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Wpływ temperatur kriogenicznych na stan funkcjonalny pacjentów z zespołem bólowym kręgosłupa lędźwiowego

The influence of cryogenic temperatures on the functional status of patients with lumbar spine pain syndrome

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Streszczenie:

Wstęp.

Krioterapia jest jedną z nowoczesnych metod terapeutycznych w fizjoterapii, w których wykorzystuje się wpływ temperatur kriogenicznych (-110º do -160º C) na organizm człowieka.

Cel pracy.

celem pracy jest ocena wpływu temperatur kriogenicznych na stan funkcjonalny pacjentów z zespołem bólowym odcinka lędźwiowego kręgosłupa.

Materiał i metody.

badaniem objęto 40 pacjentów z zespołem bólowym odcinka lędźwiowego kręgosłupa: 24 kobiety i 16 mężczyzn w wieku od 35 do 55 lat. Pacjentów podzielono na dwie grupy. Wyróżniono pacjentów poddanych krioterapii ogólnoustrojowej i 30 minutowej kinezyterapii analitycznej (grupa badana) oraz pacjentów poddanej tylko kinezyterapii (grupa kontrolna). Terapia trwała 10 dni. W badaniach zastosowano metody subiektywne (ocena odczucia intensywności bólu według skali VAS, ocena siły mięśniowej według skali Lovetta) i obiektywne (pomiar zakresu ruchomości kręgosłupa lędźwiowego – test Schobera, pomiar rotacji kręgosłupa lędźwiowego).

Słowa kluczowe:

krioterapia ogólnoustrojowa, zespół bólowy kręgosłupa lędźwiowego

Abstract

Introduction.

Cryotherapy is one of the modern therapeutic methods in physiotherapy, in which the impact of cryogenic temperatures (-110ºC to -160ºC) on the human body is used.

Aim of the study.

The aim of this study is to evaluate the effect of cryogenic temperatures on the functional status of patients with lumbar spine pain syndrome.

Material and methods.

The study involved 40 patients with lumbar spine pain syndrome: 24 women and 16 men, from 35 to 55 years old. The patients were divided into two groups. There were patients who underwent systemic cryotherapy and 30-minute analytical kinesitherapy (study group) and patients who underwent only kinesitherapy (control group). The therapy lasted for 10 days. In the study, subjective methods (assessment of intensity of the experienced pain according to VAS scale, assessment of muscle strength according to Lovett scale) and objective methods (measuring the range of lumbar spine flexion – Schober's test, measuring lumbar spine rotation) were used.

Key words:

systemic cryotherapy, lumbar spine pain syndrome

Introduction

Cryotherapy is one of the modern therapeutic methods in physiotherapy, in which the impact of cryogenic temperatures (-110ºC do -160ºC) on the human body is used. The beginning of cryotherapy dates back to 1978, when Yamauchi used a cryogenic chamber for the first time to treat patients with RA [1, 2]. Cryotherapy is impulse, stimulating superficial application of extremely low temperatures -120ºC for 2-3 minutes, in order to induce and use the physiological body response to cold, as well as to support the primary treatment and facilitate kinesitherapy. The execution of the cryotherapeutic procedure before exercise provides intensification of this treatment [3]. Cryotherapy reduces pain (with its various mechanisms, among others endorphin and met-enkephalin is produced in large quantities). The analgesic effect lasts for a few hours as a result of blocking pain impulses in the spinal cord and then in the thalamus. Cryogenic temperatures trigger an anti-edematous effect, reduce inflammatory reaction after burns and skin abrasions, enable the increase of muscle contraction strength and influence improvement in mood, desire to cooperate with the doctor and physiotherapist [3, 4]. In the therapeutic process, the human body is affected by stimuli, to which the answer are systemic or organ reactions and/or impulses that stimulate the body's natural defenses and their normalization. Poikilothermy of the skin and limbs determines homeotermy of body cavities through various changes in the cardiovascular system, especially microcirculation and intensity of metabolism under the control of thermoregulatory centers. Thermoregulation is therefore secondary to the metabolism of tissues and cardiovascular system, as if it were subordinate to them. Thermal therapy firmly enters thermoregulatory reactions through thermoreceptors, neural structures recording only temperature changes in time [4, 5].

Hypothalamus thermoreceptors, which are the center directing the majority of hormonal functions in the human body, play an important role. That is why they, otherwise called thermoenteroreceptors or thermodetectors, are sensitive to the current heat of the blood, and their stimulation or inhibition may be expressed in active and direct additional heat production (muscle tremors or shaking). In the frontal part of the hypothalamus, the thermoregulatory center is located, which is also called a "biological thermostat". The change of valency of Ca^{++}: Na^{+} ions causes an increase or decrease in the body temperature. Higher valency of sodium ions increases the body temperature, which may be due to the participation of interleukin and prostaglandin. Increase in calcium ions lowers the body temperature [4, 6].

The effect of cold is, initially, contraction of blood vessels and reduction of blood flow, decrease of tissue metabolism and impairment of tissue fluids fluctuations. Decreased perspiration can be observed. The cold reduces the nerves excitability and speed of neural conduction along with lowering reactivity of peripheral sensory-motor ends, also those responsible for regulating local tension of specific receptors (proprioceptors): of Golgi apparatus in tendons and neuromuscular spindles in the muscles; which contributes to subjective painlessness reduction of inflammatory reactions induced e.g. by trauma [3, 6].

Cryogenic treatments affect the respiratory system, improve lung ventilation: despite a temporary short-term transitional contraction, which is followed by relaxation of bronchi with a strong bronchodilatory effect. There is also an increase in partial pressure of oxygen with simultaneous decrease in partial pressure of carbon dioxide [2, 7].

The analgesic effect of cryogenic temperatures falls within the definition of the International Association for the Study of Pain, which says that pain is not only sensory, but also emotional experience. It is felt in the course of spine structural disorders and a warning sign for other diseases. Pain that occurs in patients is the primary symptom that may arise as a result of the occurring stimulus, irritating nociceptors. It acts as a warning, it is the first sign of the existing pathology. Due to the nature of the stimulus affecting the nociceptors, we distinguish physiological and clinical pain. Pain is defined as acute when it lasts up to 24 hours. Symptoms lasting longer are called chronic pain. In the absence of analgesic therapy, or its ineffectiveness, persistent pain causes pathophysiological changes in the CNS, whereas acute form of pain can turn into a chronic pain syndrome. Pain can accompany lumbar spine pain syndromes. This problem affects about 80% of adults and is very serious [3, 8].

Many years of research confirm that functional changes and inflammatory processes occurring in the intervertebral joints, muscles and supraspinal, intraspinal ligaments, ligaments of the pelvis are also the cause of pain syndromes of spinal origin. The emotional factor that affects the spine is also very important. Stress often causes anxiety, restlessness, aggression, and is an important element, causing muscle tension and spinal pain [4, 8].

Patients with various diseases are eligible for cryotherapy, they are for example: rheumatism, shoulder pain, painful elbow syndromes, fibromyalgia, joint diseases caused by metabolic disorders, gout, Sudeck syndrome, osteoporosis, discopathies, bacterial arthritis, microtraumas, bruises, swellings and effusions, torn tendon and ligaments insertions, multiple sclerosis, spastic paresis, cerebral palsy [1, 2, 9].

There are also relative contraindications, which disqualify patients for cryotherapy: history of venous thrombosis and peripheral arterial embolism, hypothyroidism, excessive emotional lability, expressed among others by increased sweating of the skin, and absolute contraindications: any technical damage, lack of experience of those using the method, intolerance to cold, claustrophobia, cancer, a large scar, severe anemia, emaciation and hypothermia, the effect of drugs, particularly neuroleptics and alcohol, purulent and gangrenous changes in the lower limbs, acute respiratory afflictions, venous and arterial leakages in the lungs [1, 2, 9].

Assumptions and aims

The aim of this study is to evaluate the effect of cryogenic temperatures on the functional status of patients with the lower spine pain syndrome.
To achieve the main aim, we set the following research hypotheses:
1. Systemic cryotherapy reduces the level of subjective pain.
2. Cryogenic temperatures affect the changes of the spine flexion.
3. Systemic cryogenic chamber treatments cause a change in muscle contraction strength.
4. The combined use of cryogenic treatment and analytical kinesitherapy is an effective form of influencing the improvement of motor function of the spine.

Material

The study involved 40 patients with the lower spine pain syndrome: 24 women and 16 men, from 35 to 55 years old (average age 44 years old). The study was conducted at the Center for Rehabilitation of Children and Adults of the Multidisciplinary Hospital – Independent Public Healthcare Center in Zgorzelec.
The percentage share of people participating in the study is shown in Fig. 1.

