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Development of a physical therapy programme for patients after hip arthroplasty due to coxarthrosis

Kateryna Satanovska*
Master's Student
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
03056, 37 Beresteyskyi Ave., Kyiv, Ukraine
https://orcid.org/0009-0006-6266-7697

Yulia Antonova-Rafi
PhD in Technical Sciences, Associate Professor
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
03056, 37 Beresteyskyi Ave., Kyiv, Ukraine
https://orcid.org/0000-0002-9518-4492

Abstract. The relevance of the study was determined by the increasing number of patients with coxarthrosis who require hip arthroplasty, as well as the need to develop effective rehabilitation programmes to improve their quality of life. The aim of the study was to justify and implement an individualised physical therapy programme that provides for the gradual restoration of musculoskeletal function after hip arthroplasty. The article presents the results of the application of a comprehensive physical therapy programme, which included early, intermediate, late and long-term stages, adapted to the functional status of patients. The programme was based on a combination of therapeutic gymnastics, exercises for developing coordination, balance, and endurance, elements of breathing exercises, the gradual expansion of mobility levels, and psychological support. Its distinctive feature was a staged approach with a gradual increase in load, as well as the possibility of integrating inpatient, outpatient, and remote rehabilitation formats. The evaluation of results was carried out using the six-minute walk test, questionnaires to determine pain levels and functional limitations, quality of life surveys according to international scales, measurements of maximal oxygen consumption, determination of the anaerobic threshold, and the Hospital Anxiety and Depression Scale. The results confirmed a significant improvement in physical and psycho-emotional indicators, a reduction in pain, an increase in functional activity, and adherence to therapy. Anaerobic threshold indicators, which reflect the patient's ability to perform prolonged physical activity without increasing fatigue, improved in patients in the experimental group to 11.5 mL/kg/min. This is 1.6 mL/kg/min more than before the start of therapy and almost 1.5 mL/kg/min more than in the control group, where the increase was only 0.4 mL/kg/min. The proposed programme demonstrated clinical efficacy, economic feasibility and the promise of standardisation as a model for physical therapists' practice, in line with current trends in evidence-based rehabilitation

Keywords: rehabilitation; functional recovery; quality of life; individualised therapy; osteoarthritis of the hip joint

Introduction

Coxarthrosis is one of the most common degenerative-dystrophic diseases of the musculoskeletal system, often requiring surgical intervention in the later stages. In studies by American scientists Z.P.J. Rostron *et al.* [1], it is emphasised that the physical therapist plays a central role in the postoperative recovery process, coordinating the interaction between the doctor, patient and family, ensuring the continuity and consistency of the rehabilitation process. Scientific publications by German researchers D.J. Hunter & S. Bierma-Zeinstra [2] emphasise that early initiation of physical therapy after arthroplasty significantly reduces the risk of complications and promotes the restoration of hip joint function. At the same time, Ukrainian authors A. Boyko & K. Kolyushko [3], N. Polyakova

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*Corresponding author

& O. Filonenko [4] drew attention to the lack of a unified rehabilitation protocol after arthroplasty, which leads to uneven treatment results. All this highlights the need to create effective, accessible, and personalised physical therapy programmes that take into account the clinical characteristics of each patient.

Studies conducted between 2019 and 2024 confirmed the effectiveness of a comprehensive approach to the rehabilitation of patients after arthroplasty of the hip, with an emphasis on individualisation, early mobilisation, telerehabilitation and home programmes. J.N. Katz *et al.* [5] emphasised the importance of physical exercise for improving functional outcomes and reducing pain. Z. Zhou *et al.* [6] demonstrated the effectiveness of telerehabilitation as a supplement to conventional therapy, especially in settings with limited access to hospitals.

