly effective intelligent methods of the rehabilitation process analysis using the contemporary paradigms from the field of the intelligent systems. In order to achieve this goal, the following tasks are formulated:

1. to systematize the existing intelligent methods of analysis of rehabilitation processes;
2. to analyse Ankylosing Spondylitis - Behterev's disease in order to achieve higher efficiency of the rehabilitation processes;
3. to analyse a chronical degenerative disease of the knee joint - Gonartrosis to achieve higher efficiency of the rehabilitation processes;
4. to analyse the legal aspects in using data connected with the physical condition of patients in hospitals;
5. to develop generalised net models of rehabilitation processes of an upper limb;
6. to gain original results concerning the application of intelligent methods of analysis of rehabilitation processes related to socially significant problems.

The results from the analysis of the estimated rehabilitation processes have been presented at three international conferences: the 21th International Conference on Intuitionistic Fuzzy Sets – ICIFS 2017, Burgas, Bulgaria, the 13th International Workshop on Intuitionistic Fuzzy Sets – IWIFS 2017, Banská Bystrica, Slovakia, the 9-th IEEE International Conference on Intelligent Systems – IS 2018, Madeira Island, Portugal, as well as at a national conference: A Scientific session "Biomedicine And

Quality of Life- Young People In Science", organized by organized by the Institute of Biophysics and Biomedical Engineering - BAS, 2016, Sofia, Bulgaria.

The dissertation work has the following structure: an introduction, four chapters and a conclusion and is accompanied by a declaration of originality of the results achieved, as well as by a bibliography.

The dissertation work's publications list includes six papers, two of them in SCImago Journal Rank (SJR) - International Journal Bioautomation, two articles in Notes on Intuitionistic Fuzzy Sets magazine, an article in the magazine of the Polish Academy of Science- Issues in Intuitionistic Fuzzy Sets and Generalized Nets and one article included in the database of IEEEXplore. All publications are referenced and indexed in world famous data base containing scientific information, thus complying with the requirements of the Act of the Development of the Academic Personnel in the Republic of Bulgaria.

CHAPTER 1. REVIEW OF THE INTELLIGENT METHODS OF ANALYSIS OF COMPLEX PROCESSES

Main accent in this dissertation work was put on the analysis of the considerable diversity of research and the existing methods which were supposed to define the most appropriate approaches, methods and algorithms by being tested on certain classes of objects. The efforts for achieving the desired results were directed mainly towards different elements of the overall procedure of choosing suitable instruments for carrying out the procedures for estimating the tested systems-comparative analysis, choice and justification of some of its elements, evaluation of their strong sides and restrictions, the realisation perspectives in the spirit of world trends.

A number of mathematical devices for modelling of biological and medical processes can be found in literature. A great part of the development of these sciences is due to the use of mathematical and statistical means and approaches, as well as of approaches and methods from the sphere of the 'artificial intellect'. Every real process is, in fact, an aggregation of separate sub-processes, running in parallel in time. This

makes it quite difficult to reveal the regularities in the functioning of a certain biological system. In this connection the use of the mathematical means of modelling, the Generalized Net Model (GNM) in particular, is seen as an exceptionally adequate and correct method. The Generalized Net Modelling provides opportunities for precise tracking of all parameters of the sub-processes being set in different conditions and different time moments.

The process of taking decisions in the course of a certain treatment and rehabilitation programme is of key importance for the favourable outcome, so, taking this into consideration, the construction and simulation of different models makes it possible to estimate the condition, make prognoses about critical moments or situations, and plan the process of treatment and the necessary facilities. The GN model has been used through the years for modelling of a number of biological processes. The most prominent example we can give in this sphere is the modelling of the human body and its particular systems.

This dissertation work will also use a recently-defined new approach for supporting decision-taking, named ‘Inter Criteria Analysis’. In this approach from several data arrays obtained through the measurement of a lot of objects based on many criteria, correlations between each pair of criteria are calculated as intuitionistic fuzzy pairs/sets of values in the interval [0, 1]. This approach takes into consideration the effect of uncertainty, gives opportunity of working with arrays missing certain data and works both with numbers and linguistic variables with an introduced regulation. The inter criteria analysis can also be applied with tasks in which the measurement of some of the criteria is slower or more expensive, which in turn makes the whole decision-taking process slower or more expensive. Such problems require a method of justified elimination, thus leading to economy and efficiency.

GN models help researchers in studying the logic of processes connected with diagnosis and treatment, they also help medical students and postgraduates to acquire diagnostic skills and also when checking students’ knowledge with real time simulations.

GN can use and send information from and to expert and/or IT systems as well as connect to specialized medical computer equipment through suitable interface. This

helps the diagnosis process through confirming the specialist's opinion or supplementing the decision with an expert evaluation. Presents an aggregation of GN models which will allow the development of specific modelling software to support the diagnosis process. A lot of different types of GN models have been built so far in medicine, for example:

- GN models of the human body- modelling of physiological processes.
- GN models for disease diagnosis in emergency medicine, behavioural medicine, gynaecology, urology, neurology, nephrology, pharmacology, etc.

The multicriteria decision making is often to be found in practice (DM). Both the criteria and the available data obtained through measurement and evaluation of the objects to the criteria can be diverse and varied. Sometimes some of the criteria come at a higher cost than others, e.g. are harder, more expensive, more human resource or time consuming to measure or evaluate. In such cases it would be of substantial benefit for the decision making person (DMP) to disregard all or parts of these 'unfavourable' criteria from the further decision making process without considerably losing accuracy. The aim is to identify high enough levels of correlation between these 'unfavourable' criteria and others that are easier, cheaper or quicker to measure or evaluate. It is considered that the disregard (without considerable loss of accuracy) of some of the criteria in DM, based on an established correlation between these and other criteria could lead to considerable boosting or reduction in the price of the entire process of DM, which is always favourable and can even be of vital importance in certain cases.

The inter criteria analysis method is introduced in. It is based on two mathematical formalisms - the apparatus of index matrices for processing of data arrays with different dimensions and the intuitionistic fuzzy sets as a mathematical tool for treating uncertainty.

CHAPTER 2. REHABILITATION PROCESS ANALYSIS WITH ANKYLOGING SPONDYLITIS AND CHRONICAL DEGENERATIVE DISEASE OF THE KNEE JOINT

The observations show that 0.5% of the population on average suffers from Behterev's disease. Men suffer nearly four times more than women. The disease affects people at the end of puberty and in their twenties (age range 16-30 years).

This disease leads to disability and has serious consequences both for the diseased and for the society. The clinical symptoms and the resulting disease progression lead to considerable functional disabilities and influence the quality of healthy life. They influence the mood, motivation and the ability to deal with everyday activities. Such patients are more likely to show reactive depression and frustration combined with disturbed self-assessment and difficulties in their social integration. A great part of the patients have decreased self-perception and lack stimulus for an adequate life. According to some studies 2/3 of the diseased men have difficulties in their work, 1/3 have social problems and over 2/3 suffer from sexual imbalance. Quite often there are problems connected with their energy and tone. Among the greatest fears patients share is that of losing their independence. Most of them say they need help with their dressing, taking a bath or shopping. They also feel uncertain about their future e, particularly concerning the unclear state of the disease progression. The patients are concerned about their outer appearance, they feel worried that they are hunched and don't look good. The disease affects the patients' relationship with their family and friends restrict their social life.

The ankylosing spondylitis (Behterev's disease) is a disease of the spine, but it also affects the big limb joints- the hip joint, the knee joint and the shoulder joint. It is more common with men.

It is not totally clear yet what causes ankylosing spondylitis. What is already known is that some hereditary (genetic) factors, as well as some environmental factors (both inside and outside the system) can lead to the development of the disease. It is found out that the inclination to this development is transferred genetically and most of

the patients having Behterev (about 90%) possess a gene from the complex of the tissue compatibility called HLA-B 27.

The most characteristic symptoms of the disease are: pain in the sacroiliac region, limited mobility, entezopathy, arthritis of peripheral joints**.**

Treatment

Non-steroidal anti-inflammatory agents (NSAIA) - they suppress the inflammatory process and the pain, corticosteroids - they suppress the inflammatory process, myorelaxants - they relax the stiff paravertebral muscles, immunosupressants (methotrexate, sulfasalazine), biological means - the latest medicines in the treatment of Behterev's disease and other rheumatological diseases. They control the activity of the disease and stop its development. A very important role in the treatment of Behterev's disease is played by the **kinesitherapy and rehabilitation**, applied in periods when the disease is suppressed by medicines or is not active (remission). The purpose is to keep the mobility of the spine and the affected joints as long as possible.

