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## Comparison of the effectiveness of whole-body cryotherapy and local cryotherapy for the treatment of rheumatoid arthritis

Porównanie skuteczności krioterapii ogólnoustrojowej i krioterapii miejscowej w leczeniu reumatoidalnego zapalenia stawów

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### ABSTRACT

Rheumatoid arthritis (RA) is a progressive autoimmune disease affecting connective tissue, leading to joint damage and multi-organ changes. Cryotherapy is one of the most frequently used physical methods during the treatment process of patients with RA. To evaluate the effectiveness of whole-body cryotherapy and local cryotherapy in the treatment of RA patients. Study group consisting of 20 patients with RA (mean age  $61 \pm 10.9$  years) was examined. Among them, there were 11 patients underwent a series of 10 whole-body cryotherapy (group A), and 9 patients who underwent 10 sessions of local cryotherapy (group B). Using a questionnaire, the Visual Analogue Scale and a Baseline hand dynamometer the patient's condition was examined before and after the therapy. After the application of whole-body and local cryotherapy, a decrease of subjective pain feeling was observed among the studied patients. In group B, a greater decrease in joint pain within the knee and elbow was noted compared to group A. Whole-body cryotherapy led to reduction in pain of the wrist, shoulder, ankle, and foot joints compared to the local cryotherapy. In both study groups subjective improvements in well-being, independence, and manual efficiency were observed after the therapy. Additionally, a decrease in the duration of morning stiffness and an improvement of hand muscle strength were noted. However, these differences were not statistically significant. The application of both form of cryotherapy had a beneficial effects on the occurrence of symptoms related to RA in the study groups. Local cryotherapy proved to be an effective method of reducing joint swelling, which contributed to improvement in well-being, independence, and manual efficiency in patients.


**Keywords:** Rheumatoid arthritis (RA), whole-body cryotherapy (WBCT), local cryotherapy (LC)

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## STRESZCZENIE

Reumatoidalne zapalenie stawów (RZS) jest postępującą chorobą autoimmunologiczną obejmującą tkankę łączną, prowadzącą do uszkodzenia stawów i zmian wielonarządowych. Krioterapia jest jedną z najczęściej stosowanych metod leczenia fizykalnego pacjentów z RZS. Ocena skuteczności krioterapii ogólnoustrojowej i krioterapii miejscowej w leczeniu chorych na RZS. Grupę badaną stanowiło 20 pacjentów z RZS (średnia wieku  $61 \pm 10,9$  lat). Wśród nich 11 pacjentów poddano serii 10 zabiegów krioterapii ogólnoustrojowej (grupa A), a 9 pacjentów poddano serii 10 zabiegów krioterapii miejscowej (grupa B). Za pomocą kwestionariusza ankiety, wizualnej skali analogowej (VAS) i ręcznego dynamometru Baseline zbadano stan pacjentów przed terapią i po terapii. Po zastosowaniu krioterapii ogólnoustrojowej i miejscowej zaobserwowano zmniejszenie subiektywnego uczucia bólu wśród badanych pacjentów. W grupie B odnotowano większe zmniejszenie bólu stawów kolanowych i łokciowych w porównaniu z grupą A. Krioterapia ogólnoustrojowa spowodowała zmniejszenie bólu stawów nadgarstkowych, barkowych, skokowych i stopy w porównaniu z krioterapią miejscową. W obu badanych grupach zaobserwowano subiektywną poprawę samopoczucia, samodzielności i sprawności manualnej. Odnotowano skrócenie czasu trwania sztywności porannej oraz poprawę siły mięśni dłoni. Różnice te nie były istotne statystycznie. Zastosowanie serii obu form krioterapii zmniejszyło występowanie objawów choroby u badanych pacjentów. Krioterapia miejscowa okazała się skuteczną metodą zmniejszania obrzęków stawów, co przyczyniło się do poprawy samopoczucia, samodzielności i sprawności manualnej chorych.

