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**ORIGINAL PAPER**

# The effect of a physical therapy programme on the condition of upper limb muscles in patients with rheumatoid arthritis

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**ABSTRACT**

**Introduction and aim**. Rheumatoid arthritis is a chronic progressive systemic disease of the connective tissue affecting the joints, mainly small, of the erosive-destructive polyarthritis type, and frequent systemic inflammatory damage to internal organs. The purpose of the research is to evaluate the effectiveness of physical therapy on the muscles of upper limbs in patients with rheumatoid arthritis by the dynamics of muscle strength and strength index.

**Material and methods**. To determine the strength of the muscles of the affected upper limbs were used dynamometry, calculated strength index as a percentage to assess the functional ability of the affected limb. All patients were divided into control (n=92) and main (n=96) groups, taking into account the functional insufficiency of the joints.

**Results.** After 6 months of physical therapy, muscle strength indicators in the main group of patients with 1st degree of functional joints insufficiency (FJI) in the affected right limb increased by 3.1 kg, in the left by 3 kg; with 2nd degree FJI – in the right limb by 4.2 kg, in the left – by 3.7 kg, significantly exceeded the same indicators in patients of the control group ($p<0.05$). Similarly, there was an increase in the strength index in the patients of the main group.

**Conclusion.** Physical therapy technology has been developed and implemented effectively influenced the increase in muscle strength and strength index of affected upper limbs of the main group of patients with rheumatoid arthritis.

**Keywords.** dynamometry, muscles strength, physical therapy, rheumatoid arthritis, strength index

## Introduction

Rheumatoid arthritis is a chronic progressive systemic disease of the connective tissue with damage to the joints, mainly small ones, a type of erosive-destructive polyarthritis and frequent systemic inflammatory lesions of the internal organs, registered in all countries of the world with a frequency of 0.4 to 1.5%.[1,2]

This disease is one of the four large-scale medical problems of humanity, and more than 14 million people around the world suffer from it.[3]

In Ukraine, the prevalence of rheumatoid arthritis is 340 cases per 100,000 of adult population, and the disease mainly affects people of working age (20–50 years), which leads to frequent and long-term hospitalization, and often to disability. According to generalized statistical data, women suffer from rheumatoid arthritis 3-4 times more often than men. At the same time, the peak incidence of rheumatoid arthritis occurs in women aged 40-50.[4,5] The disease leads to frequent and long-term hospitalization of patients, a decrease in their working capacity, disability and large economic costs.[6-8] The mortality rate in patients with rheumatoid arthritis is 2 times higher than in the general population. This indicator worsens every year.[6,9]

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Autoimmune inflammatory process, chronic pain syndrome has a steadily progressive nature. All this, without proper treatment, leads to the destruction of articular cartilage in the form of erosions and destruction of the bones that form the joint. In the future, the joints are deformed and their functional ability is impaired.[10-12]

As a result of the inflammatory process affecting the upper limbs of patients with RA, there is a decrease in the amplitude of movements in the joints, and in muscle strength.[13] An early and permanent sign of rheumatoid arthritis is progressive muscle atrophy, which leads to sharp decline in strength, muscle weakness and is accompanied by a significant decrease or cessation of the patient's physical activity.[14,15]

Numerous clinical data indicate a high degree of reduction in physical activity of patients with rheumatoid arthritis due to impaired mobility and functional insufficiency of joints.[1,10,11,16,17]

According to most authors, in order to increase the effectiveness of drug treatment, a special role is given to physical therapy, which should be an integral part of the comprehensive restorative treatment of patients with rheumatoid arthritis.[6,9,13,14,18,19]

As of today, there is a need for the development and implementation of effective physical therapy technology, which would include an individual approach to the use of innovative restorative physical therapy measures, objective methods of evaluating the effectiveness of the measures and predicting the results.[4,15,20,21]

The lack of such works devoted to a personalized approach to physical therapy of patients with rheumatoid arthritis determined the relevance of the presented work.

## Aim

The purpose of research is to evaluate the effectiveness of physical therapy on the muscles of upper limbs in patients with rheumatoid arthritis by the dynamics of muscle strength and strength index.