Kinesitherapy with Behterv's disease

The purpose of the kinesitherapy is to keep the mobility and function of the spine and the affected joints.

Tasks and means:

Acute period - supporting the healing process:

1. Pain relief- treatment through position - physiological, without pain.
2. Maintaining the cardio-respiratory activity - by periodically changing the baseline, respiratory exercises.
3. Maintaining the joints' movements - by passive and isometric exercises.

Sub-acute period - recovery of the patient's health:

1. Strengthening of the general condition - by breathing and general development exercises.
2. Improving the tissue trophy - by trophic massage.
3. Recovery of the normal volume of movement in the joints - by passive exercises, active exercises from obsolete baseline, using techniques from PNF, PIR.
4. Muscular strengthening - by exercises against metered resistance (manual, mechanical, in water).

5. Recovery of the proper gait- by training the correct execution of the support and flywheel phase during walking.

6. Self-service training- by everyday activities.

Chronic period - stage of the disease development:

- I early stage - pain prevails, but there is no functional deficit.

Group exercises lasting for about 30-40 minutes are suitable, at least 3 times a week. The kinesitherapeutical set is performed at home using the devices from the previous period. Some sports like swimming, cycling, hiking and hardening procedures are recommended, according to the patient's preferences.

- II stage - slight functional restrictions with preserved working capacity.

Special attention is paid to the existing contracts; the exercises from the previous period are supplemented with exercises with special direction- manual mobilization, passive joint movement in water, underwater gymnastics, underwater shower massage, pain-releasing procedures.

- III-IV stages - big functional restrictions, reduced working capacity, and disability.

The existing ankyloses are of significant importance here. The means which are used are considerably different from the previous stage - passive exercises, manual mobilization and izometric trainings which should be done in warm water. Special attention is paid to the gait.

Chronic degenerative disease of the knee joint - Gonartrosis

The knee performs the function of a medial motor link in the kinetic chain of the lower limb. The knee joint endures the weight of the body that is why it must have mobility, stabilization and dynamism in order to hold the body in different postures.

One of the most common diseases of the locomotory system is the osteoarthritis of the knee joint. It affects mainly middle-aged people, prevailing female. The gonarthrosis leads to medical, social and psychological problems, deriving primarily from the accompanying restricted movements of the affected lower limb and the tendency to invadilizing the people suffering from it. The main reasons why the knee joint is being worn out are old age, static abnormalities (e.g. overloading, traumas, inner joint injuries and diseases). Among the most widely-spread causes are the

constant overloading, obesity, hard physical labour and hypokinesia. All these unfavourable factors lead to surgical intervention and inserting of artificial joints at a later stage. However, before this surgical interference the patient can undergo kinesitherapy which could have quite favourable effect on their condition. In this way the endoprosthesis of the knee joint is delayed in time.

Symptoms of the Gonartrosis

The most common symptom of the Gonartrosis is pain, joint oedema with transitional hydrops, joint rigidity, gradual restriction of the knee folding and unfolding, hypotrophy of the quadriceps muscle of the thigh, presence of crippling during knee joint movements, distortion of the lower leg inwards to the other leg (various deformation), or more rarely, outwards (warp deformation), flexion contracture, joint deformation to an extent of complete change of the knee shape and considerable distortion of the gait.

Treatment

The conservative treatment includes joint burden, body mass reduction, use of facilities (canes, crutches, etc.), kneeling's and other dynamic splints for correction of lower limb centre, change of the shoe heels, correcting pads in case of various or warp deformation. Conservative treatment also includes physiotherapeutic procedures, balneo-sanatorium treatment as well as kinesitherapeutical procedures for keeping the muscular tonus and increasing of the movement volume.

A massage is recommended in its varieties - manual, hydro massage, mechanotherapy, less mobile games. Most suitable procedures are cycling on a stationary simulator, and swimming (water gymnastics). The kinesitherapeutist should work in collaboration with the whole rehabilitation team - the orthopaedist, the rheumatologist, the general practitioner, the nurse, the social worker, etc.

Surgical intervention is applied in case of unsuccessful conservative treatment. The aim of kinesitherapy in case of gonarthrosis is as with all other degenerative joint illnesses, to rehabilitate the locomotory function of the lower limbs to the maximum possible degree. According to some resources, most exercises with patients having osteoarthritis are based on the biomechanical concept stating that muscles have an important protective function over the joints sustaining normal alignment and

absorption of stress and pressure. Patients with osteoarthritis also show muscular fibres atrophy which is more clearly expressed than the one typical of aging. Thus the pressure which cannot be taken by these weakened muscles, tendons and ligaments goes to the joint cartilage and the liable bone. That is why the kinesitherapeutical programme puts an accent on training the m.quadriceps femoris, mainly the m. vastus medialis.

The main functional problems of osteoarthritis of the knee joint are: pain while moving or joint load (walking, going up/down stairs), restriction of the movement volume (including difficulties in performing everyday activities, requiring bigger flexion of the knee joint), muscular imbalance and reduced muscle strength, restricted motor activity. The kinesitherapy with patients having osteoarthritis (gonartrosis) should functionally combine restorative, compensatory and educational element.

Tasks and means:

1. Mobilizing of the soft tissues - a massage is used to improve the mobility of the ligaments, tendons, insertions and the tendon adhesions.
2. Pain decrease and joint protection - getting the right position in the bed, using splints to avoid contractures and deformations. Doing the right active exercises in full volume of movement.
3. In case of restricted joint game - applying suitable techniques for joint mobilization. (Joint mobilization can lead to stretching the shortened joint capsule.)
4. Extension of the shortened tissue - applying of auto stretching or mechanical stretching.
5. Maintenance of the soft - tissue and joint mobility - applying of passive, actively assisted or active movements. They are applied within the limits of the possible painless volume of movement.
6. Restoring muscle control - active movements are applied within the painless volume, gradually including slight resistance.
7. Maintenance of the muscular function and prophylaxis of the adhesions around the patella - isometric contractions for the quadriceps and the sciatic musculature from painless positions.

8. Restoring the muscular stabilization - controlled exercises in a closed kinetic chain. The pressure is increased either through increasing the amplitude of movements or through decreasing of the given help.

9. Muscle endurance - active exercises emphasizing on the control are applied at the beginning, gradually including resistance. The rule of low loading and a great number of repetitions is observed, without breaking the coordination. In case of fatigue the exercises should be stopped.

Examination methods

Among the methods used for examination is angulation, applied with reporting the results based on the standard SFTR methodology.

Another widely-used method is the one using a generic instrument for estimation of the general health - Health Survey Form (SF-36). It is divided into physical and mental components and estimates different aspects such as vitality, physical function, pain, general condition, emotional state, social realization, etc. It has got an 8-scale profile of the functional results concerning the health and general well-being, psycho-metrically based generalized measurement of the physical and mental health, as well as a preferentially based index of health utility. This instrument is widely applied because it can be used regardless of the age or the pathology of the patients. The generic instrument provides information for the functional and general condition from the patients' point of view.

Kinesitherapy

The aim of kinesitherapy is to maintain and improve the function of the knee joints and of the whole lower limb.

Methodology of kinesitherapy

The procedures in kinesitherapy are specified according to the patients' condition. With patients having primary gonartrosis conservative methods of kinesitherapy are usually applied.Patients do individual activities. The length of the activities is 45 minutes, the exercises being repeated 10-15 times. The application of cryotherapy aims at releasing the pain symptoms and reducing the swelling of the affected limb. The cryotherapy is performed with an ice cube for about 3-5 minutes, until redness appears.

Mobilization of the patella is also passively applied, because the function of the patellofemoral joint is quite important for the normal function of the whole knee complex. Parting of the joint surfaces and penetration of joint liquid between them is achieved through mobilization of the tibiofemoral joint, realized by traction along the axis of the lower leg. Thus the trophic process is additionally improved.

The aim of the application of passive exercises in painless volume is to improve the trophic process of the affected area without causing pain. The multiple repetitions of the passive exercises give opportunity for stirring of the joint liquid.

Mobilization of the peripheral nerves is applied in order to improve the circulatory disorders, the limited volume of movement and contractions. Manifesting symptoms of the patient should be looked for. Analytical exercises are also applied from starting back-lying position or sitting position with a weight of 1-1,5 [kg] for strengthening of the quadriceps femurs.