**Słowa kluczowe:** reumatoidalne zapalenie stawów, krioterapia ogólnoustrojowa, krioterapia miejscowa

## INTRODUCTION

Rheumatoid arthritis (RA) is an autoimmune chronic disease. It results in progressive joint deformities, as well as numerous changes in other systems and organs leading to disability, and significant reduction in the quality of life (Smolen, 2016). According to research, between 0.5 and 1.5% of the adult population suffers from RA. In Poland, this number is estimated at 0.9% of the adult population (Marcol-Majewska, 2017). In 2020 it was estimated that the number of RA patients averaged 17.6 million people around the globe. To balance the data collected, 4.9 million are men and 12.7 million are women. In Central Europe alone, the number of patients is about 349 000, and in Eastern Europe 514 000. The etiology of RA is still not fully understood (Strońska, 2021). A slow, gradual, progressive development of the disease is typical for RA. Less often, we are dealing with a sudden onset of the disease. The dynamics of the disease cannot be anticipated. The course of RA consists of periods of relapses and remission, how long a given period will last is an individual matter that depends on many factors. In some cases, the disease develops

continuously with the same intensity. Joint symptoms usually manifest symmetrically. Stiffness, pain and swelling accompanying the disease make it increasingly difficult to move the joints. Pain and swelling alternately appear and disappear, after a period of exacerbation there is a temporary relative improvement (Smith, 2022). Patients often complain of a feeling of stiffness, especially immediately after awakening, which gradually subsides during a subsequent movement. The duration of morning stiffness is dependant on the severity of the ongoing inflammatory process. After a few years the patient presents advanced damage to the musculoskeletal system (Książopolska-Orłowska, 2013). Ulnarization occurs as the elbow deviation of the fingers coincides with the tendons sliding to the same side extensors which are located over the metacarpophalangeal joints (Baran, 2019). Typical for this disease are also deformities such as “swan neck” and “boutonniere fingers”. Deformation known as “swan neck” is caused by the rupture of the lateral bands of the extensor tendon of the finger, hyperextension in the proximal interphalangeal joints (PIP) and flexion in distal interphalangeal joints (DIP). Due to the complex

nature of the disease, it requires a multidisciplinary approach. The treatment process includes both physiotherapy and pharmacotherapy, as well as psychotherapy and education (Juszczak, 2018; Barłowska, 2021). According to the recommendations of The European Alliance of Associations for Rheumatology (EULAR) from 2018, physical activity and kinesiotherapy should be an important element in the process of RA treatment (Osthoﬀ, 2018). Physiotherapeutic interventions in RA aim to reduce disease activity and thus the risk of comorbidities; maintaining the greatest possible efficiency and independence of the patient, pain relief and education (Hu, 2021). One of the most common methods in the field of physical therapy used in the treatment of RA patients include local cryotherapy and whole-body cryotherapy (WBCT). The whole-body cryotherapy is carried out in a cryogenic chamber, where the temperature is up to  $-130^{\circ}\text{C}$ . This treatment has analgesic, anti-inflammatory, anti-swelling effects, and has a positive effect on the well-being and general condition of patients. Under the influence of cryogenic temperatures applied to the whole body, systemic reactions modulate the functioning of all systems and organs (Gmernicka, 2017). Local cryotherapy (LC) is applied to the selected body area. There are two types of local cryotherapy machines. Some use as coolant the liquid nitrogen, the others carbon dioxide. In the case of the first equipment type, the temperature at the nozzle outlet ranges between  $-196$  and  $-160^{\circ}\text{C}$ . The temperature at the nozzle outlet in the second equipment type is higher compared to those using liquid nitrogen and reaches about  $-78^{\circ}\text{C}$ . The treatment time is about 3 minutes. Cryostimulation causes a decrease in body temperature by 2–4 degrees Celsius compared to the skin surface temperature which contributes to a decrease in the intensity of pain felt immediately after the procedure and it is conducive to reducing the swelling and relieving the feeling of stiffness (Stanek, 2014; Guillot, 2014; Mau, 2016).

The aim of this study was to compare the effectiveness of whole-body cryotherapy and local cryotherapy in the treatment of patients affected by rheumatoid arthritis. The main objective of the study was to assess the impact of

both therapeutic measures to reduce the symptoms of the disease and improve the quality of life of patients. Survey allowed to analyse potential differences in the effectiveness of both therapeutic forms in relation to the various symptoms associated with this disease.

## MATERIAL AND METHODS

The study group consisted of 20 patients with RA (average age 60.8 years [SD – 11 years, min. 35, max. 78 years]). The patients were qualified by a rheumatologist for physical procedures (local or whole-body cryotherapy). Among them, 11 patients received a series of 10 whole-body cryotherapy (group A), and 9 patients received a series of 10 local cryotherapy (group B). There were 6 women and 5 men in the group undergoing whole-body cryotherapy (mean age 62.5 years [SD – 8.7]), and in the group undergoing local cryotherapy there were 4 women and 5 men (mean age 58.7 years [SD – 13.4]). In group A, the mean duration of the disease was  $18.2 \pm 8.7$  years, while in group B it was  $20.8 \pm 13.9$  years.