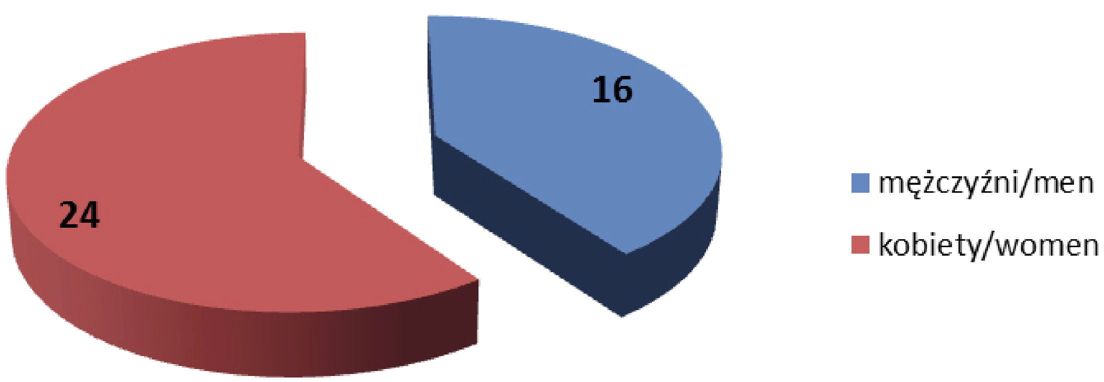


Fig. 1. Percentage distribution of tested groups with division by gender

During recruitment, a physician – specialist in internal medicine – conducted a thorough interview concerning the underlying disease and co-morbidities that could be a contraindication for treatments in a cryogenic chamber. The patients who had absolute contraindications for treatments in a cryogenic chamber were excluded from the study by the physician.
Each patient signed an informed consent to participate in the study. Participation was entirely voluntary.

Methods

The patients were divided into two groups depending on the physiotherapy applied. We distinguished patients who underwent systemic cryotherapy and 30-minute analytical kinesitherapy (study group) and patients who underwent only analytical kinesitherapy (control group). Each group consisted of 20 people (including 12 women and 8 men). The therapy lasted for 10 days. The selection of study material for each group was randomized.
All people from the study group underwent ten treatments in a cryogenic chamber. Each treatment in the "Wrocław-type" cryogenic chamber was performed once a day and lasted for 3 minutes at a temperature -120ºC to -130ºC. The chamber consists of a vestibule, in which the temperature is -60ºC, and there the adaptation of the organism to low temperatures takes place. Each patient was wearing: woolen socks, woolen gloves, headband protecting auricles, surgical mask, bathing suit (women), shorts (men), clogs on feet. Each of the tested patients, before entering the cryochamber, put on a surgical mask and breathed according to the principle: inhale two times shorter than exhale. Directly before each entering the cryochamber, and after leaving it, blood pressure was measured. During the procedure, the tested patients had constant eye contact with the medical staff who were able to intervene in case of adverse reactions. After each leaving the cryochamber, the tested patients were subjected to 30 minutes of individual kinesitherapy according to the established programme under the supervision of a physiotherapist.
The exercise programme included: breathing exercises, exercises according to the Maigne's programme, exercises strengthening the abdominal muscles, back muscles, gluteal muscles, active exercises of the upper and lower limbs, exercises on the cycloergometer.
In the study we used subjective and objective methods.
Subjective methods are:
● assessent of intensity of the experienced pain according to VAS scale – we evaluated the intensity of pain in all patients based on it. We assumed that 0 is no pain, 5 – severe pain, 10 – its maximum intensity. The test of subjective feeling of pain was conducted before the therapy and after its completion.
● assessment of muscle strength using the Lovett method – we assessed the muscle strength using a 5-step scale:
0 – no sign of muscle contraction
1 – trace of muscle contraction without motor effect

2 – non-weight bearing movement in full range
3 – movement in full range bearing the weight of the limb or a given body part
4 – muscle movement as before, against a little resistance
5 – normal muscle strength
We assessed the strength of the following muscle groups: abdominal muscles, muscles rotating the thigh to the outside, muscles rotating the thigh to the inside, erector spinae muscle.
Objective methods are:
● measuring the range of lumbar spine flexion determined by Schober's test,
● measuring lumbar spine rotation:
The measurement was performed in a standing position. Before the measurement, we marked the following points on the tested patient's body, using a dermograph: xiphoid process of the sternum and spinous process of the fifth lumbar vertebra. Then the tested patient did a maximum rotation of the torso. The measure of the lumbar spine flexion in the transverse plane is the difference of distance between the points in the standing position and during maximum rotation of the spine. We made the measurement to the right and left side.
For statistical analysis of the data collected during the study, we calculated the median, minimum and maximum, and the lower and upper quartile for measurable characteristics. We compared the obtained results of both groups using Wilcoxon matched pairs test. In the analyses the level of significance of $p<0.05$ was assumed.

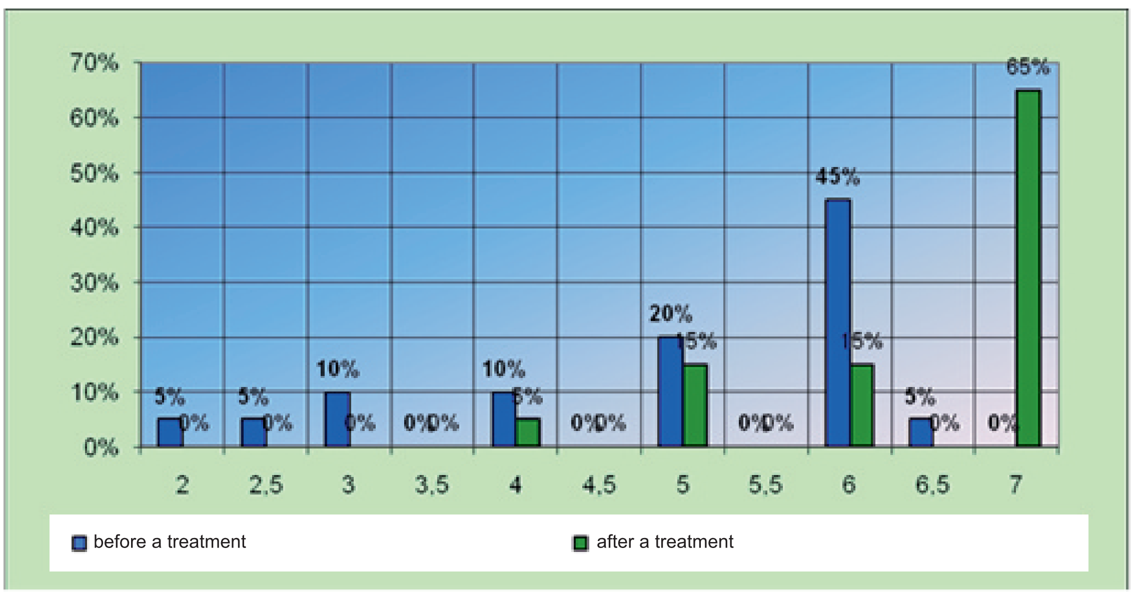


Fig. 2. Characteristics of lumbar spine flexion in the sagittal plane in the study group

Results

The figure shows that after the therapy, lumbar spine flexion reached a physiological value in 65% of the tested patients. Only 5% of respondents obtained a value of 6.5 cm.

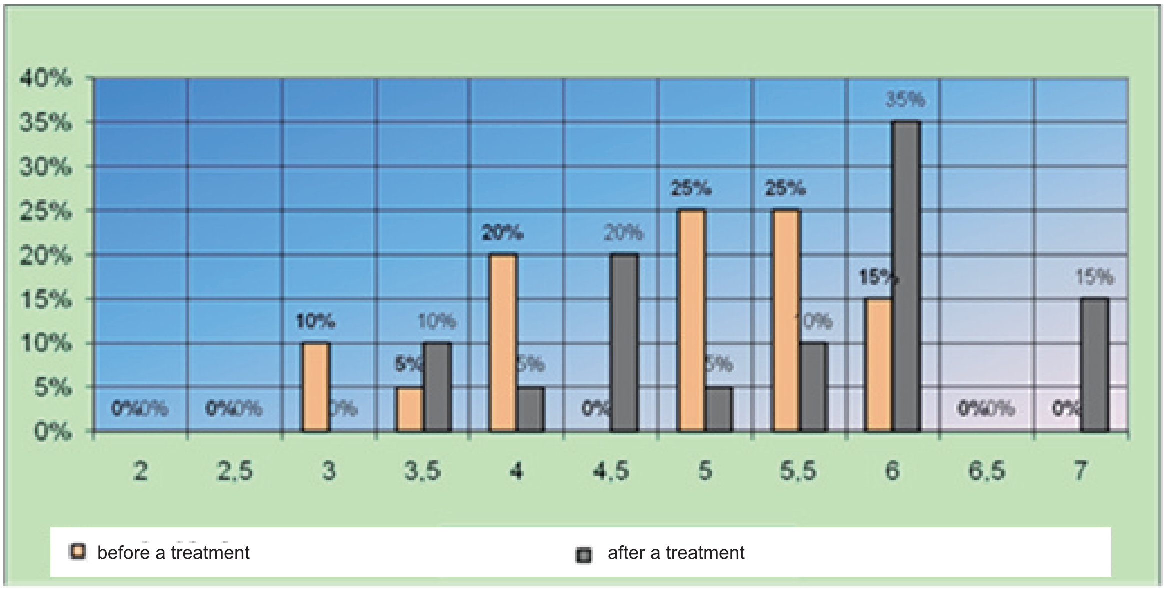


Fig. 3. Characteristics of lumbar spine flexion in the sagittal plane in the control group

The figure shows that after the therapy 35% of the tested patients obtained a value of 6 cm, and 15% obtained a physiological value.