Through application of PNF techniques - Hold-Relax, the muscular tone is decreased while increasing the movement volume of the respective joint. When there is no pain and complaints, exercises in a closed kinetic chain are also included-mini-squats for improving the stabilizing function and control of the muscles. The improved gait is achieved through walking in front of a mirror applying visual control. This aims at improving of the coordination and stability.

CHAPTER 3. EXPERIMENTAL RESULTS FROM THE APPLICATION OF INTELLIGENT METHODS FOR ANALYSIS OF REHABILITATION PROCESSES

Application of Inter Criteria Analysis with patients having ankylosing spondylitis - Behterev's disease

Subject of examination is the health status of patients with rheumatoid arthritis concerning their quality of life. The surveyed patients are aged between 25 and 80 years. They are divided into two groups- an experimental and a control group. The division of the patients in number is as follows: a control group - 45 patients, 38 female and 8 male; an experimental group - 43 patients, 33 female and 10 male.

The applied test is a **standardized examination test-Health Survey Form (SF-36).**The SF-36 test is a multipurpose standardized test for estimation of the general health state containing 36 questions. It has got an 8-scale profile of the functional results concerning the health and general well-being, psycho-metrically based generalized measurement of the physical and mental health, as well as a preferentially based index of health utility. The following are estimated in quantity: Physical Functioning (PF), Role-Physical Functioning (RP), Bodily Pain (BP), General Health (GH), Vitality (VT), Social Functioning (SF), Role-Emotional (RE), and Mental Health (MH).

A specialised methodology of kinesitherapy is carried through to the patients. Its purpose is to achieve possible functional influence compliant with the rehabilitation potential. The following means of kinesitherapy are applied: passive exercises for the wrist and the hand, analytical exercises, terrain treatment , underwater gymnastics, exercises for building a muscle corset, resistive exercises, active exercises using appliances, manual mobilization of peripheral joints, isometric exercises, PNF, mechanotherapy, treatment with a position.

Fig. 3.1 shows results from the standardized test SF-36 after a conducted treatment. All data from the examinations for the 8 indexes of SF-36 can be observed for the two groups EG and CG - beginning and end. The obvious big fluctuations emphasize once again on the relapse nature of the disease rheumatoid arthritis, its unpredictability and almost impossible foreseeing. This confirms the hypothesis that together with the medication and physical apparatus treatment kinesitherapy can change positively some of the indexes of the SF-36 test concerning the quality of life of the patients with rheumatoid arthritis, in spite of its unpredictable character and the constant surprises both for the patient and the therapist.

Tables 3.1 and 3.2 present the results received from the application of the Inter Criteria analysis of the rehabilitation processes data.

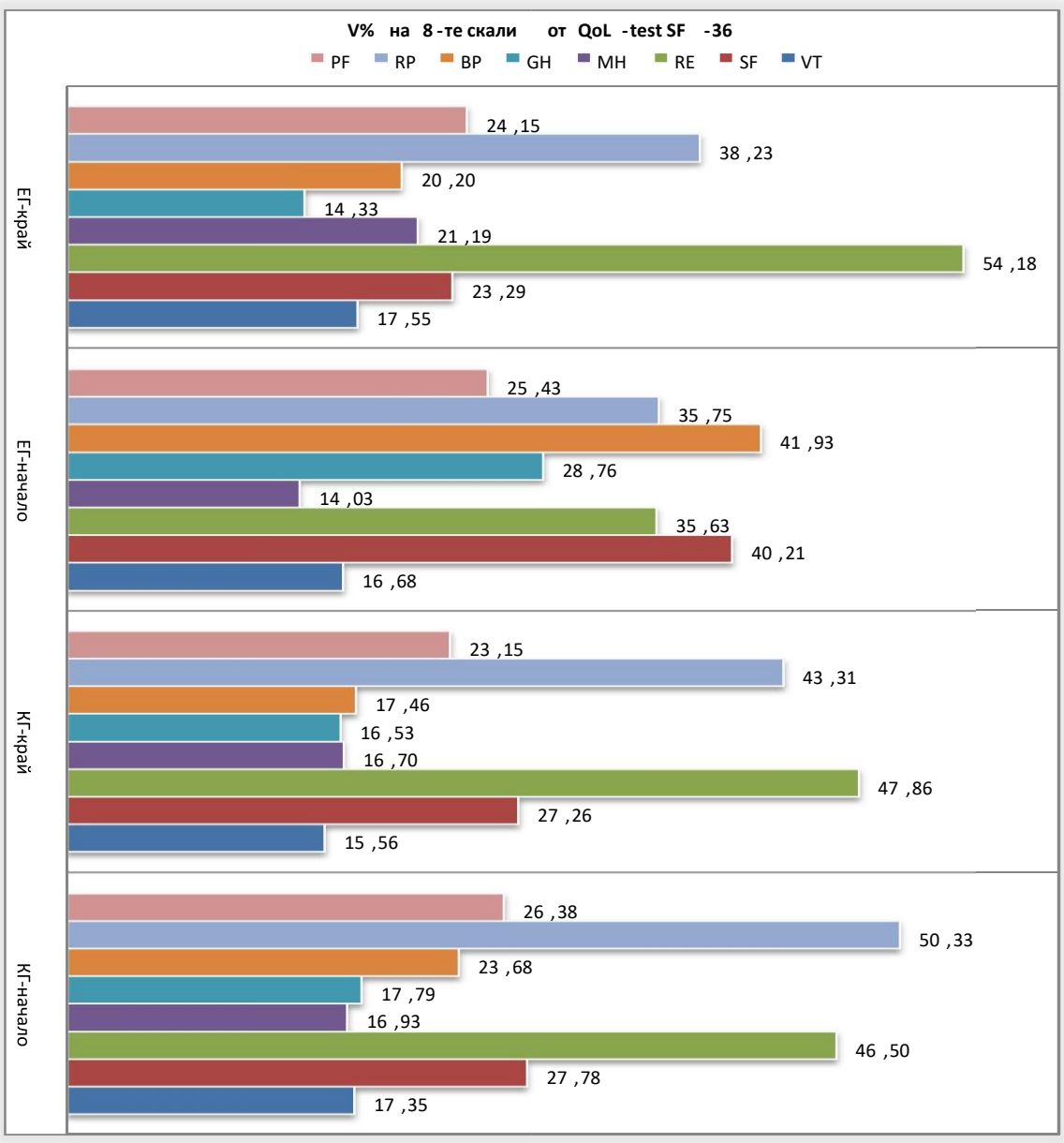

Fig. 3.1. Results ot test SF36

μ	PF	RP	BP	GH	MH	RE	SF	VT
PF	1	0.5	0.833333	0.666667	0.5	0.333333	0.666667	0.666667
RP	0.5	1	0.333333	0.5	0.666667	0.5	0.5	0.5
BP	0.833333	0.333333	1	0.833333	0.333333	0.166667	0.833333	0.5
GH	0.666667	0.5	0.833333	1	0.166667	0	1	0.333333
MH	0.5	0.666667	0.333333	0.166667	1	0.833333	0.166667	0.833333
RE	0.333333	0.5	0.166667	0	0.833333	1	0	0.666667
SF	0.6667	0.5	0.833333	1	0.166667	0	1	0.333333
VT	0.666667	0.5	0.5	0.333333	0.833333	0.666667	0.333333	1

Table 3.1. Membership pairs of the intuitionistic fuzzy InterCriteria correlations

ν	PF	RP	BP	GH	MH	RE	SF	VT
PF	0	0.5	0.166667	0.333333	0.5	0.666667	0.333333	0.333333
RP	0.5	0	0.666667	0.5	0.333333	0.5	0.5	0.5
BP	0.166667	0.666667	0	0.166667	0.666667	0.833333	0.166667	0.5
GH	0.333333	0.5	0.166667	0	0.833333	1	0	0.666667
MH	0.5	0.333333	0.666667	0.833333	0	0.166667	0.833333	0.166667
RE	0.666667	0.5	0.833333	1	0.166667	0	1	0.333333
SF	0.333333	0.5	0.166667	0	0.833333	1	0	0.666667
VT	0.333333	0.5	0.5	0.666667	0.166667	0.333333	0.666667	0

Table 3.2. Non-membership pairs of the intuitionistic fuzzy InterCriteria correlations

Two of the indexes - social functioning and health condition show strong correlation. It is normal for these two factors to be related because social functioning is determined to a great extent by health condition. When a person's health condition – physical and emotional, is very good, they also feel good, have self-esteem and thus improve their social functions. And vice versa - if a person is ill, they don't feel emotionally and physically good and this disturbs their social life. The patient gets depressed, becomes introverted and lacks socializing desire. The obtained results show convincingly this strong connection between the two criteria.