## Material and methods

The research was conducted on the basis of the rheumatology department, the department of restorative treatment with traditional and non-traditional methods of the Municipal Enterprise "Rivne Regional Clinical Hospital named after Yuriy Semenyuk". Accumulation of research results was carried out as patients were admitted to hospital treatment. 188 patients with rheumatoid arthritis were examined, 156 (83%) were women, 32 (17%) were men, and their average age was 44.9±7.6 years. All patients were randomly divided into control (n=92, men – 16 (17.4%), women – 76 (82.6%)) and main (n=96, men – 16 (16.6%), women – 80 (83.4%)) groups. In the control group, there were 34 patients with functional joint disability of the first degree, 58 patients with functional joint disability of the second degree; in the main group, 32 patients with functional joint disability of the first degree, and 64 patients with functional joint disability of the second degree.

The inclusion criteria were: the presence of a confirmed diagnosis of rheumatoid arthritis based on the criteria of ACR/ EULAR 2010.[20] and in accordance with the Order of the Ministry of Health of Ukraine of 11.04.2014 № 263 "Unified Clinical Protocol of Primary, Secondary, Tertiary Medical Care and Medical Rehabilitation of Patients with Rheumatoid Arthritis".[8]

The exclusion criteria: age over 60 years, IV radiological stage of joint damage, the third stage of inflammation, acute inflammatory pain, the patient's refusal to participate in the research. The joints-exceptions included distal interphalangeal, the first wrist-heel, the first shoulder-phalangeal joints.

The research was carried out in compliance with the main provisions of the "Rules of Ethical Principles of Conducting Scientific Medical Research with Human Participation", approved by the Declaration of Helsinki (1964-2013), ICH GCP (1996), EU Directive No. 609 (from November 24, 1986) orders of the Ministry of Health of Ukraine No. 690 of 09/23/2009, No. 944 of 12/14/2009, No. 616 of 08/03/2012. Patients participated in the research completely of their own free will, which is confirmed by personally signing the appropriate informed consent.

Patients were carried out anthropometric (BMI, goniometry, dynamometry), X-ray examinations, MMT, VASH scale, laboratory parameters were studied, joint index was determined.

To determine the strength of the muscles of the flexor of the hand of the affected upper limbs, dynamometry was used (with the help of a carpal dynamometer). In the initial standing position, the patient moved his straight hand to the side and squeezed the carpal dynamometer. At the same time, the free hand was relaxed and lowered down. The dynamometric measurement was conducted alternately with both hands in three attempts, with the best possible outcomes for each hand. The results of the measurements, their comparison with the initial data and the evaluation were carried out three times: before the beginning of the course of physical therapy, after 3 months and after 6 months in the course of rehabilitation activities. In addition, the strength index of the muscles of the hand (relative strength index) was calculated in percentages, which is of great importance for assessing the functional capacity of the affected limb. The calculation was performed using the formula: hand strength index = hand strength (kg): weight (kg) • 100. The average hand strength index for men is 65–75%, for women – 50–60%.

Science-based and developed rehabilitation technology intervention with the use of physical therapy

products with a personalized approach to patients with rheumatoid arthritis and in accordance with the ICF domains and taking into account the factors affecting the level of functional disorders and the quality of their life. For the main group, a 6-month physical therapy programme was developed and implemented, which included the following elements: therapeutic exercises, therapeutic massage and self-massage, physiotherapy procedures, hydrotherapy, orthotics, kinesiotaping of the upper extremities, mechanotherapy and psychological support.

The statistical description of the samples was carried out by determining the arithmetic mean (M) and its error (m). The type of distribution of parameters in the variational series was determined by the Shapiro-Wilk test. The significance of differences between samples was assessed using non-parametric methods for dependent and independent samples (Wilcoxon T-test, Mann-Whitney U-test). The criterion of the reliability of the estimates was the level of significance with an indication of the probability of a false estimate (p). The difference in means was considered significant at $p<0.05$. The resulting digital material was statistically processed using the statistical analysis package Statistica 10 (Serial Number: STA999K347150-W, StatSoft Inc. 2017, Tulsa, OK, USA).