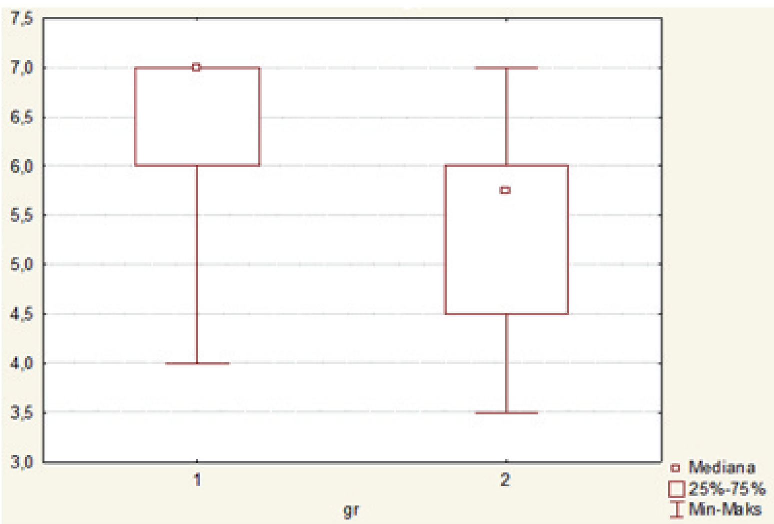


Fig. 4. Comparing lumbar spine flexion in the sagittal plane in the study group and control group

The figure shows that spine flexion reached the physiological value in the studied groups. The Wilcoxon test (2.853780, $p<0.004320$) indicates that the results are statistically significant.

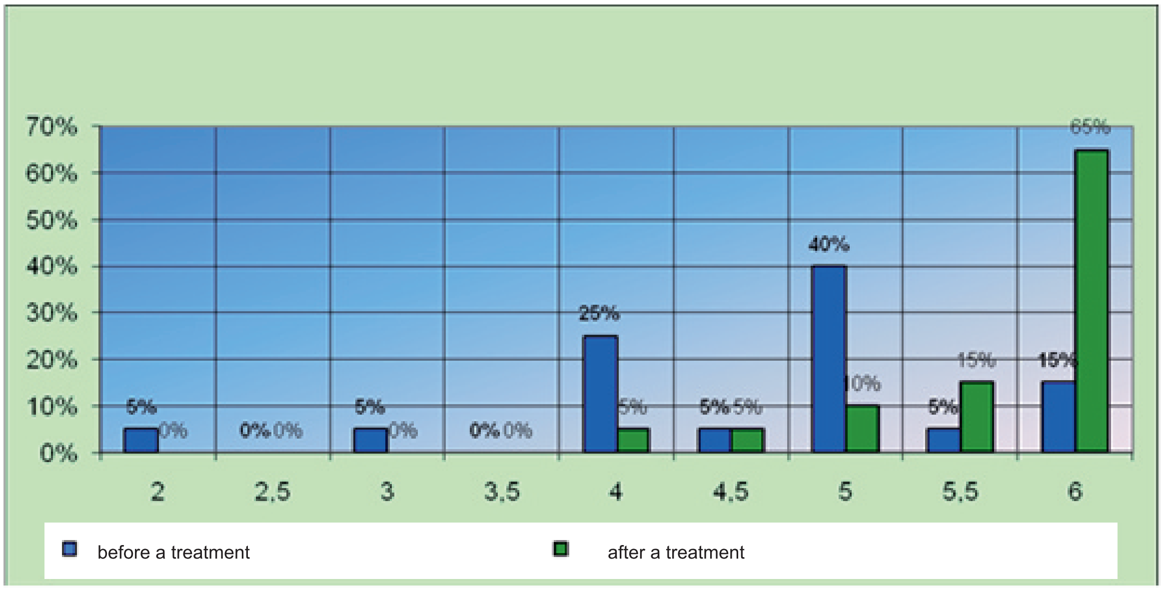


Fig. 5. Characteristics of lumbar spine flexion in the cross section to the left side in the study group.

The figure shows that after the therapy in the study group 65% of the patients obtained a physiological value, and in 15% of the studied patients this value amounted to 5.5 cm.

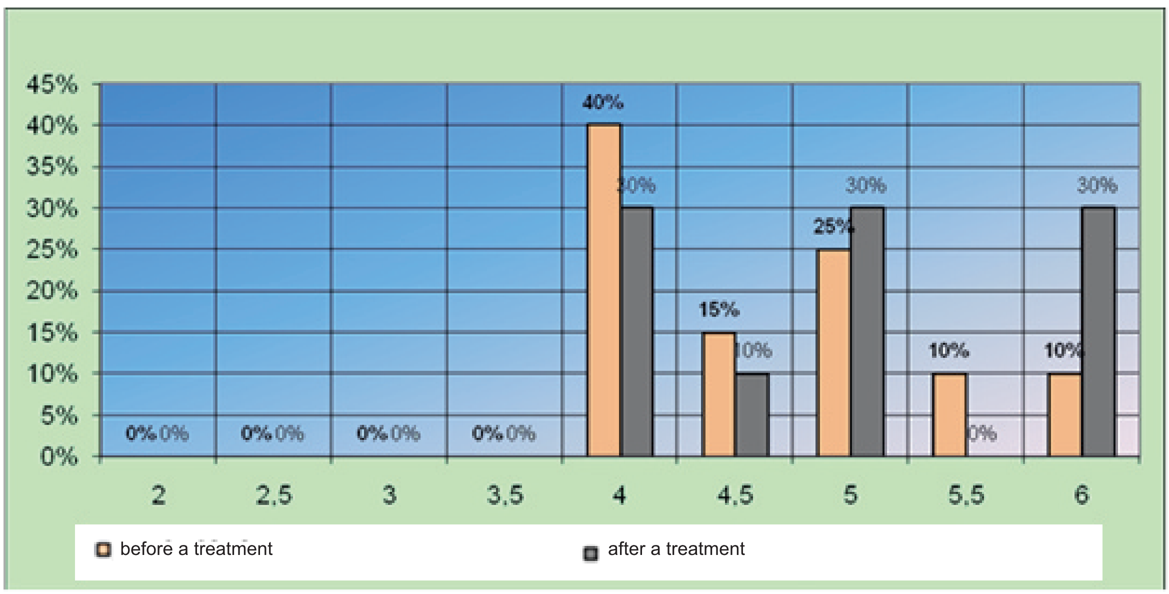


Fig. 6. Characteristics of lumbar spine flexion in the cross section to the left side in the control group

The figure shows that after the therapy in the control group 30% of the patients obtained a value of 5 cm, and 30% obtained a physiological value.

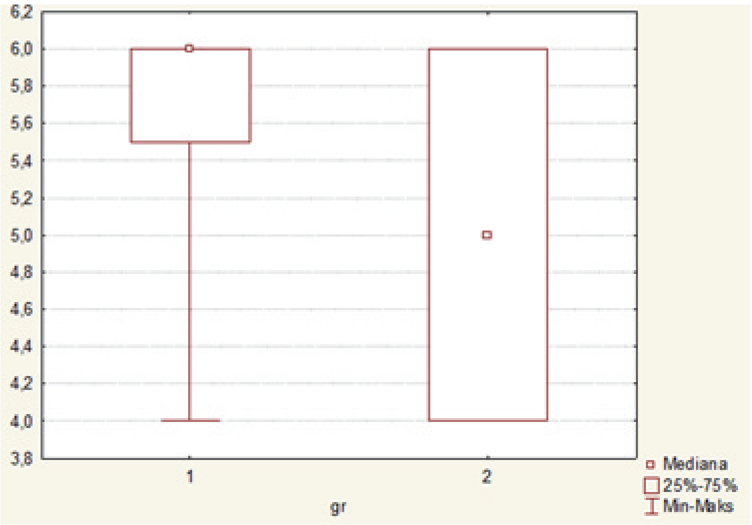


Fig. 7. Comparing lumbar spine flexion in the cross section to the left side in the study group and control group.

The figure shows that spine flexion reached a physiological value in the studied groups. The Wilcoxon test (2.665570; $p<0.007686$) indicates that the results are statistically significant.