Other criteria with a relatively high mutual correlation are:

- Pain intensity and physical development - there is also high correlation between these two criteria. This is due to the fact that when the patients don't have pain, they are able to develop physically. All activities which do not cause pain are performed willingly and lead to satisfactory results from the patient. On the contrary, if the pain is persistent, constant and cannot be overcome, the patient gives up certain exercises and everyday activities. This leads to worsening of their physical development - the patient gets immobilized and their muscles get atrophied.
- Health condition and pain intensity - the same correlations are observed between the indexes of health condition and pain intensity. When health condition is good, pain intensity is lower and vice versa.
- Social functioning and pain intensity - similar connections are observed between these indexes as well.

- Vitality and mental health - these two criteria are also strongly related. Good mental health leads to greater vitality of the patients.

Criteria which have relatively weak correlation are:

- Health condition and role functioning, based on the emotional state- the correlation between these two criteria is very weak because they are quite different in their nature. The health condition of the patients could be not so favourable, but emotionally they might want to have high role functioning. The patients should be objective concerning their illness and momentary state.
- Social functioning and role functioning based on the emotional state - in this case we can also observe very weak correlation between the two criteria due to reasons similar to the aforementioned.

Specialized kinesitherapeutical methodology with patients having Ankylosing Spondylitis with accent on the locomotor component

The presented survey shows 25 patients -14 female and 11 male, aged 25 to 67 years. They have been subject to specialized kinesitherapy methodology aiming at increasing the movement volume in the cervical part and decreasing the stiffness. The kinesitherapeutical methods of treatment applied in this case are as follows:

1. Pain examination - quantitative measurement of pain using the visual - analogue scale (VAS), degree 0 meaning lack of pain and degree 10-maximum pain. The patients themselves define the pain degree.

2. Angulation using the SFRT methodology - angulation is a method of measuring the volume of joint mobility. The results are registered using the SFRT methodology. The spinal mobility is measured with three axes of mobility: flexion/extension, lateral inclination to the left and to the right and rotations.

3. Специализирани тестове:Specialized tests:

- Ott's test - shows the mobility of the thoracic division of the spine.
- Forestier's test - shows the extension in the thoracic division.

The aim of kinesytherapy in this case is to keep and increase the mobility and function of the spine-cervical division.

The kinesitherapy methodology is individual for each patient. Most important is the active participation of the patients in the recovery process. The kinesitherapy

should influence the psycho-emotional tone of the patient by increasing their self-esteem and confidence in their own abilities. A conservative methodology of kinesitherapy is applied in a stage of remission with patients having ankylosing spondylitis. Patients do individual exercises lasting for 60 minutes.

Patient	Pain	Fl of head	Ext of head	lateral move left	lateral move right	Ottis test	Forestie test
	beginning	beginning	beginning	beginning	beginning	beginning	beginning
1	6	45	30	15	13	2,5	4
2	6	30	35	12	14	2,5	4
3	7	35	31	7	10	2	5
4	8	30	40	4	6	2	6
5	6	45	50	17	20	2,5	5
6	7	15	45	8	6	2,5	7
7	6	30	44	25	20	2,5	3
8	6	40	50	30	25	2,5	4
9	8	45	28	6	6	1,5	7
10	10	15	30	5	6	1	8
11	6	50	40	15	13	2	3
12	7	30	43	6	7	2	5
13	7	30	45	5	7	1,5	6
14	8	15	28	4	8	1	8
15	8	20	30	6	8	1,5	9
16	6	45	48	20	20	2,5	4
17	6	40	50	25	22	2	3
18	5	55	50	20	20	2,5	3
19	5	60	54	15	10	2,5	4
20	7	30	28	7	5	2	5
21	10	10	30	5	6	0,5	8
22	10	15	25	6	8	1	9
23	6	50	40	10	12	2	5
24	6	45	45	12	12	2,5	4
25	5	60	50	20	25	2	3

Table 3.3. Results of patients before KT course

The results obtained after a course of kinesitherapeutical and physiotherapeutical treatment are shown in Table 3.3 for the beginning of the course, and in Table 3.4 for the end of the treatment.

The tables 3.5 and 3.6 show the results from the application of the Inter Criteria Analysis of the data at the beginning of the rehabilitation processes. The table 3.5

shows the results of ‘membership’ of the intuitionistic fuzzy sets, while Table 3.6 shows the results of ‘non-membership’ of the intuitionistic fuzzy sets.

Patient	Pain	Fl of head	Ext og head	Lateral move left	Lateral move right	Ottis test	Forestie test
	end	end	end	end	end	end	end
1	4	50	37	22	20	3,3	3
2	5	36	38	15	19	3	2
3	4	39	45	15	15	3,3	3
4	4	42	50	13	17	3	4
5	3	55	55	20	25	3,5	2
6	4	30	50	16	13	3,5	4
7	4	50	50	30	30	3,3	2
8	3	60	55	38	33	3,5	2
9	5	50	35	18	16	2,5	4
10	5	23	38	15	13	2,2	4
11	5	62	47	25	25	3	0
12	4	52	50	18	15	3,5	3
13	5	45	55	28	20	2,5	4
14	4	20	34	12	16	2	4
15	5	30	40	15	15	2,2	7
16	3	62	54	30	33	3,5	2
17	4	60	54	30	30	2,8	1
18	4	60	55	28	25	2,8	1
19	4	63	58	20	18	3	2
20	4	43	33	20	15	3	3
21	6	17	40	10	12	2	5
22	8	20	30	12	12	2	5
23	4	64	48	15	15	2,5	4
24	4	54	49	20	18	3	2
25	3	72	55	28	30	3,5	1

Table 3.4. Results of patients after KT course

μ	Pain	Fl of head	Ext of head	Lateral left	Lateral right	Ottis test	Forestie test
Pain	1.00	0.09	0.11	0.09	0.13	0.14	0.75
Fl of head	0.09	1.00	0.62	0.63	0.62	0.57	0.15
Ext of head	0.11	0.62	1.00	0.67	0.66	0.58	0.18
Lateral move left	0.09	0.63	0.67	1.00	0.79	0.62	0.12
Lateral move right	0.13	0.62	0.66	0.79	1.00	0.55	0.15
Ottis test	0.14	0.57	0.58	0.62	0.55	1.00	0.20
Forestie test	0.75	0.15	0.18	0.12	0.15	0.20	1.00

*Table 3.5. Results of **μ** reached by ICA analysis at the beginning of survey*

ν	Pain	Fl of head	Ext of head	Lateral left	Lateral right	Ottis test	Forestie test
Pain	0.00	0.67	0.63	0.67	0.63	0.57	0.02
Fl of head	0.67	0.00	0.20	0.20	0.22	0.15	0.64
Ext of head	0.63	0.20	0.00	0.19	0.20	0.12	0.62
Lateral move left	0.67	0.20	0.19	0.00	0.09	0.09	0.72
Lateral move right	0.63	0.22	0.20	0.09	0.00	0.16	0.66
Ottis test	0.57	0.15	0.12	0.09	0.16	0.00	0.57
Forestie test	0.02	0.64	0.62	0.72	0.66	0.57	0.00

*Table 3.6. Results of **ν** reached by ICA analysis at the beginning of survey*

μ	Pain	Fl of head	Ext of head	Lateral left	Lateral right	Ottis test	Forestie test
Pain	1.00	0.13	0.16	0.16	0.15	0.11	0.53
Fl of head	0.13	1.00	0.69	0.72	0.71	0.61	0.13
Ext of head	0.16	0.69	1.00	0.66	0.64	0.60	0.22
Lateral move left	0.16	0.72	0.66	1.00	0.79	0.61	0.14
Lateral move right	0.15	0.71	0.64	0.79	1.00	0.60	0.14
Ottis test	0.11	0.61	0.60	0.61	0.60	1.00	0.22
Forestie test	0.53	0.13	0.22	0.14	0.14	0.22	1.00

*Table 3.7. Results of **μ** reached by ICA analysis at the end of survey*

ν	Pain	Fl of head	Ext of head	Lateral left	Lateral right	Ottis test	Forestie test
Pain	0.00	0.53	0.51	0.48	0.51	0.56	0.11
Fl of head	0.53	0.00	0.22	0.18	0.18	0.25	0.68
Ext of head	0.51	0.22	0.00	0.23	0.23	0.23	0.57
Lateral move left	0.48	0.18	0.23	0.00	0.09	0.21	0.65
Lateral move right	0.51	0.18	0.23	0.09	0.00	0.21	0.67
Ottis test	0.56	0.25	0.23	0.21	0.21	0.00	0.55
Forestie test	0.11	0.68	0.57	0.65	0.67	0.55	0.00

*Table 3.8. Results of **ν** reached by ICA analysis at the end of survey*

The tables 3.7 and 3.8 show the results from the application of the Inter Criteria Analysis of the data at the end of the rehabilitation processes. The table 3.7 shows the results of 'membership' of the intuitionistic fuzzy sets, while Table 3.8 shows the results of 'non-membership' of the intuitionistic fuzzy sets.