A Visual Analogue Scale (VAS) was used to assess the subjective pain feeling before and after therapy in the studied patients. With the use of the Baseline manual hydraulic dynamometer, the strength of the hand muscles was tested twice, as well as the occurrence and duration of morning stiffness, joint swelling, the level of manual efficiency and the well-being of the subjects were assessed using the author's questionnaire.

Inclusion and exclusion criteria:

Each patient was qualified for cryotherapy by a rheumatologist after excluding contraindications. Patients were informed about the purpose and course of the study. Each patient gave informed and voluntary consent to participate in the study before the start of the study and was informed that they could withdraw from the study at any time. Excluded were the patients with acute radicular pain of the lumbosacral spine, patients with other rheumatic diseases, as well as patients with individual contraindications for the use of local cryotherapy or whole-body cryotherapy (Fig. 1).

Whole-body cryotherapy was performed in the cryogenic chamber (Type KR-3) by a period

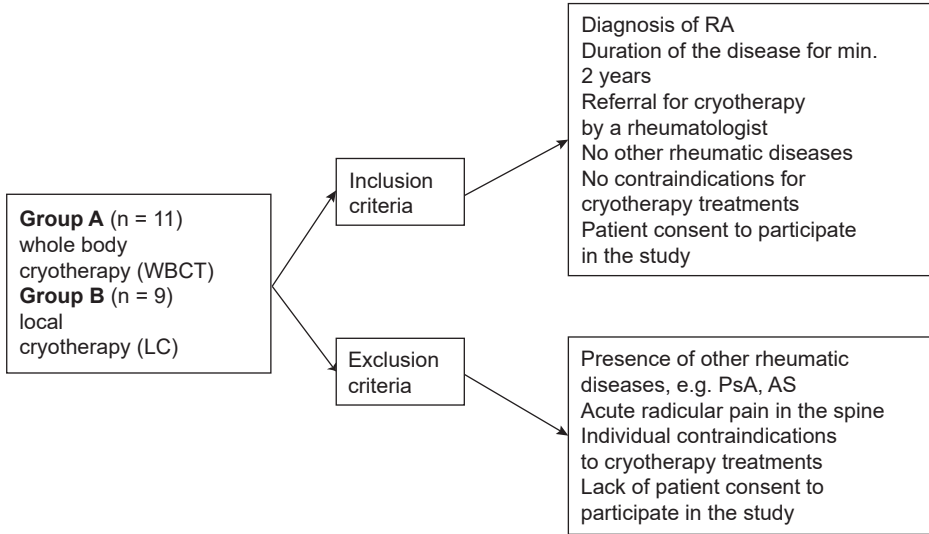


Figure 1. Flow diagram for inclusion and exclusion criteria

Source: own source.

of two weeks excluding the weekend. The duration of a single treatment was from 1.5 to 3 minutes, after which patients performed rehabilitation exercises lasting about 20 minutes at the gym. The therapeutic exercises were in the form of general rehabilitation training on a treadmill or on a stationary bike. After leaving the cryogenic chamber, the patients also performed free active exercises, active resistance exercises, isometric exercises, as well as breathing and stretching exercises. Local cryotherapy treatments were performed with the use of the Kriopol R Bryza II® liquid nitrogen apparatus. The duration of the single treatment was 3 minutes. In the study group of patients undergoing local cryotherapy, this treatment was applied to the area of the wrist joint and the hand, knee, shoulder as well as the ankle joint and foot joints. The statistical analysis were made in SPSS Statistics (Mann-Whitney U Test and the Chi-Square Test). The significance level was  $p < 0.05$ .

For the purposes of this study, a positive opinion of the Research Ethics Committee was obtained (Opinion No. 118.6120.156.2023).

## RESULTS

Patients qualified for whole-body cryotherapy experienced pain in the shoulder joint and elbow joint, assessing it on average at 7.50 points on the VAS. Patients qualified for local cryotherapy experienced slightly greater pain in the wrist joint and hand area and assessed it at the level of 6.88 points on average; with ankle and foot as well as knee joint pain being assessed at the level of 7 points on the VAS.