## Results

The results of the initial examination of patients with rheumatoid arthritis indicated that the long-term inflammatory process, pain syndrome significantly reduced muscle strength.

During the initial examination of patients with rheumatoid arthritis (n=188), there was a deviation of the initial indicators of dynamometry of the affected upper limbs from normal values of muscle strength. Thus, a decrease in muscle strength was noted in the right affected limb to 27.1±6.2 kg, in the left – to 23.1±6.7 (x ±S) kg, which indicated the development of muscle atrophy in patients. A decrease in the strength of the affected hands was also observed in the examined patients, which was confirmed by the low indicators of the strength index, which are presented in the Table 1.

After the initial examination, all patients were randomly divided to a control group (92 people), 34 of them with functional joint insufficiency (FJI) of the I degree, 58 patients with functional insufficiency of the joints of the II degree, and the main group (96 people), of which there are 32 patients with functional insufficiency of the joints of the 1st degree, 64 patients with functional insufficiency of the joints of the II degree; proportionally, as they were admitted to the hospital.

All patients were examined by a standard clinical, laboratory and functional examination. They were treated in accordance with the regulatory protocol of the Ministry of Health of Ukraine and were under the supervision of doctors.[8] Against the background of drug therapy, physical therapy measures were provided for patients, according to the severity of the disease.

**Table 1**. Indicators of dynamometry of the affected limbs in examined patients with RA before the course of physical therapy (n=188)*

| Upper limb | Statistical indicators | |
|---|---|---|
| | $\bar{x}$ | S |
| Dynamometry (kg) | | |
| Right hand | 27.1 | 6.2 |
| Left hand | 23.1 | 6.7 |
| Strength index (%) | | |
| Right hand | 37.5 | 8.6 |
| Left hand | 31.8 | 9.3 |

* $\bar{x}$ – arithmetic mean value; S – standard deviation

Patients of the control group underwent rehabilitation in accordance with the recommendations of the regulatory document of the Ministry of Health of Ukraine[8] (appendix 1), according to which standard rehabilitation measures (exercises, massage, physical physiotherapy) were used.

The patients of the main group were engaged in the proposed technology of physical therapy measures, which involved the development of an individual program of physical therapy for each patient for a long term, with the necessary correction, which included inpatient and outpatient stages. Phase control was carried out after 3 and 6 months.

The rehabilitation measures included: therapeutic exercises taking into account the period of the disease and the functional insufficiency of the joint (position treatment, static, passive and active exercises with assistance, without assistance, with resistance); exercises with objects, special exercises to improve the amplitude of movements in the affected joints and muscle strength. Attention was focused on aerobic exercises, since they are characterized by lower intensity and longer duration and, in our opinion, are the most appropriate type of motor activity for patients with rheumatoid arthritis. It was recommended to perform exercises for extension and abduction of the limbs to increase the tone of the muscles that perform flexion and adduction and to reduce the tone in the muscles that extend and abduct the limb.

Therapeutic massage was applied and the patient was taught how to perform self-massage, physiotherapy procedures, hydrotherapy, orthotics, kinesiotaping of the upper limbs, mechanotherapy and psychological support were carried out. Hydrotherapy was used to improve circulation, reduce joint pain and muscle spasm. The method of mechanotherapy was differentiated depending on the features of the clinical forms of joint damage to improve the amplitude of movements, stretch

and improve the elasticity of muscles and ligaments, restore muscle strength and motor function of the joints of the upper limbs.

The study of the obtained results, their comparison with the initial data and the assessment were carried out three times: before the beginning of the course of physical therapy, after 3 months, and after 6 months in the process of carrying out rehabilitation measures.

At the beginning of the research, we found out that the patients of both groups with FJI (functional joints insufficiency) I and II degree had reduced indicators of dynamometry and strength index of the upper limbs. Weak muscle strength was noted in the joints of the hand and fingers of both the right and left hand, symmetrically affected upper limbs. The development of functional insufficiency of the joints was facilitated by early growing muscle atrophy, which was related to the affected joint. In patients with rheumatoid arthritis with FJI I and II degrees, a decrease in muscle tone, deterioration of the strength characteristics of muscles with subsequent stiffness and pain in the joints was observed.