The Inter Criteria Analysis approach is applied in order to find the correlations between the individual movements restoration in the cervical part of the spine. The

results from the patients' observation show strong correlation between two of the indexes- head flexion and lateral leanings. This result confirms the fact that the main muscle performing head flexion (m.sternocleidomastoideus) is also auxiliary in performing lateral leanings. On the other hand, the main muscles performing lateral leanings (mm.scaleni) are auxiliary in performing flexion. Respectively, the improvement in one of the movements will lead to an improvement of the other movement.

There is also correlation in the simultaneous improvement of the lateral leanings. This is due to the fact that the muscles performing lateral leanings have physiologically the same structure. The improved movement in the one side leads to counter lateral correlation of

There is also correlation in the final results from the pain degree and Forestier's test, i.e. when the patient feels no pain they will be able to touch the wall with the back of their neck, which is impossible when there is pain and stiffness in the cervical part.

Application of Inter Criteria Analysis with patients having chronic degenerative illness of the knee joint - Gonartrosis

Results from 10 patients with clinical diagnosis arthrosis of the knee joint have been used for the purposes of this dissertation work. All patients are female, with moderately expressed motor deficit and pain symptoms occurring while moving. The average age of the patients is 62.9 years. The duration of their complaints is between 5 and 7 years. 4 patients from this group have more distinct symptoms in their right limb, while 6 of them - in their left limb. With all patients we applied a methodology of kinesitherapy and registered the changes in their functional condition. All patients underwent 10 procedures. The aim of kinesitherapy is to maintain and improve the function of the knee joint and the whole lower limb.

The patients have undergone conservative kinesitherapy treatment in cases of primary gonartrosis. Individual activities lasting for 45 minutes have been carried out.

The tables 3.9 and 3.10 show the results before and after the course of kinesitherapy treatment.

Patient	Fl in knee	PF	RPF	REF	WB	SF	P	GH	PH
	begin	begin	begin	begin	begin	begin	begin	begin	begin
1	105	40	25	30	48	37	45	30	25
2	110	55	40	50	68	62	50,5	80	12,1
3	96	30,5	54	46,6	40	30	49,9	60	48
4	105	44,7	38	40	45	59	60	50	69
5	100	50	60	49	50	60	40	55	70
6	112	28	40	35	40	47	60	30	20
7	95	40	55	45	60	50	40	56	51
8	90	50,8	40,2	45	49	50	60	40	37
9	105	63,3	30	39	50	55	40	50	59
10	90	40	50	49	50	40	50	40	35

Table 3.9. Results reached before KT course

Patient	Fl in knee	PF	RPF	REF	WB	SF	P	GH	PH
	end	end	end	end	end	end	end	end	end
1	115	95	55	66,7	52	37,5	22,5	35	50
2	100	70	60	69,9	68	62,5	12,5	80	50
3	113	50	60	50	70	50	15	80	60
4	117	60	45,6	47	60	66	40	55	75
5	110	59	61	55	59	75	20	60	85,7
6	118	40	60	55	60	58	40	49	30
7	105	49	65	59	71	65	31	60	70
8	103	65	40	49	55	59	50	49	49
9	118	70	45	49	70	65	20	69	68
10	110	59	55	59	59	57	45	59	44

Table 3.10. Results reached after KT course

μ	FL	PF	RPF	REF	VT	SF	BP	GH	MH
FL	1	0.422222	0.311111	0.311111	0.355556	0.555556	0.444444	0.466667	0.377778
PF	0.422222	1	0.377778	0.533333	0.644444	0.733333	0.333333	0.533333	0.577778
RPF	0.311111	0.377778	1	0.711111	0.511111	0.488889	0.288889	0.6	0.644444
REF	0.311111	0.533333	0.711111	1	0.666667	0.644444	0.4	0.711111	0.466667
VT	0.355556	0.644444	0.511111	0.666667	1	0.666667	0.266667	0.622222	0.466667
SF	0.555556	0.733333	0.488889	0.644444	0.666667	1	0.422222	0.644444	0.644444
BP	0.444444	0.333333	0.288889	0.4	0.266667	0.422222	1	0.311111	0.266667
GH	0.466667	0.533333	0.6	0.711111	0.622222	0.644444	0.311111	1	0.577778
MH	0.377778	0.577778	0.644444	0.466667	0.466667	0.644444	0.266667	0.577778	1

*Table 3.11. Results of **μ** reached by ICA analysis at the beginning of survey*

The tables 3.11 and 3.12 show the results from the application of the Inter Criteria Analysis of the data at the beginning of the rehabilitation processes. The table 3.11 shows the results of 'membership' of the intuitionistic fuzzy sets, while Table 3.12 shows the results of 'non-membership' of the intuitionistic fuzzy sets.

ν	FL	PF	RPF	REF	VT	SF	BP	GH	MH
FL	0	0.422222	0.577778	0.555556	0.466667	0.333333	0.333333	0.466667	0.533333
PF	0.422222	0	0.533333	0.355556	0.2	0.177778	0.466667	0.333333	0.355556
RPF	0.577778	0.533333	0	0.222222	0.377778	0.466667	0.555556	0.311111	0.333333
REF	0.555556	0.355556	0.222222	0	0.244444	0.333333	0.422222	0.177778	0.488889
VT	0.466667	0.2	0.377778	0.244444	0	0.222222	0.555556	0.222222	0.444444
SF	0.333333	0.177778	0.466667	0.333333	0.222222	0	0.422222	0.266667	0.333333
BP	0.333333	0.466667	0.555556	0.422222	0.555556	0.422222	0	0.488889	0.6
GH	0.466667	0.333333	0.311111	0.177778	0.222222	0.266667	0.488889	0	0.355556
MH	0.533333	0.355556	0.333333	0.488889	0.444444	0.333333	0.6	0.355556	0

*Table 3.12. Results of **ν** reached by ICA analysis at the beginning of the survey*

μ	FL	PF	RPF	REF	VT	SF	BP	GH	MH
FL	1	0.444444	0.311111	0.288889	0.511111	0.422222	0.466667	0.355556	0.466667
PF	0.444444	1	0.222222	0.466667	0.333333	0.444444	0.4	0.4	0.488889
RPF	0.311111	0.222222	1	0.6	0.555556	0.511111	0.288889	0.577778	0.533333
REF	0.288889	0.466667	0.6	1	0.4	0.311111	0.333333	0.444444	0.355556
VT	0.511111	0.333333	0.555556	0.4	1	0.555556	0.311111	0.688889	0.555556
SF	0.422222	0.444444	0.511111	0.311111	0.555556	1	0.444444	0.533333	0.777778
BP	0.466667	0.4	0.288889	0.333333	0.311111	0.444444	1	0.155556	0.377778
GH	0.355556	0.4	0.577778	0.444444	0.688889	0.533333	0.155556	1	0.533333
MH	0.466667	0.488889	0.533333	0.355556	0.555556	0.777778	0.377778	0.533333	1