After the therapy, patients using whole-body cryotherapy indicated pain in the shoulder joint and elbow joint and in other than those mentioned, grading it at 5 on the VAS. In patients after local cryotherapy, pain in the wrist joint and hand; ankle and foot and knee joints was reduced to 5.5 points on the VAS. The difference of subjective pain feelings after the therapy between the study groups was not statistically significant ( $p > 0.05$ ) (Table 1).

Patients in group A experienced morning stiffness everyday in the morning, for less than an hour (63.6%) or only during periods of the disease exacerbation (27.3%), while patients in

group B experienced stiffness every morning for more than 1 hour in case of 55.6% or no stiffness at all (11.1%). After treatment in group A, the study patients experienced morning stiffness for less than an hour or only during periods of the disease exacerbation (22%), while patients using local cryotherapy experienced morning stiffness lasting slightly more than 1 hour (44%) or no stiffness at all (11.1%). The difference of experienced morning stiffness before and after the therapy in the study groups was not statistically significant (group A –  $p = 0.338$ , group B –  $p = 0.510$ )

Prior to the treatment in group A, joint swelling was constantly present in 9% of patients, most of the time it was troublesome for 54.5% of the subjects, and occasionally it appeared in 36.4% of the patients. In group B, the largest number of respondents (44.4%) experienced swelling from time to time, in 22% it occurred constantly, while 11.2% of respondents admitted that they had swelling most of the time, rarely or not at all.

After treatment in group A, swelling occurred most of the time in 54.5% of patients, occasionally in 36.4% and rarely in 9.1% of patients. In group B, 33.3% of respondents admitted that they experience swelling most or occasionally, and 22.2% have swelling rarely. The difference of occurrence of joint swelling before and after the therapy was statistically significant

in group A –  $p = 0.048$ , but was not statistically significant in group B –  $p = 0.463$ ) (Table 2).

Before the therapy, 27.3% of patients from group A declared that they rarely needed help in activities of daily life or at all (45.5%), while the respondents from group B more often admitted that they needed help often (11.1%) or very often (33.3%). After the therapy, 54.5% of patients from group A declared that they did not need help at all in activities of daily life, and rarely such help was expected by 27.3% of the respondents. After therapy, 22.2% of patients from group B needed help very rarely, and only 22.2% of the subjects needed it often. The difference of self-reliance before and after the therapy in the study groups was not statistically significant (group A –  $p = 0.865$ , group B –  $p = 0.912$ ).

Subjects from group A more often described their current well-being as very good (27.3%) or good (27.3%); while respondents from group B more often considered their current well-being to be moderate (44.4%), poor (11.1%) or bad (11.1%). After the therapy, patients from group A described their current well-being as very good (45.5%) or good (45.5%), while the subjects using local cryotherapy were more likely to believe that their current well-being is moderate (33.3%). The difference of well-being before and after the therapy in the study groups was not statistically significant (group A –  $p = 0.284$ , group B –  $p = 0.534$ ).

Table 1. The difference in the subjective pain feeling (Visual Analogue Scale [VAS]) in selected joints after WBCT and LC

Pain level [pkt]	WBCT	LC	Test Mann-Whitney - U	p
Wrist joint pain	-2.45	-1.56	31.500	0.175
Ankle/foot joint pain	-1.82	-0.89	27.000	0.095
Knee joint pain	-1.09	-1.11	48.000	0.941
Elbow joint pain	-0.45	-0.67	39.500	0.456
Arm joint pain	-0.91	-0.89	48.500	0.941
Other joint pain	-1.09	0.33	42.500	0.603

WBCT – whole body cryotherapy, LC – local cryotherapy

Source: own source.

Table 2. The difference in occurrence of joint swelling before and after the therapy in the study groups

	Joint swelling	Before	After	Chi-Square Test	p
WBCT	prevent daily functioning	9.1	0.0	7.905	0.048
	make everyday functioning very difficult	54.5	9.1		
	hinder daily functioning	36.4	72.7		
	hinder daily functioning to a small extent	0.0	18.2		
LC	prevent daily functioning	55.6	22.2	2.571	0.463
	make everyday functioning very difficult	22.2	55.6		
	hinder daily functioning	11.1	11.1		
	hinder daily functioning to a small extent	11.1	11.1		

WBCT – whole body cryotherapy, LC – local cryotherapy

Source: own source.