J. Ripoll S-Melchor *et al.* [7] showed that early mobilisation on the day of surgery helps reduce the length of hospitalisation without increasing the risk of complications. G. Kelmer *et al.* [8] found that home rehabilitation is as effective as inpatient rehabilitation, provided that proper instruction is given. M.C.A. Arnold *et al.* [9] conducted a systematic review of the literature to assess the prevalence of pathogenic injuries caused by the use of power tools in orthopaedic surgery and to discuss current methods for their detection and risk reduction. To reduce the risk of injury, they recommend the use of robotic systems, simulation training, instrument settings, and feedback technologies such as spectroscopy and electromyography. R. Laasik *et al.* [10] emphasised the benefits of individual consultations with a physical therapist to increase adherence to the programme.

K.C. Madara *et al.* [11] developed and tested an innovative rehabilitation programme after total hip arthroplasty, which included a limited number of supervised sessions in the early stages and a gradual increase in exercise intensity in the later stages. This programme was tailored to the individual goals of patients, including sports and recreational activities, with the best results coming from a combination of aerobic and strength exercises. T.W. Wainwright *et al.* [12] emphasised the benefits of preoperative physical training for better postoperative recovery.

These studies highlighted the need to develop modern, evidence-based rehabilitation programmes that take into account the individual needs of patients and the capabilities of the healthcare system. The use of multi-stage programmes focused on functional goals allows for a more holistic approach to treatment, taking into account not only physical but also psychological recovery. This is especially important for elderly patients, who often have comorbidities and reduced motivation. In addition, the experience of EU countries shows the economic feasibility of early and individualised rehabilitation, which reduces the length of hospital stays and the burden on the healthcare system. The aim of the study was to evaluate a developed individualised step-by-step physical therapy program for patients after arthroplasty due to coxarthrosis.

Materials and Methods

The study was conducted in 2023 at the orthopaedic and traumatology department of the Institute of Traumatology and Orthopaedics (Kyiv, Ukraine). A total of 20 patients diagnosed with grade III coxarthrosis who had undergone unilateral hip arthroplasty were examined. Participants (12 women and 8 men) aged 58 to 72 were randomly divided into two equal groups: the experimental group (EG) and the control group (CG). The experimental group underwent an individualised step-by-step physical therapy programme, while the control group underwent a standard rehabilitation programme.

Inclusion criteria were: age 55-75 years, primary unilateral arthroplasty, absence of severe comorbidities (cardiovascular or oncological pathology, neurodegenerative conditions). Exclusion criteria were bilateral prosthetics, cognitive impairment, mental illness, and refusal to participate in the study. Patients were randomised in blocks of 4 to ensure an even distribution by gender and age. This allowed to avoid systemic errors and ensure comparability between groups.

The individualised physical therapy program consisted of four main stages: early postoperative (1-3 days), intermediate (4-14 days), late (3-6 weeks), and long-term (6-12 weeks). Each stage had a clear goal, a set of exercises, and expected results. The physical therapy programme in the experimental group included: early mobilisation in the first three days, breathing exercises and preventive gymnastics, gradual physical activity, balance and coordination exercises, strengthening of the lower limb muscles, training in self-care skills and psycho-emotional support. The sessions were conducted under the supervision of a physical therapist twice a day for the first two weeks, with a subsequent transition to an outpatient regimen three times a week. All patients in the experimental group underwent a programme adapted to their individual characteristics: functional status, comorbidities, psycho-emotional mood and level of motivation. In the early phase, the emphasis was on breathing and isometric exercises, verticalisation and prevention of complications. The intermediate stage involved developing balance, gradually loading the operated limb and training walking with support. The late stage was aimed at restoring daily activity, endurance, and independence. In the long-term stage, patients gradually returned to their usual lifestyle, and therapy was supplemented with remote monitoring and recommendations to maintain results. The programme was adjusted for each patient depending on their functional progress. This approach made it possible to identify difficulties in performing exercises in a timely manner and to quickly change the load, which helped to reduce the risk of complications and increase motivation to participate in the rehabilitation process. The control group performed a standard set of exercises, including basic therapeutic physical training, stretching exercises, breathing exercises, and daily walks using assistive devices (crutches, walkers). These activities were carried out according to the instructions of medical staff but did not involve in-depth adaptation to the individual needs of patients.