*Table 3.13. Results of **μ** reached by ICA analysis at the end of survey*

ν	FL	PF	RPF	REF	VT	SF	BP	GH	MH
FL	0	0.511111	0.555556	0.6	0.422222	0.511111	0.444444	0.533333	0.466667
PF	0.511111	0	0.644444	0.422222	0.6	0.488889	0.511111	0.488889	0.444444
RPF	0.555556	0.644444	0	0.244444	0.288889	0.377778	0.577778	0.311111	0.355556
REF	0.6	0.422222	0.244444	0	0.466667	0.6	0.555556	0.422222	0.555556
VT	0.422222	0.6	0.288889	0.466667	0	0.355556	0.622222	0.177778	0.355556
SF	0.511111	0.488889	0.377778	0.6	0.355556	0	0.488889	0.377778	0.177778
BP	0.444444	0.511111	0.577778	0.555556	0.622222	0.488889	0	0.733333	0.555556
GH	0.533333	0.488889	0.311111	0.422222	0.177778	0.377778	0.733333	0	0.377778
MH	0.466667	0.444444	0.355556	0.555556	0.355556	0.177778	0.555556	0.377778	0

*Table 3.14. Results of **ν** reached by ICA analysis at the end of survey*

The tables 3.13 and 3.14 show the results from the application of the Inter Criteria Analysis of the data at the end of the rehabilitation processes. The table 3.13 shows the results of 'membership' of the intuitionistic fuzzy sets, while Table 3.14 shows the results of 'non-membership' of the intuitionistic fuzzy sets. The applied Inter Criteria Analysis shows the clear correlation between the increased movement volume and the vitality. The more the patient's motor abilities increase, the easier some of the everyday activities become. This is due to the better results deriving from the increased abilities of the patient in relation to their knee joint. These results lead to a feeling of strength and energy with the patient. Another index pair which has strong correlation are the degree of pain and the depressive states. With the increase of the pain symptoms the patient gets into depressive states and vice versa- the decrease of pain leads to more positive emotions, the patient's confidence comes back and this results in an exit from the depressive state. There is also correlation between the social functioning and the depressive states. When the patient is in good general and motor shape, they increase their social contacts, come out of the depressive states which are due to the illness. The patient feels confident and full of energy. On the contrary, if there is a restriction in the motor abilities, negative emotions prevail and the patient's social contacts decrease.

Application of the Generalized Net Model with patients having musculoskeletal complaints

Musculoskeletal complaints are among the most common problems in clinical medicine. These complaints are a major cause of limitations in daily activities, health care usage and work disability. Typically around 50% of the population report musculoskeletal pain [6]. Musculoskeletal problems can broadly be categorized as regional or generalized, although there is often considerable overlap between these two categories. The most important part of the evaluation of a patient with musculoskeletal complaints is the physical examination. The process of physical examination in kinesitherapy is usually divided into several sections: clinical anamnesis, inspection,palpation, range of motion, muscle testing, sensation testing, reflex testing, special tests and overall dynamic motion of the body segments. The clinical anamnesis or the patient's history forms the basis of the working diagnosis. The history provides

the subjective data that will direct the physical examination. The initial goal is to determine whether the complaint is acute or chronic. In patient with acute injuries, the manner in which the accident occurred can provide sufficient information for the present illness. Chronic complaints usually require an extensive review of the past medical records. After the history is taken the physical examination starts with a visual inspection of the patient posture and gait. The two sides of the body should be observed for symmetry in contour and size, and any differences measured. Atrophy, masses, deformities, swelling, and skin color changes should be noted. The origin of a pain symptom and changes of the body temperature may be localized by palpation of the various anatomic structures. Palpation of the bones may determine their discontinuity in fracture assessment. Palpation of masses and swelling for consistency can distinguish between bony masses, edema, and joint effusion. To determine the presence of a muscle spasm, muscle palpation with the patient at rest will identify sustained involuntary reflex contraction resulting from pain. Valuable information is then extracted from the active and passive range of motion (ROM) examination. The active ROM provides information about the patient's willingness to move, coordination, level of consciousness, movements that cause or increase pain, muscle strength and ability to follow instructions and perform functional activities. Passive ROM is assessed to determine the amount of movement possible at the joint and to perceive the “end feel” at the very end of the available range of motion. The end feel for a particular joint may be the joint's end feel, or it may be pathological in nature. James Cyriax, specified six different end feels [3]. After the assessment of ROM has been completed it is essential to perform a manual muscle testing (MMT), to evaluate contractile units, including muscles and tendons, and their ability to generate forces. Traditionally, muscle strength has been evaluated by assigning the muscle a grade from 0 to 5. Analytical resistive testing can also yield additional diagnostic information. In particular, reproduction of the patient's pain during resistive testing of a particular muscle suggests a diagnosis of tendinitis, muscle strain, or contusion of the muscle-tendon unit being tested. Resisted contraction of a muscle that crosses a painful joint can often elicit or exacerbate the associated joint pain. Interpretation of the specific findings during the physical examination process will permit the therapist

to establish a database for the patient. This information is used to develop goals and a treatment plan. From that point of view, a certain strategy is necessary to guide physical therapists for patients with musculoskeletal complaints.

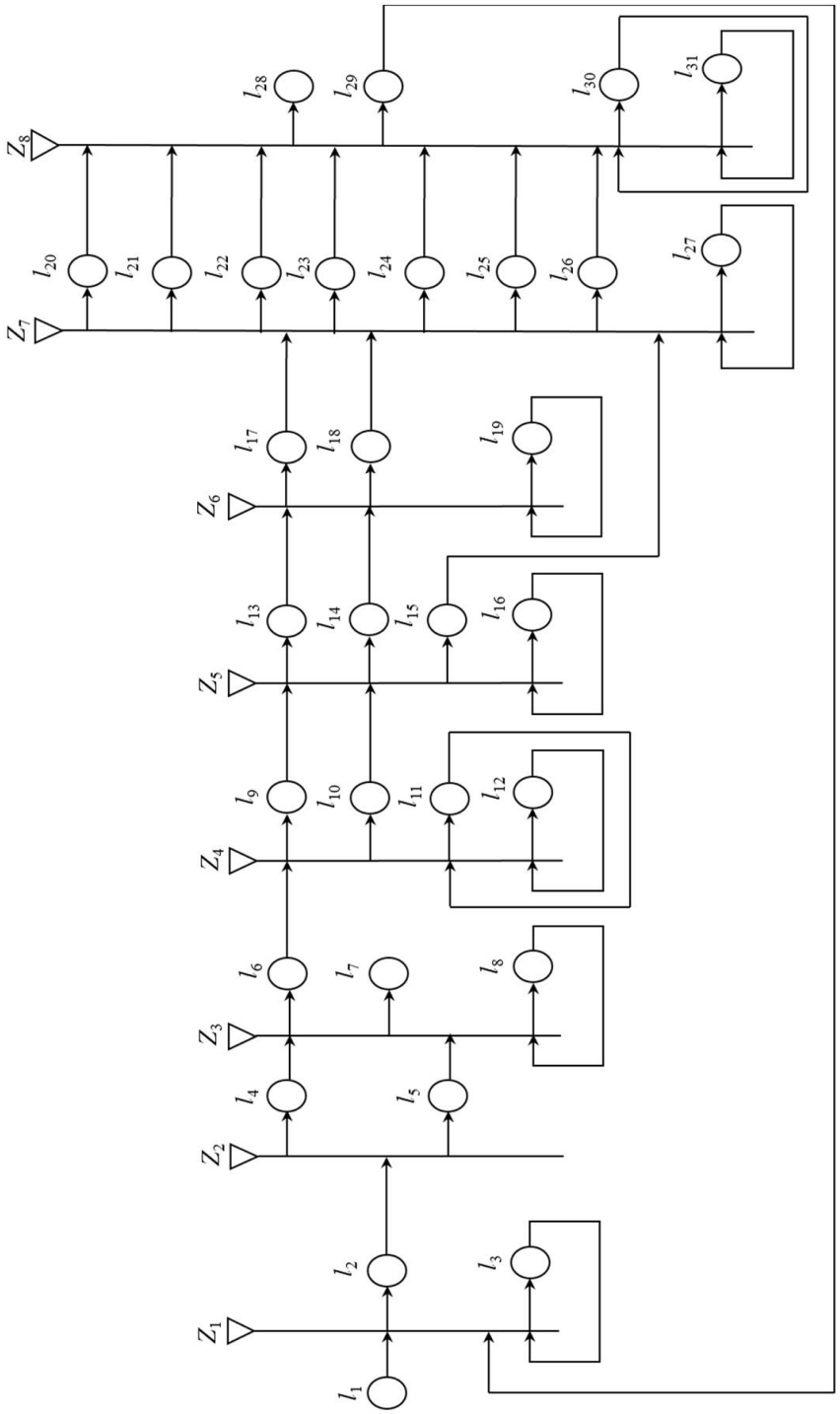

Fig. 3.2. GN model of physical examination on patient with musculoskeletal complaints

This study presents a Generalized Net model (GN-model) for physical examination approach in kinesitherapy. The presented GN-model is the first one which represents the physical examination approach in patient with musculoskeletal complaints. In general, the GNs may or may not have some of the components in their definition. GNs which do not have some of the components form special classes called reduced GNs ([2]). A reduced GN-model of physical examination in kinesitherapy is represented here. The proposed model is shown on Fig. 3.2.