Before starting therapy, patients from group A more often declared that their manual efficiency was very good (27.3%) or moderate (27.3%); while patients from group B slightly more often described their manual efficiency as good (22.2%) or poor (44.4%). After the therapy, respondents from group A more often declared that their manual efficiency was very good (36.4%) or moderate (36.4%), while respondents from group B were slightly more likely to describe their efficiency as good (22.2%) or poor (33.3%). The difference in the degree of manual efficiency before and after the therapy in the study groups was not statistically significant (group A –  $p = 0.733$ , group B –  $p = 0.924$ ).

Before whole body cryotherapy, the muscle strength of the right dominant hand was 49.3 [pounds] while of the left dominant hand – 44.4 [pounds] in patients from group A. After the therapy, patients in group A achieved a slightly higher score for muscle strength in the right hand 56.1 [pounds] and the left hand 47.5 [pounds] ( $p = 0.056$ ). In patients from group B muscle strength of the right dominant hand was 46.1 [pounds], while of the left dominant hand – 40.1 [pounds] before local cryotherapy. After the therapy, patients in group B achieved a slightly higher score for muscle strength in the right hand 50 [pounds] and the left hand 41.2 [pounds] ( $p = 0.152$ ). Both differences were statistically not significant.

## DISCUSSION

Both local and whole-body cryotherapy are used among rheumatology patients due to their beneficial effect on the musculoskeletal system. They contribute to the reduction of pain, morning stiffness, swelling; and offer the alleviation of fatigue (Lubkowska, 2014; Capadoglio, 2022). Studies confirm the beneficial effect of cryotherapy on improving the well-being and mood of patients (Rymaszewska, 2008).

In the context of the increasing availability of this form of therapy, it is important to answer the question of which form of cryotherapy brings better results, and which of them is more effective in the case of the RA patients. Other studies have looked at the effects of kinesitherapy in combination with whole body cryotherapy compared to traditional kinesitherapy in combination with other physical treatments.

The study of Gizińska *et al.* (2015) was conducted among 25 RA patients. After the end of therapy, a significant decrease in pain levels was observed on the Visual Analog Scale (VAS). A reduction in the duration of morning stiffness – which was measured in minutes – was demonstrated. To assess the degree of independence, the researchers used the Health Assessment Questionnaire-Disability Index. After the end of therapy, a reduction in specific difficulties in performing daily activities was shown (Gizińska *et al.*, 2015).

Similar results were obtained in our own research. In all the indicated joints, there was also a decrease in the level of subjective pain feelings after the completion of whole-body cryotherapy. In everyday life, improvements in manual efficiency, independence and reduction of stiffness were observed, but the results were not statistically significant.

Other studies evaluated the effects of two types of local cryotherapy on the laboratory parameters of 40 patients; 20 of whom were receiving cryotherapy using liquid nitrogen vapors, while the rest were receiving cold air cryotherapy. The level of perceived pain on the VAS after the completion of therapy in both groups was reduced. The duration of morning stiffness was examined, the fatigue severity scale was used, and the degree of independence in everyday life was assessed.

The VAS was used to measure the intensity of fatigue, while the HAQ was used to assess the degree of independence. The result of both forms of local cryotherapy was a reduction in the time of feeling stiffness, a reduction in the severity of fatigue and an increase in independence in daily life activities (Jastrzabek, 2013).

The own study also showed a decrease in the level of pain after the end of local cryotherapy treatments in each of the indicated joints; although, as in the case of whole-body cryotherapy, the differences obtained turned out to be statistically not significant.

Comparing the above studies – which assess the wellbeing of patients with RA, their independence in everyday life and the reduced occurrence of morning stiffness – in relation to the results of our own studies, an improvement in wellbeing, the degree of independence in everyday situations and a reduction in the severity of stiffness were also noticed after using both forms of cryotherapy,

Although the differences were not statistically significant, they were noticeable in the subjective assessment of patients. A group of Croatian researchers in 2021 investigated the effect of localized cryotherapy on the grip strength of the dominant hand muscles before and after the application of local cryotherapy. For this purpose, a measurement was made with a manual

dynamometer. The results show that muscle strength improved after the therapy but with this parameter the results turned out to be not statistically significant (Laktašić Žerjavić *et al.*, 2021).