Thus, at the beginning of the research, the patients of the main group with FJI I degree, there was a decrease in muscle strength in the right affected limb to 28.2±3.3 kg, in the left – to 24.3±3.2 kg; respectively, in patients of the control group with FJI I degree, in the right affected limb – up to 29.4±2.7 kg, in the left – up to 25.1±2.7 (x ±S) kg.

Similarly, in patients of the main group with the II degree of FJI, a more significant decrease in muscle strength was observed in the right affected limb – up to 25.5±3.1 kg, in the left – up to 21.6±3.4 kg; in patients of the control group with FJI of the II degree, in the right affected limb – up to 27.1±3.0 kg, in the left – up to 22.8±3.1 kg, which is a deviation from the normal values of muscle strength according to dynamometry indicators (x±S) (Table 2).

Both standard treatment and physical therapy after 3 months contributed to the improvement of dynamometry indicators in the affected upper limbs (both right and left) of all patients, indicating the results shown in Table 2. However, in patients of the main group, the changes were more pronounced than in the patients of the control group, where the indicators were significantly lower. So, in general, after 3 months of physical therapy in patients of the main group with FJI I degree, the strength of the muscles in the affected right limb increased from 28.2±3.3 kg to 34.4±3.4 kg (x±S), which is significantly higher than the figure of the control group of patients with FJI of the 1degree, at repeated examination: from 29.4±2.7 kg to 32.1±2.9 kg (x±S) ($p<0.05$). The strength of the muscles of the affected left limb in the main group with FJI 1 degree, also increased from 24.3±3.2 kg to 30.3±3.2 kg (x±S), the indicator of patients of the control group with FJI 1 degree, was comparatively lower: from 25.1±2.7 kg to 27.3±2.8 kg (Table 2) (x±S).

Accordingly, in the patients of the main group with FJI of the II degree, an advantage was also observed in terms of increasing dynamometry indicators: muscle strength in the affected right limb increased from 25.5±3.1 kg to 32±3.4 kg, in the left – from 21.6±3.4 to 27.6±3.3 kg; in patients of the control group, muscle strength in the affected right limb increased from 27.1±3 kg to 29.9±3.1 kg, in the left – from 22.8±3.1 to 24.9±3 kg, which demonstrates significantly lower dynamometry indicators (Table 2) (x±S).

As a result of the use of the recommended means of physical therapy in the main group, the indicators of the strength index increased significantly. In particular, in the dynamics of the strength index of the affected right limb of the main group of patients with FJI of the 1 degree, increased on average by 4.2%, in the left – by 4.1% (x±S) ($p<0.05$). At the same time, patients of the control group with FJI I degree the strength index of the affected right limb increased by only 2.1%, in the left one by 2% (Table 2) (x±S).

Accordingly, the strength index of the affected right extremity of the main group of patients with the II degree of FJI, increased on average by 4.3%, in the left –

**Table 2**. Dynamics of dynamometry indicators and strength index in both groups of patients before and 3 months after the course of physical therapy*

| Upper limb | Before the course of physical therapy | | | | After 3 months | | | |
|---|---|---|---|---|---|---|---|---|
| | Main group | | Control group | | Main group | | Control group | |
| | FJI I (n=32) | FJI II (n=64) | FJI I (n=34) | FJI II (n=58) | FJI I (n=32) | FJI II (n=64) | FJI I (n=34) | FJI II (n=58) |
| | $\bar{x}$±S | | $\bar{x}$±S | | $\bar{x}$±S | | $\bar{x}$±S | |
| Dynamometry (kg) | | | | | | | | |
| **Right** | 28.2±3.3 | 25.5±3.1 | 29.4±2.7 | 27.1±3 | 34.4±3.4# | 32.0±3.4# | 32.1±2.9 | 29.9±3.1 |
| **Left** | 24.3±3.2 | 21.6±3.4 | 25.1±2.7 | 22.8±3.1 | 30.3±3.2# | 27.6±3.3# | 27.3±2.8 | 24.9±3 |
| Strength index (%) | | | | | | | | |
| **Right** | 39.4±5 | 37.1±4.6 | 39.5±6 | 35.7±5.6 | 43.6±5.2# | 41.4±4.8# | 41.6±5.9 | 37.9±5.5 |
| **Left** | 33.4±4.8 | 31.4±4.4 | 33.7±5.6 | 30.1±5.3 | 37.5±4.7# | 35.4±4.2# | 35.7±5.8 | 32.1±5.4 |