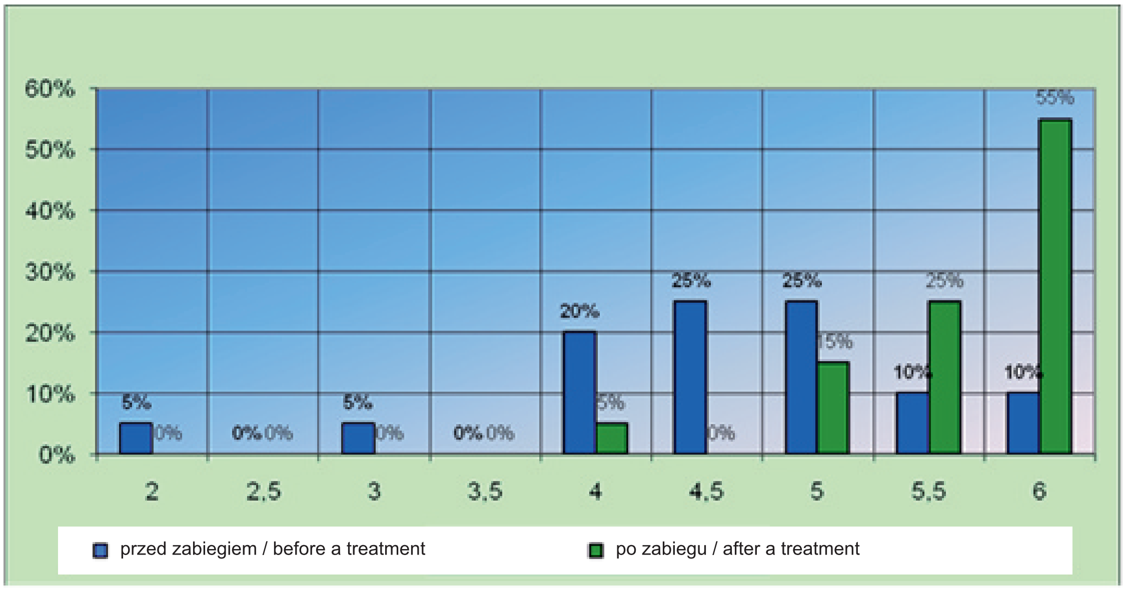


Fig. 8. Characteristics of lumbar spine flexion in the cross section to the right side in the study group

The figure shows that after the therapy in the study group 55% of the patients obtained a physiological value, 25% of the patients reached 5.5 cm, and in 15% of the patients this value increased to 5 cm.

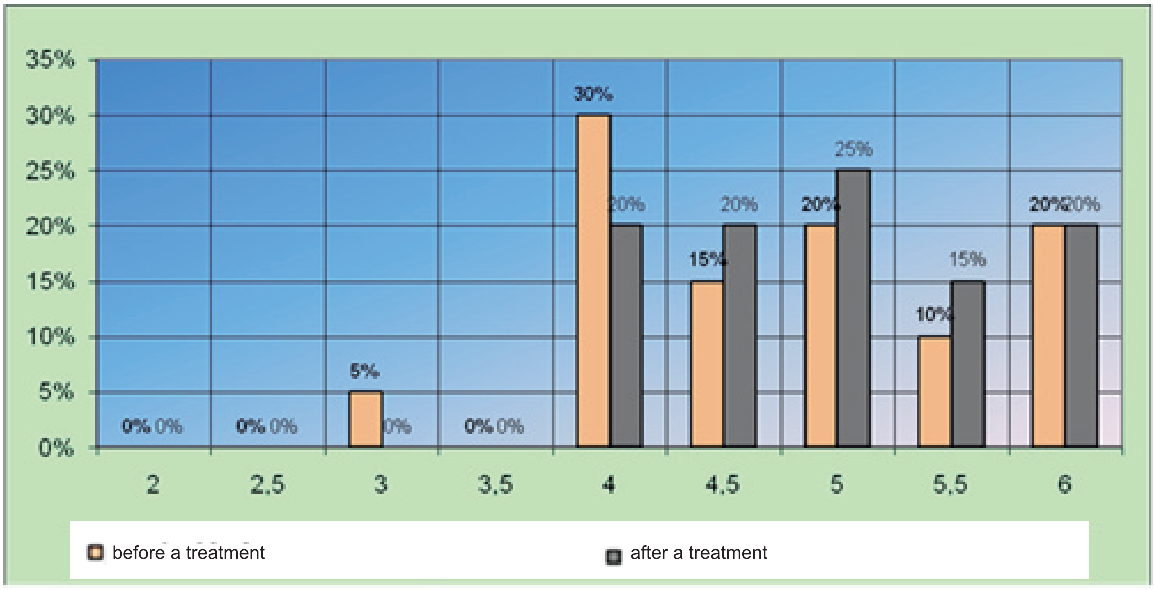


Fig. 9. Characteristics of lumbar spine flexion in the cross section to the right side in the control group

The figure shows that after the therapy in the control group 25% of the tested patients obtained a value of 5 cm, in 15% of the patients this value increased to 5.5 cm, and 20% of the tested patients obtained a physiological value.

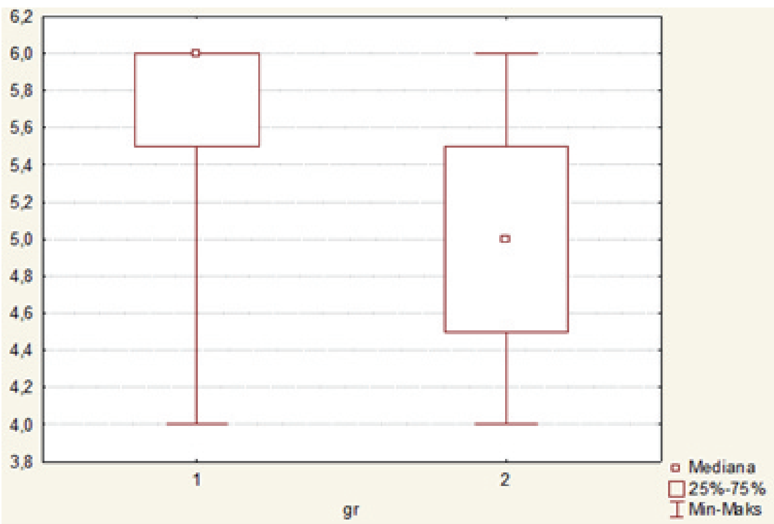
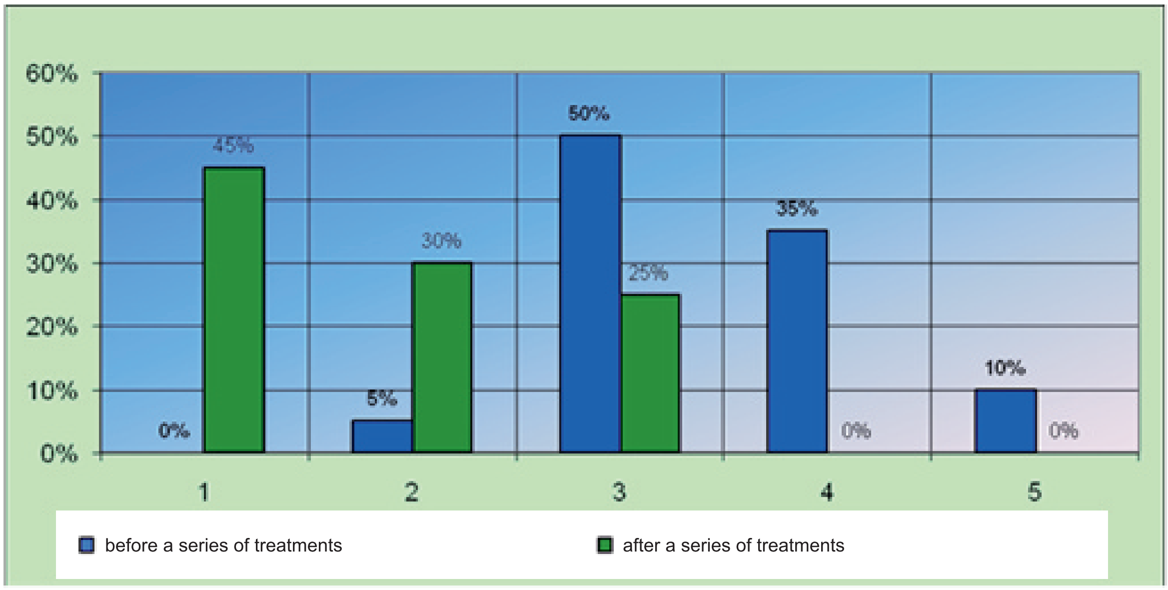


Fig. 10. Comparing lumbar spine flexion in the cross section to the right side in the study group and control group.

The figure shows that spine flexion reached physiological values in the studied groups. The Wilcoxon test (2.201398; $p<0.027709$) indicates that the results are statistically significant.