Follow-up examinations were conducted three times: on the 14th, 30th, and 90th days after surgery. Not only physical endurance and strength were assessed, but also psychological state, since the patient's emotional well-being significantly affects their motivation and recovery results. To assess the effectiveness of rehabilitation, a 6-minute walk test (6MWT), the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) scale, the SF-36 questionnaire, the calculation of maximum oxygen consumption (VO_2max) and anaerobic threshold (AT) based on walking speed and heart rate (HR), as well as the Hospital Anxiety and Depression Scale (HADS). All data were recorded in standardised forms for further processing using the SPSS v.25 statistical package. Student's t-test was used to test for intergroup differences, with a statistical significance level of $p < 0.05$. The study was conducted in accordance with the ethical principles of the Helsinki Declaration [13] and the recommendations of the European Commission on ethics and data protection [14]. All patients were informed about the risks of participating in the experiment and the publication of its results, as well as the privacy policy, and gave their voluntary written consent to participate in the study and to the processing of their personal data.

Results and Discussion

The six-minute walk test is an effective indicator of functional recovery after hip arthroplasty. Table 1 shows the intra- and intergroup analysis of the average distance of a six-minute walk in patients after hip arthroplasty due to coxarthrosis before physical therapy. In particular, the results of the first postoperative measurement, which was performed on the 14th day after surgery, are presented. This corresponds to the early postoperative stage, when patients still have limited mobility, experience pain, use assistive devices, and are unable to demonstrate high functional performance.

Table 1. Intra- and intergroup analysis of the average distance of a six-minute walk in patients

Group	Pre-operative stage (m)	Post-operative stage (m)	P
Control group	61.5 ± 10.2	58.4 ± 9.1	0.02
Experimental group	60.3 ± 11.4	63.7 ± 10.0	0.35
p	0.12	0.47	

Notes: P – sample power; p – level of statistical significance, $p < 0.05$
Source: developed by the authors

In the control group, patients demonstrated a slight reduction in walking distance after surgery ($P = 0.02$), indicating a decline in functional capacity following standard rehabilitation. In contrast, patients in the experimental group who followed an individualised physical therapy programme maintained or improved their walking distance ($P = 0.35$), which indicates the effectiveness of the programme. Table 2 presents the indicators recorded before the start of active physical therapy, which were collected at the time of discharge from hospital, and at three weeks after surgery, when patients already had a substantially higher functional capacity. The table also shows comparative data for the 6MWT, VO_2max and anaerobic threshold between the two groups after the intervention. At this stage, pain is significantly reduced, patients walk much more actively, have a greater radius of mobility and are able to perform daily activities. Measurements were carried out in two stages: pre-intervention, which involved assessment of patients' condition before the start of physical therapy, that is, during the postoperative examination (baseline values); and post-intervention, which involved repeated assessment after completion of the physical therapy course (mainly after 6-8 weeks of active recovery), allowing changes resulting from the programme to be identified.

Table 2. Comparison of 6MWT, VO_2max and AT parameters between groups after the intervention ($\bar{x} \pm s$)

Group	Time	6MWT (m)	VO_2max (ml/kg/min)	AT (ml/kg/min)
Control group (n = 10)	Before the procedure	370.2 ± 19.7	14.5 ± 1.3	9.6 ± 1.0
	After the procedure	390.7 ± 21.4	15.3 ± 1.1	10.0 ± 1.2
Experimental group (n = 10)	Before the procedure	373.1 ± 18.9	14.8 ± 1.4	9.9 ± 1.1
	After the procedure	435.8 ± 23.5	17.2 ± 1.3	11.5 ± 1.1