The so described GN-model may provide a framework that can be used by physical therapists to guide physical examination approach to patient with musculoskeletal complaints, enabling more accurate and efficient identification of potential causes and would assist in optimizing patient outcomes and more effective treatment and rehabilitation.

Application of Generalized Net Model with patients having proximal humeral fractures

Diagnostic evaluation of proximal humerus fractures is critical in assessing effective treatment. The initial evaluation of a patient suspected of having proximal humeral fracture should begin with a detailed history of the mechanism of injury, clinical examination and a plan for image testing. Most patients with proximal humeral fracture tell about an acute pain following trauma. Pain and loss of function with swelling of the involved extremity are the most common symptoms on initial presentation. Severe point tenderness over the fracture site can be found with palpation and caution should be used to prevent further damage at the fracture site. Swelling usually appears immediately about the shoulder and upper arm. Bruise may spread to the chest wall, flank, and forearm. A thorough physical examination is the next step in the evaluation. Physical examination should inspect length differences between the affected and the contralateral limb, active and passive range of motion and any signs of deformities. Gross deformity of the shoulder or a pronounced subacromial sulcus may suggest an associated dislocation of the humeral head. Special attention should be paid to examination for potential concomitant injuries to the elbow, forearm, and wrist. It is essential to determine the presence of any associated injury. After the patient's clinical status has been established and stabilized, X-ray examination of the injured

shoulder is mandatory. A “trauma X-ray” series shoud be performed. Computed tomography (CT) scans are indicated in cases of clinically suspected vascular or neural lesions and complex injuries.Numerous types of proximal humeral fractures may occur and fracture classifications are used to guide treatment, estimate prognosis, and predict the risk of complications.

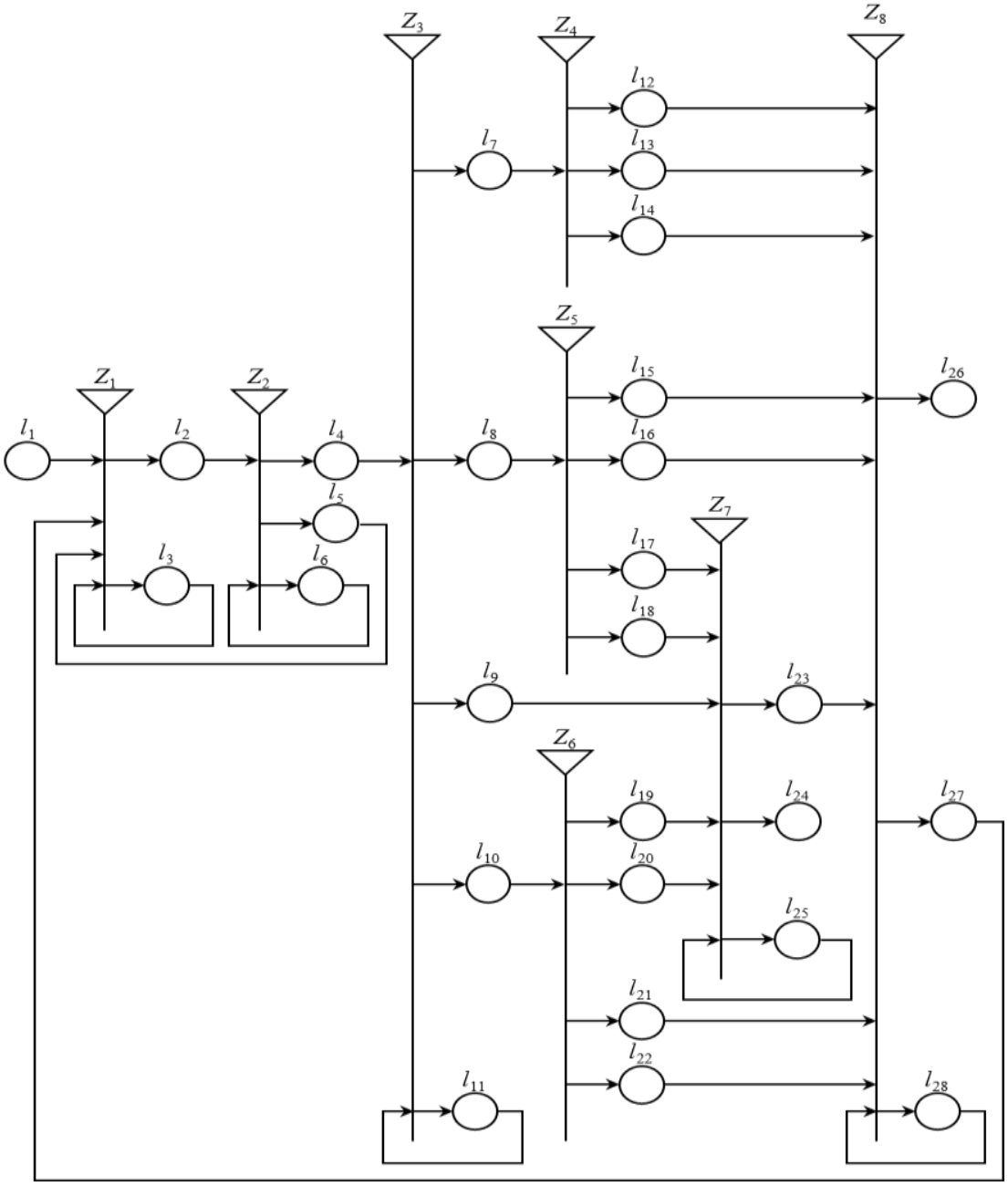

Fig. 3.3. GN model for diagnostic of proximal humerus fractures

The most frequently used system for classification of proximal humeral fractures is Neer's four-part system. There are 17 different potential types of fractures. Regardless of the number of fracture lines present, a proximal humerus fracture is considered to be nondisplaced by Neer's criteria when plain radiographs reveal less than 1 cm of displacement and 45 degrees of angulation of any one fragment with respect to all others. Fracture patterns may occur in combination with a glenohumeral dislocation. Due to the variety of factors which influence the classification and the diagnosis of these fractures, early detection is the key factor for an appropriate and successful treatment. The objective of the present work is to propose a novel approach to timely detection and diagnostics of proximal humeral fractures using the apparatus of generalized nets. The represented GN model has got parallel characteristics with previous models for medical diagnosing [6, 7, 8]. But it is the first one which highlights the diagnostic algorithm for patient suspected of having proximal humeral fracture and thus represents an application of GNs in traumatology. The developed GN model is presented in Fig. 3.3.

The developed GN model provides a frame which can be used by practitioners for diagnostics of patients who are supposed to have proximal humeral fractures. This model can be complex and detailed, including more thorough physical and neurological examination which will improve considerably the accuracy of the primary diagnosis and the reliability of the suggested algorithm. This method will define precisely the different steps of the diagnostic processes and will lead to higher level of healthcare. The obtained results could also be used to support the decision-taking process in diagnosing other illnesses.

CHAPTER 4. ETHICAL NORMS IN APPLYING OF INTELLIGENT METHODS OF ANALYSIS OF REHABILITATION PROCESSES

Discussing the ethics in the relationship between creator and user of the modern methods in medicine, as well as in all spheres of human communication, is inevitable in practice. The matter of the responsibility while applying intelligent methods of

analysis of the rehabilitation processes is particularly important due to the specificity of the methods themselves and the patients' and users' expectations about the influence of the intelligent treatment in rehabilitation and recovery from illnesses' consequences in particular. The actuality of the problem requires defining its ethical perspectives because of the use of technical and technological methods in medicine and more specifically, of rehabilitation techniques of improving the quality of life of patients with neurological complaints. The researchers using the latest achievements in the field of the design of highly effective and complex algorithms for data processing of the results of patient monitoring in hospitals should consider the moral aspects of their action in order to prevent its influence on the patients and on their public image from disrupting.

There are different criteria for distinguishing the human relations ethics, applied ethics and normative ethics being considered for the aims of this study.