Ryc. 11. Zmiana intensywności odczuwania bólu według skali VAS u pacjentów w grupie badanej
Fig. 11. Changing the intensity of the experienced pain according to VAS scale in patients in the study group

The figure shows that after the therapy in the study group in 45% of the patients the pain scale value is 1 point, and in the remaining patients the values vary between 2 and 3 point.

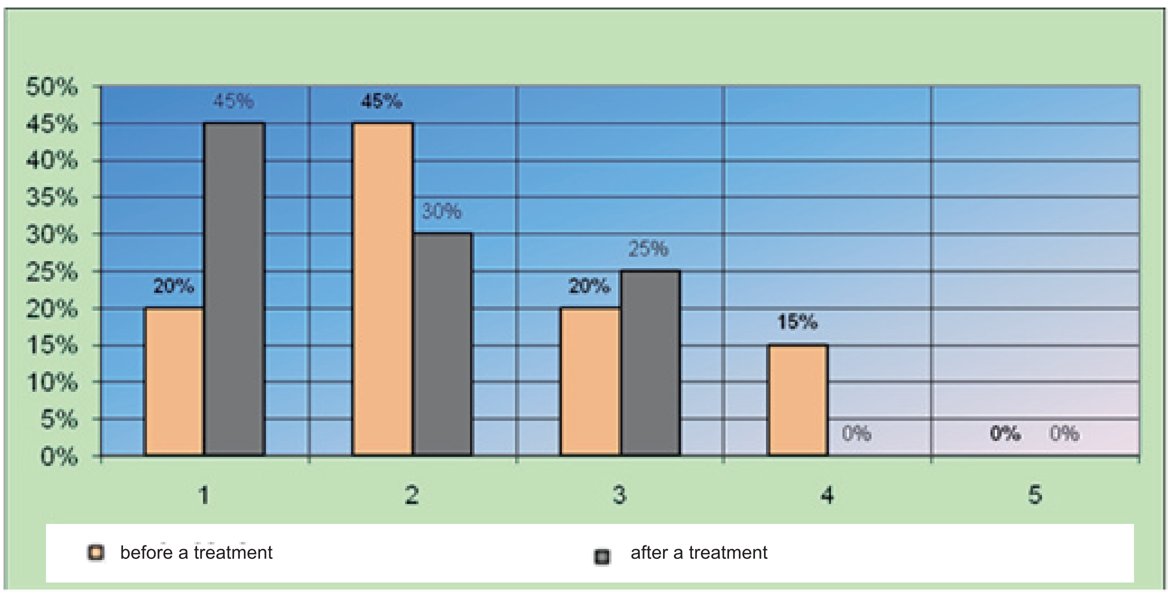


Fig. 12. Changing the intensity of the experienced pain according to VAS scale in patients in the control group

The figure shows that in the control group the intensity of the experienced pain decreased by 1 point according to VAS scale.

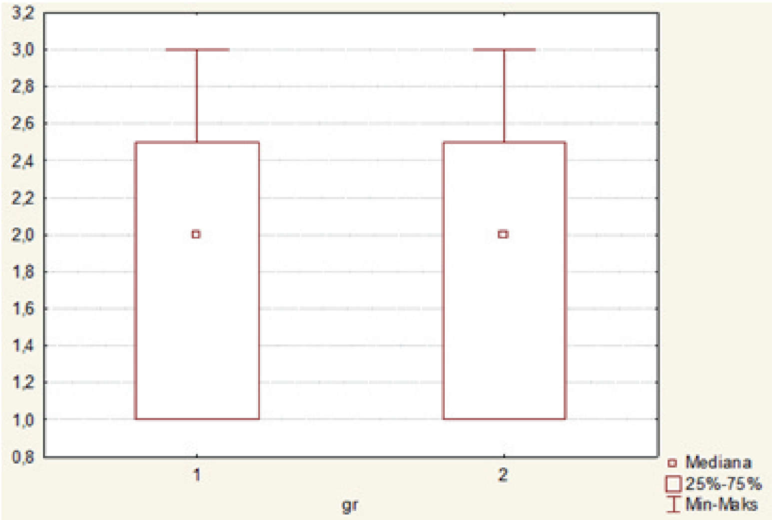


Fig. 13. Comparing the intensity of the experienced pain according to VAS scale in patients in the study group and control group

The figure shows that in the studied groups the intensity of the experienced pain decreased equally. The Wilcoxon test (2.803060; $p<0.000562$) indicates that the results are statistically significant.

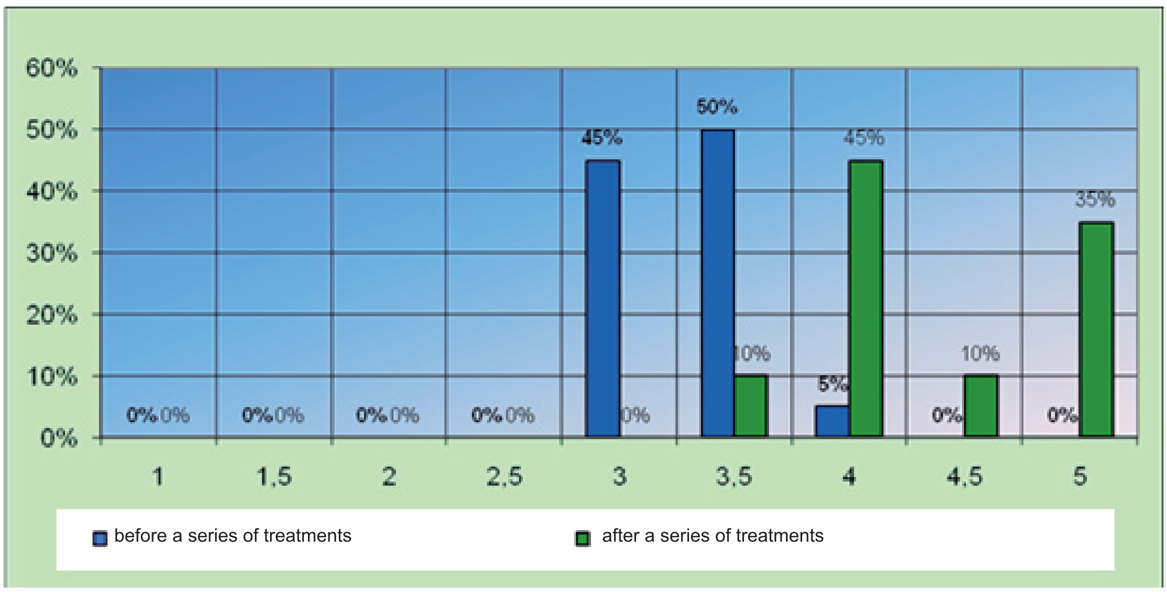


Fig. 14. Characteristics of abdominal muscle strength according to Lovett scale in the study group

The figure shows that after the therapy in the study group 35% of the patients obtained a maximum value, while 45% of the patients were assessed at 4 points according to Lovett scale, and 10% of the patients were assessed at 4.5 points.

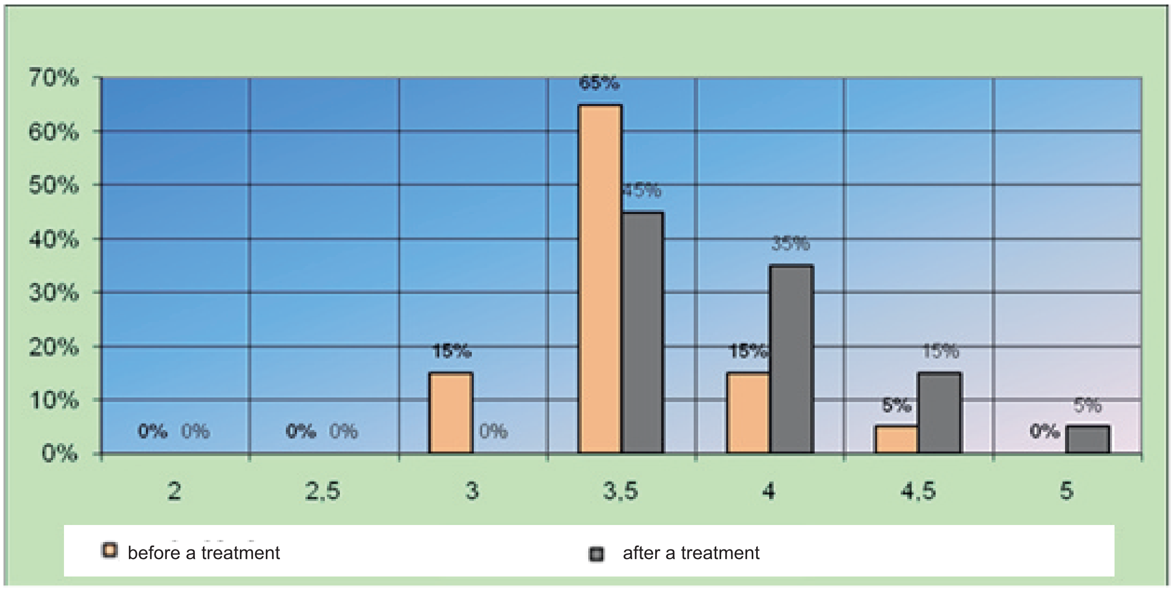


Fig. 15. Characteristics of abdominal muscle strength according to Lovett scale in the control group

The figure shows that after the therapy in the control group 5% of the patients were assessed at 5 points according to Lovett scale, 15% of patients were assessed at 4.5, and 35% of patients at 4 points.