* $\bar{x}$ – arithmetic mean value; S – standard deviation; # – $p<0.05$ between the indicators of the main and control groups

**Table 3**. Dynamics of dynamometry indicators and strength index in both groups of patients 3 and 6 months after a course of physical therapy*

| Upper limb | Indicators after 3 months | | | | Indicators after 6 months | | | |
|---|---|---|---|---|---|---|---|---|
| | Main group | | Control group | | Main group | | Control group | |
| | FJI I (n=32) | FJI II (n=64) | FJI I (n=34) | FJI II (n=58) | FJI I (n=32) | FJI II (n=64) | FJI I (n=34) | FJI II (n=58) |
| | $\bar{x}$±S | | $\bar{x}$±S | | $\bar{x}$±S | | $\bar{x}$±S | |
| Dynamometry (kg) | | | | | | | | |
| **Right** | 34.4±3.4 | 32.0±3.4 | 32.1±2.9 | 29.9±3.1 | 37.5±4.2# | 36.2±3.9# | 34.6±2.8 | 32.5±3.3 |
| **Left** | 30.3±3.2 | 27.6±3.3 | 27.3±2.8 | 24.9±3.0 | 33.3±3.1# | 31.3±3.5# | 29.6±3.1 | 27.1±3.2 |
| Strength index (%) | | | | | | | | |
| **Right** | 43.6±5.2 | 41.4±4.8 | 41.6±5.9 | 37.9±5.5 | 50.2±5.4# | 48.2±4.7# | 46.8±5.7 | 43.1±5.7 |
| **Left** | 37.5±4.7 | 35.4±4.2 | 35.7±5.8 | 32.1±5.4 | 43.4±4.9# | 41.5±4.9# | 40.1±5.9 | 36.4±5.5 |

* $\bar{x}$ – arithmetic mean value; S – standard deviation; # – p<0.05 between the indicators of the main and control groups

by 4% (x±S) (p<0.05). In patients of the control group with FJI of the II degree. the strength index of the affected right limb increased by 2%, in the left limb by 2.0%, which shows significantly lower indicators than in patients of the main group (Table 2) (x±S).

The analysis of the dynamometry indicators of the affected joints of the hand in rheumatoid arthritis after 6 months of the course of physical therapy indicated their probable improvement in the examined patients of the main group. So, muscle strength in patients with FJI of the 1 degree, in the affected right limb increased from 34.4±3.4 kg to 37.5±4.2 kg, in the left – from 30.3±3.2 kg to 33.3±3.1 kg (Table 3) (x±S) (p<0.05). In patients of the control group with FJI of the I degree an increase in muscle strength was also noted in both affected limbs (in the right – from 32.1±2.9 kg to 34.6±2.8 kg, in the left – from 27.3±2.8 kg to 29.6 ±3.1 kg), however, their dynamometry indicators were significantly lower, compared to the indicators of the main group, which is presented in the Table. 3.

Similarly, the indicators of muscle strength improved in patients of the main group with FJI of the II degree in the affected right limb – from 32±3.4 kg to 36.2±3.9 kg, in the left – from 27.6±3.3 kg to 31.3±3.5 kg and significantly exceeded the same indicators in patients of the control group with FJI of the II degree: muscle strength in the right limb increased from 29.9±3.1 kg to 32.5±3.3 kg, in the left – from 24.9±3 kg up to 27.1±3.2 kg (Table 3) (x±S) (p<0.05).

The increase in the muscles strength of the right and left hand as a result of the use of a 6-month course of physical therapy contributed to the increase in the strength index of the affected upper limbs in the patients of the main group. In particular, the strength index of the right limb in patients of the main group with FJI of the I degree, increased from 43.6% to 50.2%, the left – from 37.5% to 43.4%, which was significantly better than in the patients of the control group with 1degree of FJI – from 41.6% to 46.8% (right limb) and from 35.7% to 40.1% (left limb) (Table3) (x±S) (p<0.05).