Source: developed by the authors based on the results of the study

Patients in the experimental group who underwent a personalised physical therapy programme after hip joint arthroplasty demonstrated a marked improvement in functional capacity. A comparison of both groups in terms of physical parameters clearly illustrates the advantages of individualised physical therapy. In particular, the mean distance covered by patients in the experimental group during the six-minute walk test increased from 373.1 m to 435.8 m, indicating a substantial improvement in endurance. This increase exceeded 60 m and has a clinically meaningful impact on daily functional performance. In contrast, the control group showed an increase of only 20 m, from 370.2 m to 390.7 m, indicating the limited effect of the standard programme. Statistical analysis confirmed that the difference between the groups after the intervention was significant ($p < 0.01$). Assessment of maximal oxygen consumption as a marker of aerobic endurance also confirmed the advantages of the proposed programme. In patients in the

experimental group, this indicator increased from 14.8 mL/kg/min to 17.2 mL/kg/min, that is, by 2.4 mL/kg/min or 16%, which indicates a substantial improvement in the functional capacity of the cardiovascular system. By contrast, in the control group VO_2max increased only to 15.3 mL/kg/min, with a gain of approximately 0.8 mL/kg/min or 5%, representing minimal positive change. Indicators of the anaerobic threshold, reflecting the patient's ability to perform prolonged physical activity without increasing fatigue, improved in patients of the experimental group to 11.5 mL/kg/min. This is 1.6 mL/kg/min higher than before the start of therapy and almost 1.5 mL/kg/min higher than in the control group, where the increase was only 0.4 mL/kg/min. These findings allow the conclusion that an individualised approach is considerably more effective in restoring aerobic-anaerobic capacity in patients.

Table 3 presents the quality of life indicators of patients in the control and experimental groups assessed using the SF-36 questionnaire. As shown by the data, patients in the experimental group demonstrated significantly better outcomes on the scales of physical functioning, role physical functioning and mental health after completion of rehabilitation. This indicates the superior effectiveness of the individualised programme compared with standard rehabilitation.

Table 3. Quality of life indicators in patients of the control and experimental groups after completion of treatment and rehabilitation measures

Quality of life criteria according to SF-36	CG, n = 10	EG, n = 10
Physical functioning	45.3 ± 3.4	52.2 ± 4.3
Role physical functioning	37.4 ± 4.6	42.3 ± 5.8
Pain intensity	42.1 ± 14.8	40.1 ± 12.9
General health	57.2 ± 4.9	61.5 ± 5.1
Vitality	55.5 ± 4.2	57.6 ± 6.8
Social functioning	60.2 ± 5.5	64.6 ± 4.2
Role emotional functioning	59.4 ± 4.7	66.5 ± 5.2
Mental health	49.3 ± 6.7	51.8 ± 5.9

Notes: CG – control group; EG – experimental group
Source: developed by the authors based on the results of the study

Patients in the experimental group showed significant improvements across key domains: physical functioning increased by 6.9 points, social functioning by 4.4 points, and role emotional functioning by 7.1 points. These changes were also accompanied by an overall improvement in general well-being, a reduction in anxiety levels (according to HADS), and a higher level of satisfaction with treatment outcomes, which is indirectly confirmed by a low level of complaints and a high level of motivation to adhere to the programme. The results demonstrated high clinical and functional effectiveness of the individualised programme. Its novelty lies in the combination of a multilevel structure with stepwise load progression and the consideration of psycho-emotional factors. The practical value of the programme consists in shortening the recovery period, reducing medication costs, and lowering the likelihood of repeated hospitalisation.

After completion of the programme, patients in the experimental group demonstrated statistically significant improvements in functional indicators: increased distance in the 6MWT, higher VO_2max, reduced pain, improved quality of life according to the SF-36, and decreased levels of anxiety and depression. Compared with the standard protocol, the proposed programme proved to be more effective due to individualisation: exercises were selected according to patient needs, the pace of rehabilitation was adjusted weekly, and support included both face-to-face and remote forms of interaction. The programme demonstrated clinical relevance, economic efficiency and flexibility, enabling its implementation in both urban and rural settings.