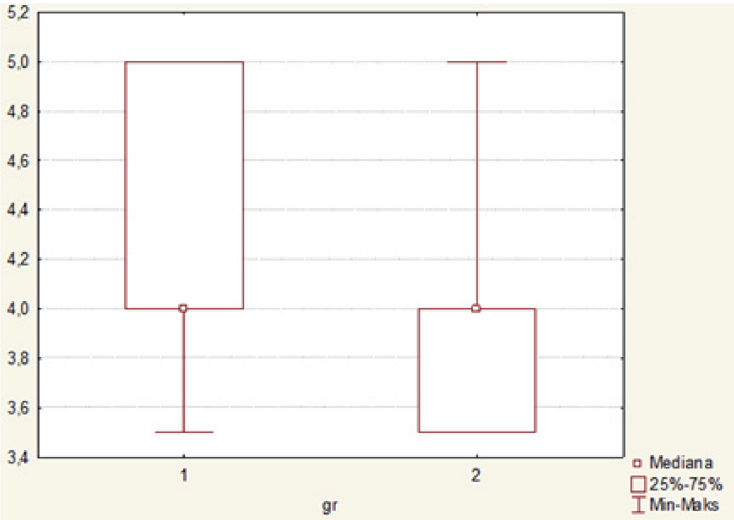


Fig. 16. Comparing abdominal muscle strength according to Lovett scale in the study group and control group

The figure shows that abdominal muscle strength increased in a greater number of patients in the study group. The Wilcoxon test (3.295765; $p<0.000982$) indicates that the results are statistically significant.

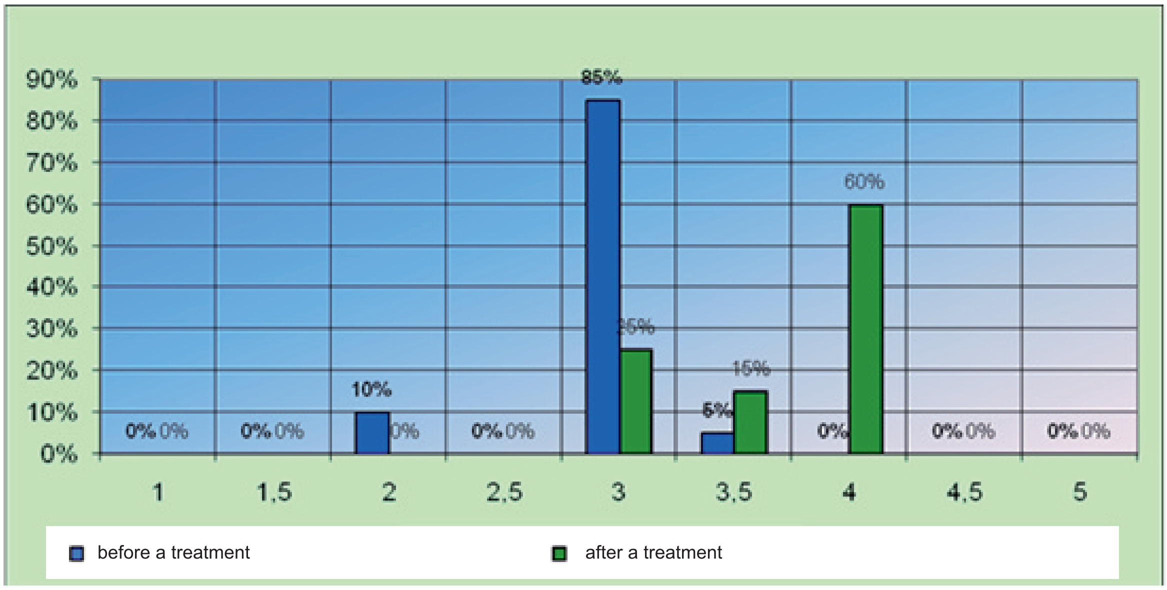


Fig. 17. Characteristics of erector spinae muscle strength according to Lovett scale in the study group

The figure shows that after the therapy in the study group erector spinae muscle strength in 60% of the patients was assessed at 4 points according to Lovett scale, 15% of patients were assessed at 3.5 points, and 25% of patients obtained 3 points.

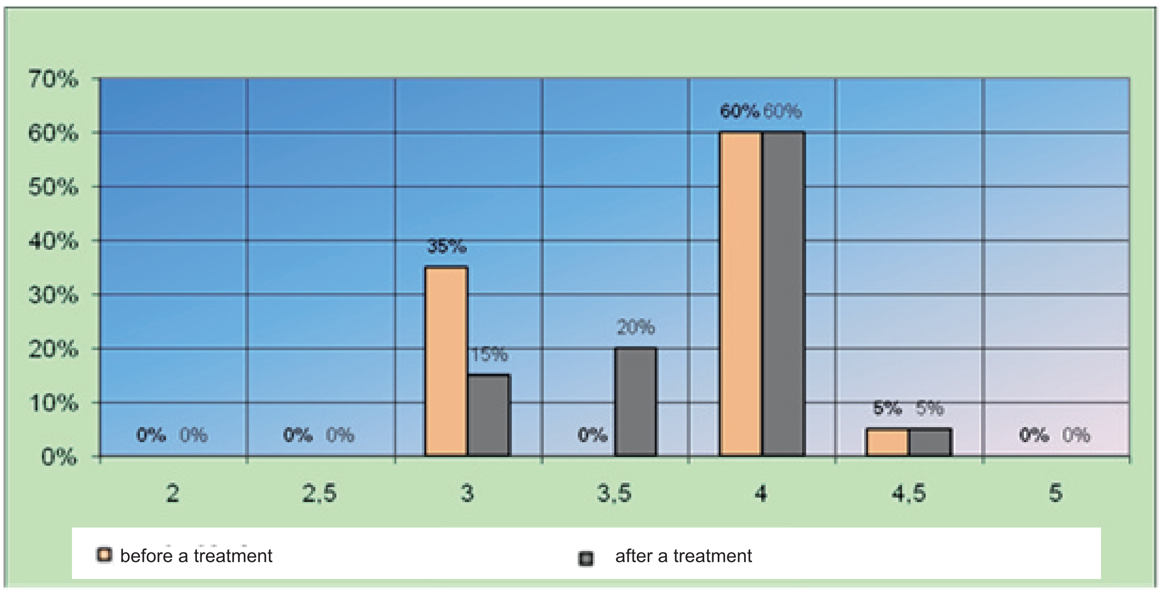


Fig. 18. Characteristics of erector spinae muscle strength according to Lovett scale in the control group

The figure shows that the therapy in the control group had no effect on improving erector spinae muscle strength.

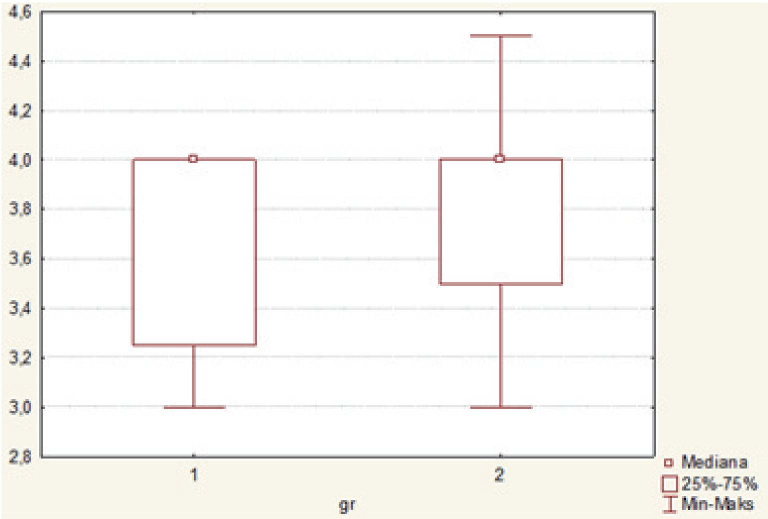


Fig. 19. Comparing erector spinae muscle strength according to Lovett scale in patients in the study group and control group

The figure shows that in the studied groups after the therapy, most patients obtained 4 points. The Wilcoxon test (1.825742; p<0.067890) indicates that the results are not statistically significant.