Similar effects were obtained in another study. When measuring the strength of both hands, the positive end result after therapy turned out to be of no statistical significance in this case as well (Jastrzabek, 2015). Hirvonen *et al.* project investigated the effect of various forms of cryotherapy on pain and disease activity in the course of the seropositive RA. For this purpose, 60 patients were recruited and divided into 4 groups: each of them undergoing a different form of cryotherapy. For the purpose of the result analysis, 2 patient groups receiving local cryotherapy were combined into one, while patients using whole-body cryotherapy at  $-60^{\circ}\text{C}$  and  $-110^{\circ}\text{C}$  were analyzed separately. After 7 days, it was checked how each of the methods affected – among other things – the strength of the hand muscles, which was measured in [kg] using a hand dynamometer. The results obtained showed an improvement in hand muscle strength in all 3 groups. The best result was obtained in the group undergoing systemic therapy at  $-110^{\circ}\text{C}$ , while the weakest result was obtained in the case of local cryotherapy (Hirvonen, 2006).

In our own study, the muscle strength of both hands was tested using a similar type of tool. The results illustrate an increase in muscle strength with both forms of cryotherapy, but whole-body cryotherapy gave slightly better results in both the right and left hands. As in the case of the experiments of the three above-mentioned research teams, the differences were not statistically significant. The greater effectiveness of general cryotherapy compared to local cryotherapy could be related to the patients' warm-up and general improvement exercises after leaving the cryogenic chamber. Systematic performance of these exercises every day after cryotherapy could translate into improved muscle strength and the range of joints motion, and consequently improved manual efficiency and independence in everyday life. This, in turn, could probably have contributed to better wellbeing after completing a series of whole-body cryotherapy sessions. In our own study – in the case of the elbow and knee

joints – better results in terms of pain reduction were obtained after the use of local cryotherapy. In the wrist and hand joints, ankle and foot joints, shoulder joint and other joints subjected to therapy, whole-body cryotherapy turned out to be more effective.

There are several possible hypotheses to explain the differences in the effectiveness of both cryotherapy methods depending on the specific joint. Because whole-body cryotherapy cools the entire body at the same time, it can be more effective in areas with more diffuse pain localization, such as the shoulder joint. A topical method – on the other hand – may be more effective in the case of concentrated pain located in a small area with easy access. By applying the cooling agent directly to the painful area of the elbow or knee joint, it is possible to direct the cold exactly where it is needed, which can result in better pain relief. Joints with greater mobility in different planes – such as the joints of the hand, feet or shoulder – may be more susceptible to micro injuries. In these cases, the whole-body cryotherapy, which affects the whole body, can better reduce inflammation and pain. Local cryotherapy turned out to give better results in reducing pain within the knee joint, perhaps because it is a hinge-type joint with a smaller range of motion possibilities compared to the other joints mentioned above; and in this case the method limited to a strict area worked better. It is also worth noting that the presence of differences in the effectiveness of local and whole-body cryotherapy may be the result of the complexity of interactions between the therapy and the individual characteristics of patients (e.g. skin thickness, amount of adipose tissue in specific areas, structure of articular cartilage), which may affect cold penetration and effectiveness of the therapy. Summing up our own results supported by the results of research conducted by other authors, both methods of cryotherapy seem to have a positive effect on reducing pain, reducing morning stiffness, as well as improving wellbeing and independence in activities of daily life in patients with RA. However, differences in the effectiveness of local and whole-body cryotherapy may be due to the complexity of the interactions between the therapy and individual patient characteristics

(e.g., skin thickness, amount of fat in specific areas, structure of articular cartilage), which may affect cold penetration and therapy effectiveness.

## CONCLUSIONS

1. Both whole-body cryotherapy and local cryotherapy had a positive effect on RA symptoms in the studied patients.
2. The use of a series of whole-body cryotherapy treatments resulted in a significant reduction in discomfort associated with the occurrence of joint swelling in the studied patients.
3. After using a series of both forms of cryotherapy, a subjective improvement was observed in terms of the severity and duration of morning stiffness, subjective pain feeling, wellbeing, independence and manual efficiency, but none of the therapeutic methods used was more effective at the level of statistical significance.
4. Both after a series of whole-body and local cryotherapy, hand muscle strength improved, but better results were noted in the group of patients using whole-body cryotherapy, which was probably related to the use of general rehabilitation training performed each time after leaving the cryogenic chamber to warm up the body after exposure to cold.

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