Since medical ethics is bound to all aspects of medical practice, the norms it defines cover the whole sphere of healthcare. Thus, medical ethics, or doctor's ethics concerns all participants in the healthcare- institutions, organizations, patients, their families and society as a whole. The following main values are accepted world-wide:

- the wellbeing and welfare of the patient;
- the prohibition of harm - primum non nocere;
- the patients' right of self-determination or the principle of autonomy;
- the principle of human dignity.

The main ethical principles grouping the ethical esteems about the methods of people's treatment are:

1. respect to the autonomy and the person's right for taking decisions;
2. non-harming;
3. to do as good as possible, rationally balancing the risks;
4. useful cooperation;
5. justice and honesty in distributing the benefits and costs.

The consultant and researcher should feel obliged to consolidate the society's and each patient's trust in the quality, reliability and the social benefit of the intelligent methods of treatment and rehabilitation. They should seek for honesty and correctness

in collecting, processing and disclosure of data, results, methods and procedures, pursuant to the requirements for personal data protection and qualified information and the rules of protection of copyrights and related rights, as well as the stricter European requirements for intellectual property protection and opposition to cyber-threats.

The researcher should abstain from false data fabrication or using of wrong data and from popularizing their knowledge of such behaviour. They should collect, analyse and estimate all facts and circumstances connected with their work in a true, accurate and impartial way, without allowing influence of their own or other people's interests, avoid deliberate planning of the experiment, the analysis and interpretation of the data and take care of the fair distribution of the benefits and harms of the research.

CONCLUSION

This dissertation work examines the development of new, highly effective intelligent methods for analysis of rehabilitation processes, possessing optimal statistic characteristics. The latest achievements in designing highly effective algorithms for data processing obtained from patients' observation in hospitals are applied. The intelligent methods used require processing of large data streams based on the whole available information about the observed clinical picture.

The dissertation work uses mathematical modelling means for the purposes of the analysis, the most suitable one being the Generalized Net Model (GN). Another approach used in the dissertation work is the Inter Criteria Analysis based on two mathematical formalisms: the algebraic apparatus of Index Matrices (IMs), when it is necessary to apply algebraic operations upon matrices with different dimensionalities, and Intuitionistic Fuzzy Sets (IFSs) as a mathematical tool for treating uncertainty.

The dissertation work consists of four chapters.

Chapter 1 contains an overview of the already known intelligent methods and algorithms for analysis of complex processes. The advantages and disadvantages of the observed methods and algorithms are estimated. A system analysis has been made and the necessity of choosing suitable intelligent techniques for analysing rehabilitation processes has been justified, based on it. The dissertation work presents the hypothesis

that most suitable for the purposes of the analysis of rehabilitation processes would be the net methods based on the theory of the Generalized Nets (GNs), as well as the methods using Intuitionistic Fuzzy Sets (IFSs) and Index Matrices (IMs).

Chapter 2 analyses the rehabilitation processes in cases of Ankylosing Spondylitis - Behterev's disease and chronical degenerative disease of the knee joint - Gonartrosis. It describes the etiology and pathoanatomic changes which occur in patients suffering from these diseases. A thorough observation has been presented of the applied kinesitherapeutical methods of examination, diagnosis and treatment. The main goals of kinesitherapy have been formulated, namely preservation of the flexibility and function of the spine and the affected joints.

Chapter 3 presents the experimental results from the application of intelligent methods of analysis of rehabilitation processes. The health status of patients with Rheumatoid Spondylitis concerning their quality of life has been examined. The observed patients are between 25-80 years old and are divided into two groups-experimental and control. The purpose of the kinesitherapy programme with patients having Rheumatoid Spondylitis is to achieve possible functional influence compliant with the rehabilitation potential. There is also a research based on the observation of 25 patients-14 female and 11 male, aged between 25-67 years. They have been subject to a specialized kinesitherapy methodology aiming at increasing the movement volume in the cervical part and decreasing the stiffness. Data from 10 patients with clinical diagnosis 'arthrosis of the knee joint' are analysed. All patients are female, with moderately expressed motor deficit and pain symptoms occurring while moving. The average age of the patients is 62,9 years. The aim of kinesitherapy is to maintain and improve the function of the knee joint and the whole lower limb. Generalized Net model (NG model) of physical examination in kinesitherapy has also been presented. This GN model is the first one representing a physical study approach with patients having musculoskeletal complaints.

Chapter 4 analyses the legal aspects of using data about the physical condition of patients in hospitals. There are different criteria for distinguishing the human relations ethics, applied ethics and normative ethics being considered for the aims of the dissertation work. Applied ethics is a part of the professional ethics, or the ethics of

professional realization which is specific for each profession. The matters of the professional ethics are among the most difficult and frequently discussed in law and medicine due to their immanent importance for human health and life. Normative ethics deals with the ways of achieving universal wellbeing, regulation of people's relationships in a manner acceptable to the majority in the name of common values.

The research methodology in the dissertation work includes the use of numeral and experimental approach. The numeral approach is used in the realization of the algorithms through computer calculation of the intelligent methods of analysis of the rehabilitation processes. The experimental approach is used in collecting data from observations of patients with the observed diseases.

Summary of the obtained results

The conducted research presented in the dissertation work has led to the following scientific, scientific-practical and practical results:

1. Systematizing of the existing intelligent methods for analysis of rehabilitation processes has been carried out.

2. Analysis of ankylosing spondylitis - Behterev's disease has been performed in order to achieve higher efficiency of the rehabilitation processes.

3. Analysis of chronical degenerative disease of the knee joint - Gonartrosis has been performed in order to achieve higher efficiency of the rehabilitation processes.

4. The legal aspects of using data connected with the physical condition of patients in hospitals have been analysed.

5. Original Generalized Net models of rehabilitation processes of upper limb have been developed.

6. Original results from the application of intelligent methods for analysis of

The results described in the dissertation work have been published in six articles: two of them-in a journal with SCImago Journal Rank (SJR) - International Journal Bioautomation, two articles in the Notes of Intuitionistic Fuzzy Sets magazine, one article in a magazine of the Polish Academy of Science - Issues in Intuitionistic Fuzzy Sets and Generalized Nets and one article is included in the database of IEEEXplore. All publications are referenced and indexed in world-famous database

containing scientific information, thus complying with the requirements of the Act of the Development of the Academic Personnel in the Republic of Bulgaria.

Guidelines for future research

The results obtained in the dissertation work can be applied in solving a wider range of tasks in the description of real biological and rehabilitation processes. This could be a guideline for future research which would lead to enrichment of the explored scientific field.

Publications on the topic of the dissertation work

1. Zaharieva B., L. Doukovska, I. Radeva, S. Ribagin - InterCriteria Analysis Approach to Behtetrev's Disease Analysis, Notes on Intuitionistic Fuzzy Sets (NIFS), ISSN 1310-4926, e-ISSN 2367-8283, vol. 23, № 2, pp. 119-127, 2017.

2. Zaharieva B., L. Doukovska, S. Ribagin, A. Michalíková, I. Radeva - InterCriteria Analysis of Behterev's Kinesitherapy Program, Notes on Intuitionistic Fuzzy Sets (NIFS), ISSN 1310-4926, e-ISSN 2367-8283, vol. 23, № 3, pp. 69-80, 2017.

3. Ribagin, S., B. Zaharieva - Generalized Net Model of Physical Examination of Patient with Muskuloskeletal Complaints in Kinesitherapy, Issues in Intuitionistic Fuzzy Sets and Generalized Nets, 13, EXIT Publishing House, SRI-PAS, pp. 96-108, 2017.

4. Ribagin S., B. Zaharieva, I. Radeva, T. Pencheva - Generalized Net Model of Proximal Humeral Fractures Diagnosing, International Journal Bioautomation, ISSN 1314-1902, vol. 22, № 1, pp. 11-20, 2018 (SJR 0.25).

5. Zaharieva B., L. Doukovska, S. Ribagin, I. Radeva - InterCriteria Decision Making Approach to Behterev's Disease Analysis, International Journal Bioautomation, ISSN 1314-1902, 2018 (SJR 0.25) (to be published).

6. Zaharieva, B., L. Doukovska, V. Atanassova - InterCriteria Decision Making Approach for Osteoarthritis Disease Analysis, Proc. of the 9-th IEEE International Conference on Intelligent Systems - IS'18, Madeira Island, Portugal, IEEEXplore, ISBN 978-1-5386-7097-2, 2018.