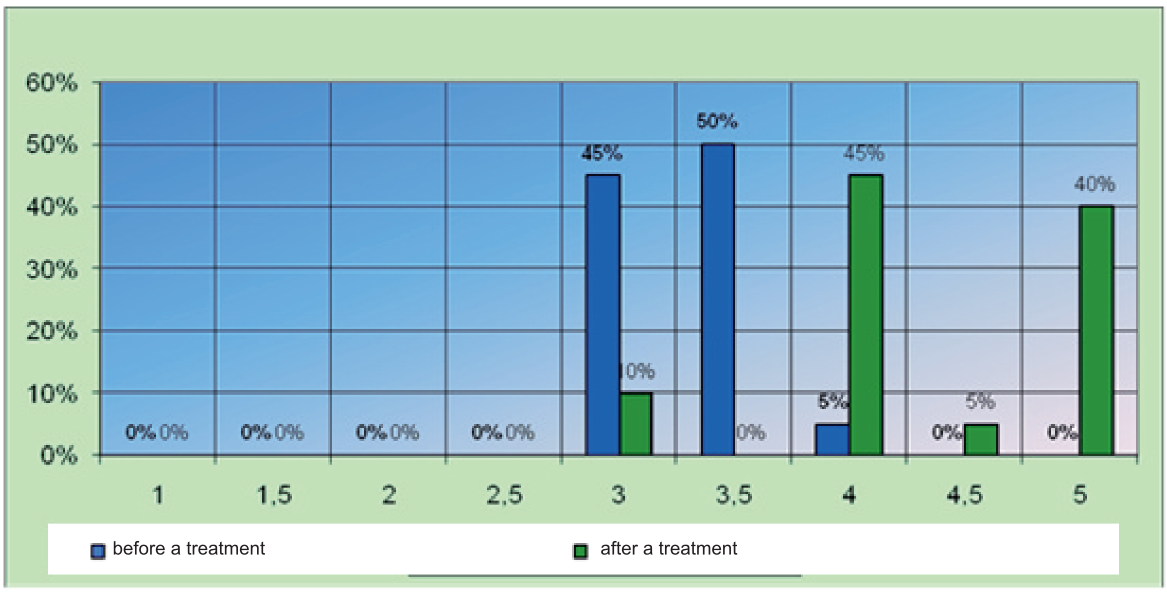


Fig. 20. Characteristics of the strength of the muscles rotating the thigh to the outside according to Lovett scale in the study group

The figure shows that after the therapy in the study group in 40% of the patients the strength of the muscles rotating the thigh to the outside was assessed at 5 points according to Lovett scale, and in 45% of patients at 4 points.

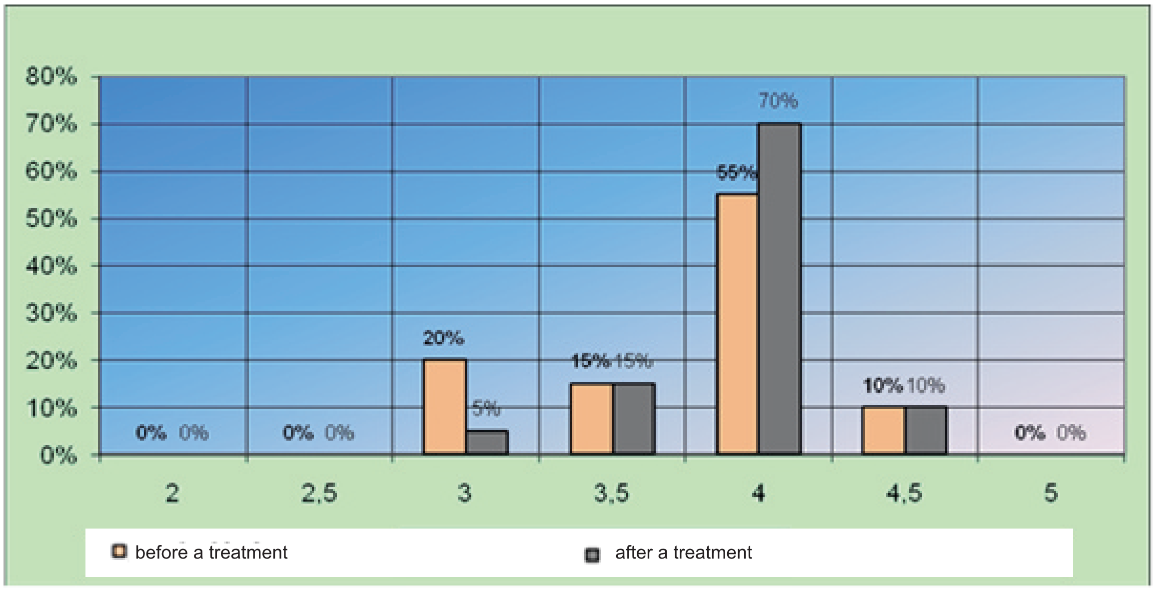


Fig. 21. Characteristics of the strength of the muscles rotating the thigh to the outside according to Lovett scale in the control group

The figure shows that after the therapy in the control group in 70% of the tested patients muscle strength was assessed at 4 points according to Lovett scale, and in 10% of the tested patients this strength amounted to 4.5 points.

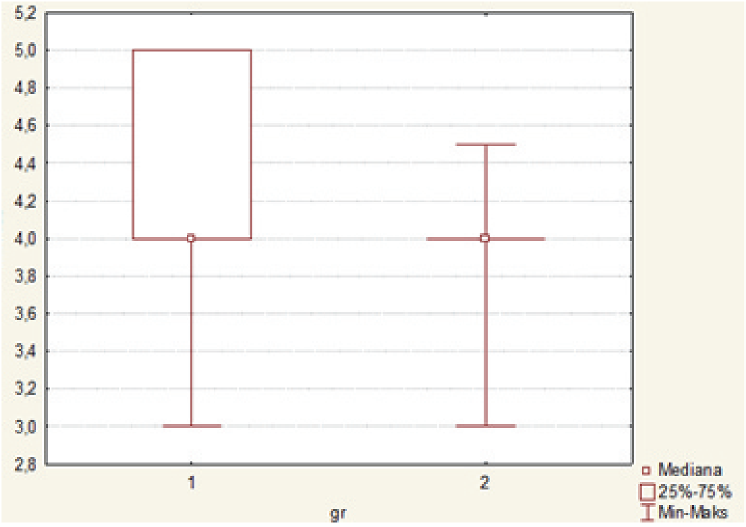


Fig. 22. Comparing the strength of the muscles rotating the thigh to the outside according to Lovett scale in the study group and control group

The figure shows that in the studied groups muscle strength improved. The Wilcoxon test (2.201398; $p<0.027709$) indicates that the results are statistically significant.

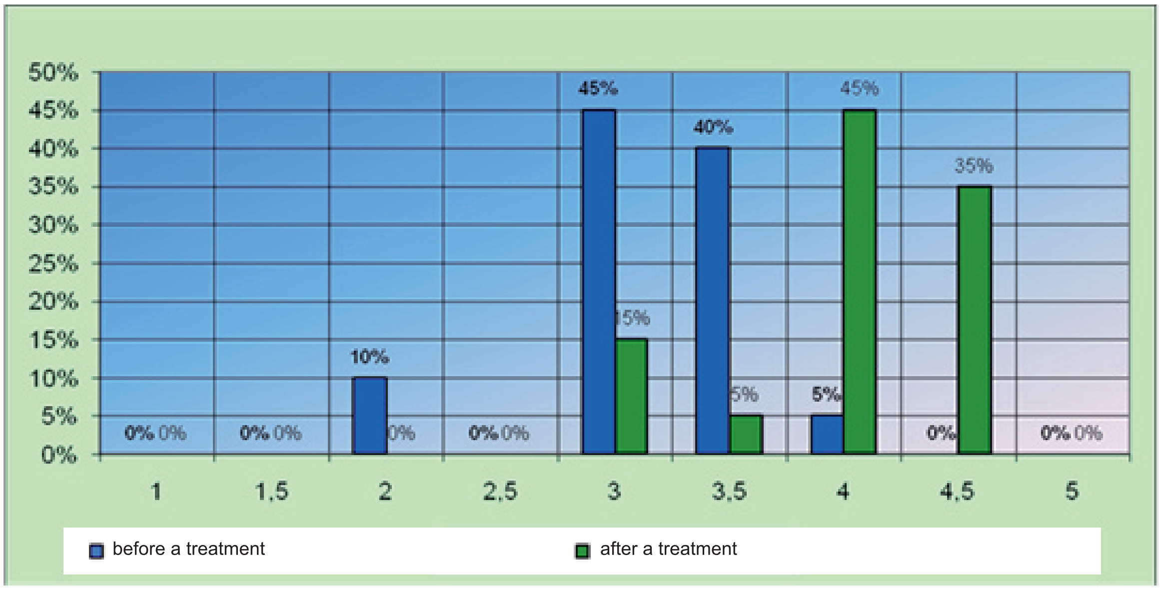


Fig. 23. Characteristics of the strength of the muscles rotating the thigh to the inside according to Lovett scale in the study group

The figure shows that 35% of the patients obtained the value of 4.5 points and in 45% muscle strength was assessed at 4 points according to Lovett scale.