Accordingly, the strength index of the affected right limb of the main group of patients with the FJI of the II degree, increased on average from 41.4% to 48.2%, in the left – from 35.4% to 41.5% (x±S) (p<0.05). In patients of the control group with FJI of the II degree the strength index of the affected right limb increased from 37.9% to 43.1%, in the left – from 32.1% to 36.4%, which shows significantly lower indicators than in patients of the main group (Table 3) (x±S).

Thus, the above results of dynamometry and strength index in the main group, which significantly exceed the same indicators of the control group, testify to the effectiveness of the developed physical therapy technology for the patients of the main group.

This was expressed in an increase in the functional capacity of the upper limbs, an improvement in the bending of the fingers of the hand, the elasticity of muscles and ligaments, and a restoration of the strength of the muscles of the upper limbs at the end of the study.

## Discussion

A group of scientists analyzed the general kinematics of the upper limbs in 3D while performing the "can opening movement" in rheumatoid arthritis and compared them with healthy people.[22] 24 women (12 healthy and 12 with rheumatoid arthritis) were included. Assessment was performed using the JAMAR dynamometer, the Health Assessment Questionnaire, and 3D kinematic analysis of the upper limb during the "can opening motion". As a result of the study, it was found that there was a statistical difference between the groups: compared to healthy people, women with rheumatoid arthritis have slower movements, more elbow flexion, and less hand grip strength.

Researchers Sferra da Silva, G., de Almeida Lourenço, M. and de Assis assessed disease activity in patients with rheumatoid arthritis.[23] Body weight and height were measured for all participants, questionnaires were used on patients' functional abilities, and

wrist dynamometry was performed. Research results have shown that hand strength in patients with rheumatoid arthritis is strongly correlated with function, but not with disease activity. This confirms our research on the formation of hand muscle atrophy in patients with rheumatoid arthritis, which negatively affected the functional capacity of the affected upper limbs and significantly reduced muscle strength.

According to the results of a number of authors, it was established that the endurance and grip strength of patients with rheumatoid arthritis is related to the functions of the upper limbs and their quality of life. This result demonstrates that the assessment of hand grip endurance can be a reference for scientists who develop a physical therapy program for the upper limbs of patients with rheumatoid arthritis.[24]

The research results presented above confirm the hypothesis that in patients with rheumatoid arthritis, as a result of a long-term inflammatory process, pain syndrome, and a significant decrease in muscle strength, the function of the upper limbs deteriorates and, accordingly, their quality of life.[15,23-25]

## Conclusion

The developed and implemented physical therapy programme effectively increased muscle strength and strength index of the affected upper limbs of patients with rheumatoid arthritis, in contrast to conventional restorative treatment. This contributed to the improvement of finger flexion, hand grip endurance, muscle and ligament elasticity, and restoration of upper extremity muscle strength in the main group at the end of the study, which confirms the effectiveness of the implemented physical therapy programme.

Prospects for further research are to study the functional status of patients with rheumatoid arthritis using the Stanford Health Assessment Questionnaire HAQ Disability Index (HAQ-DI).

## Declarations

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***Author contributions***

Conceptualization, I.G. and A.N; Methodology, I.G.; Software, A.N.; Validation, I.G.; Formal Analysis, I.G.; Investigation, A.N.; Resources, I.G.; Data Curation, A.N.; Writing – Original Draft Preparation, A.N.; Writing – Review & Editing, A.N.; Visualization, I.G.; Supervision, I.G.; Project Administration, I.G.; Funding Acquisition, I.G.

***Conflicts of interest***

The authors declare no conflict of interest.

***Data availability***

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

***Ethics approval***

The research was carried out in compliance with the main provisions of the "Rules of Ethical Principles of Conducting Scientific Medical Research with Human Participation", approved by the Declaration of Helsinki (1964-2013), ICH GCP (1996), EU Directive No. 609 (from November 24, 1986) orders of the Ministry of Health of Ukraine No. 690 of 09/23/2009, No. 944 of 12/14/2009, No. 616 of 08/03/2012.

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