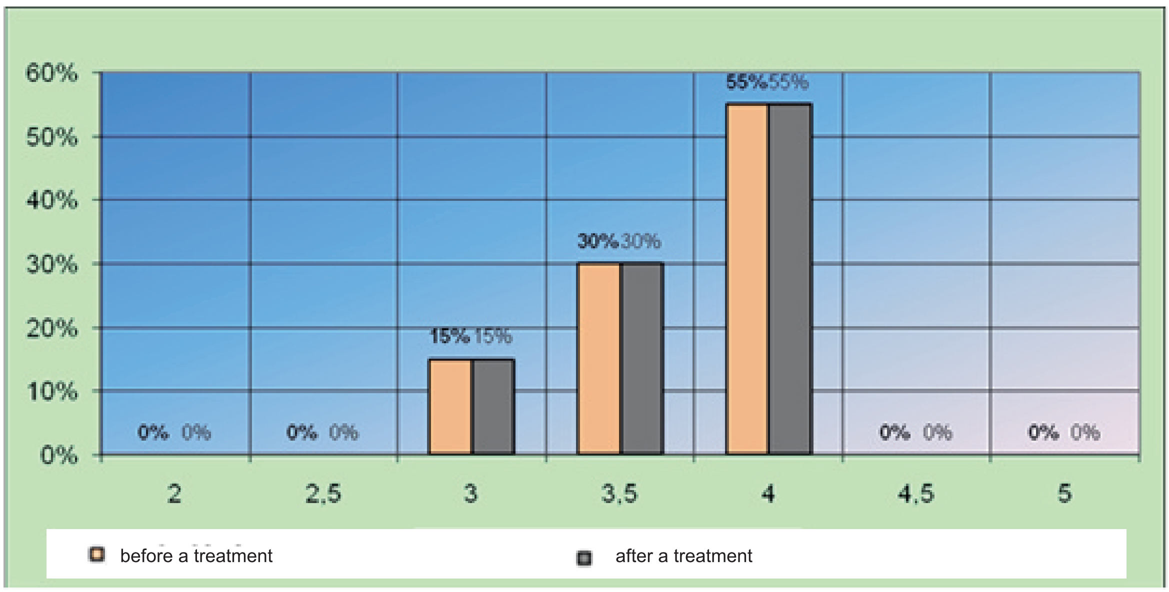


Fig. 24. Characteristics of the strength of the muscles rotating the thigh to the inside according to Lovett scale in the control group

The figure shows that muscle strength has not changed, and the values vary between 3 and 4 point according to Lovett scale.

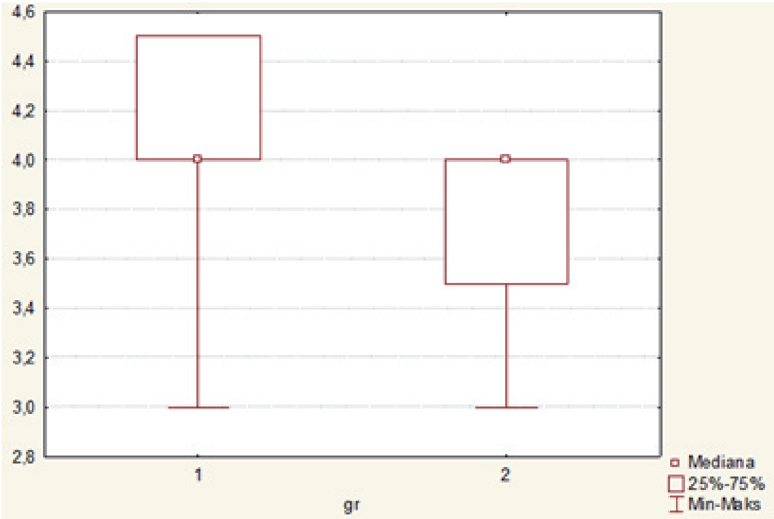


Fig. 25. Comparing the strength of the muscles rotating the thigh to the inside according to Lovett scale in the study group and control group

The figure shows that in the studied groups muscle strength significantly increased. The Wilcoxon test (2.853790; $p<0.0027608$) indicates that the results are statistically significant.

Discussion

Lumbar spine pain syndromes are currently classified as the most common locomotor system disorders and constitute one of the most serious health and medical problems in the entire population.

Physical treatment is one of the oldest forms of pain management and anti-inflammatory procedures, and is still widely used. The effects of pharmacological treatment are not always satisfactory, and a large number of various side effects reduces the attractiveness of certain painkillers. On the basis of clinical studies evaluating the efficacy of cryotherapy it is assumed that this form of therapy may have better therapeutic effects than other physiotherapy treatments used [6, 10].

In the publications of Biały [1,10] Zagrobelny et al. [2, 6, 11] you can find some information on cryomedicine with a detailed explanation of the mechanisms of the cold effect after systemic cryotherapy.

Tomaszewski et al. [3] report that the used cryotherapy, after the initial cooling period, causes vasodilation of deeper vessels, which allows for increased blood flow in the tissues undergoing treatment. The lower the cooling temperature, the greater the increase in the temperature of the skin after the therapy. The temperature after reaching the plateau is all the more increased, the lower the temperature is used in cryotherapy . After the treatment, vasodilation and increased capillary flow takes place, and this effect lasts for several hours and is additionally extended when after cooling with low temperature therapeutic exercises or other physical efforts are performed. Therefore, cryotherapy is

a valuable method facilitating the rehabilitation process [2, 6].
The mechanism of action of extremely low temperatures on the human body has not been conclusively determined as yet, although a number of significant, beneficial therapeutic effects have been achieved [1, 10, 12]. It is very important in the complex treatment of lumbar spine pain syndromes to use a method, which without any side effects will quickly eliminate pain or reduce its intensity and contribute to better motor skills [4, 13, 14].
Already a preliminary analysis of the study results showed some regularities, most of which were confirmed by a statistical study. In discussing the obtained results, I found that in patients with lumbar spine pains, rehabilitation using systemic cryotherapy with individual kinesitherapy brought much better results than in patients in which only individual kinesitherapy was used.
The obtained results show an improvement in the range of spine flexion using Schober's test and improvement of lumbar spine mobility in the transverse plane, both to the left and right side.
Kiljański et al. [9] studied the assessment of the effect of systemic cryotherapy in patients with lumbar spine pains. The results of their studies also show positive effects of systemic cryotherapy. A subjective study of the experienced pain according to VAS scale, as well as study of the range of spine flexion using Schober's test showed that there is considerable improvement.
The studies of Michalik et al. [8], Rymaszewska, Biały and Zagrobelny [2] and Miller [7] show that the reduction of pain after systemic cryotherapy treatments was the largest in post-traumatic states. Also the level of patients' satisfaction from the received treatment highly increased. The author noted a feeling of satisfaction in the studied patients after treatment with systemic kinesitherapy with individual kinesitherapy. The feeling of satisfaction is high regardless of the analgesic potency. The reason for such reactions is a proven positive effect on the human mental state.
Apart from the positive effect of cryogenic temperatures on the ranges of motion in joints, we observed their similar effect on muscle strength. The analysis of the results of measurements of these characteristics shows that the strength of abdominal muscles, muscles rotating the thigh to the outside and muscles rotating the thigh to the inside improved significantly after cryotherapy, and the result is statistically significant. It seems that this is due to the recruitment of more muscle fibers for contraction.
Lizis et al. [15] describe the effects of using cryotherapy and rehabilitation on muscle strength and changes in the range of motion of the hip joint. He stated that cryotherapy has the most effect on the improvement of muscle strength. Similar studies were conducted by Jezierski [16], who evaluated the effect of cryotherapy on the strength of muscles acting on knee joints in patients with gonarthrosis. He stated that after the application of cryotherapy, a significantly greater increase in muscle strength takes place. Brzecki et al. undertook to explain the mechanism of the increase in muscle strength in patients with RA. After the

conducted studies and their analysis, they concluded that cryotherapy not only has an analgesic effect, but it may lead to an increase in muscle strength in patients with RA[17].
Other authors also describe their experience with using cryotherapy in different conditions, from stroke or rheumatic diseases [11], cerebral palsy in children [5, 18], to MS [19].
Let this study on the use of cryotherapy and the described methodology of systemic cryotherapy treatment in patients with lumbar spine pains be an indication to use this safe treatment that brings positive effects.

Conclusions

1. Systemic cryotherapy reduces the level of subjective feeling of pain in patients with lumbar spinal pain syndrome.
2. Flexion of the lumbar spine is greater after analytical kinesitherapy, but the values increase even more when we use kinesitherapy together with cryotherapy.
3. After the application of systemic cryotherapy, the strength of abdominal muscles, muscles rotating the thigh to the outside and muscles rotating the thigh to the inside in the studied patients increased. It seems that this is due to the recruitment of more muscle fibers for contraction.

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