From the perspective of clinical practice, the study results highlighted the importance of a multidisciplinary approach, in which the physical therapist works in close cooperation with the surgeon, psychologist and nurse. Such a model allows substantially better rehabilitation outcomes to be achieved, as the patient receives not only instructions but also comprehensive support. Monitoring patient progress over a 90-day period made it possible to identify not only short-term but also sustained positive changes. Thus, the conducted study demonstrated that an individualised physical therapy programme after hip joint arthroplasty has advantages over conventional methods and represents an effective approach to optimising the recovery process in patients with coxarthrosis. Improvements in functional activity, endurance and quality of life compared with the standard rehabilitation programme confirmed the appropriateness of using a personalised approach at all stages of postoperative recovery.

The obtained data are consistent with the conclusions of Z.P.J. Rostron *et al.* [1], who in their meta-analysis demonstrated the effectiveness of programmes incorporating strength and functional exercises for patients with hip joint pathology. I.V. Malik *et al.* [15] emphasised the need to reconsider traditional rehabilitation strategies after total hip arthroplasty, noting that intensive physical activity is a key factor in successful recovery. In the present study, the implementation of a stepwise programme with gradual load progression made it possible to achieve comparable results.

In a systematic review, M. Di Monaco & C. Castiglioni [16] also highlighted the importance of weight-bearing

exercises in improving function after arthroplasty. The programme under investigation included elements of strength training and stabilisation exercises, which contributed to increased endurance and functional independence in patients. Similar conclusions are presented in the review by C.J. Minns Lowe *et al.* [17], which demonstrated the effectiveness of structured physical therapy in improving outcomes in osteoarthritis.

An important component is the possibility of home-based rehabilitation under specialist supervision, as evidenced by the review by R. Papalia *et al.* [18]. This approach allows costs to be reduced while maintaining therapeutic effectiveness. The presented programme also allows exercises to be performed at home, which is particularly relevant in conditions of limited access to inpatient rehabilitation. In addition to functional effectiveness, the programme is distinguished by its accessibility and flexibility. According to the study by M.C.A. Arnold *et al.* [9], high-quality patient support in home settings can be ensured through the use of technology, which is especially important for remote or resource-limited regions. From an ethical perspective, the programme fully complies with current European standards for personal data protection.

The long-term positive effect of physical therapy after hip joint arthroplasty has also been demonstrated in the study by K.E. Heiberg *et al.* [19], where favourable outcomes were maintained one year after surgery. In the present study, functional indicators remained consistently high even several weeks after completion of the main course of rehabilitation. Early physical engagement of the patient also has a positive effect on reducing the length of hospital stay. As noted by H. Husted *et al.* [20], the implementation of a fast-track approach (accelerated rehabilitation involving early mobilisation, optimisation of pain management and reduced invasiveness of procedures) makes it possible to shorten hospitalisation without compromising clinical outcomes. This principle was partially implemented in the developed rehabilitation model.

Preoperative physical preparation, described in the work of A. Vukomanović *et al.* [21], has a positive impact on the postoperative period. This approach deserves further investigation within the framework of expanding the developed programme. In addition, a study by K. Specht *et al.* [22] showed that patients' positive subjective perception of the rehabilitation process also correlates with clinical outcomes. This highlights the importance of incorporating elements of communication, patient education and support into physical therapy programmes. Moreover, the psycho-emotional state of patients is an integral part of the recovery process [13]. In the present study, a reduction in anxiety and depression levels according to the HADS was recorded in the experimental group. This is consistent with the findings of J. Ripoll S-Melchor *et al.* [7], who confirmed the importance of early mobilisation and emotional support in the postoperative period.

Thus, the obtained results demonstrate not only the clinical but also the social significance of the individualised physical therapy programme. It may serve as a basis for the development of national protocols for the management of patients after hip joint arthroplasty, taking into account both functional and psycho-emotional aspects of recovery. In addition, an important advantage is the possibility of phased implementation of the programme in conditions of limited access to rehabilitation facilities. In cases where patients are unable to attend a physical therapy centre regularly, part of the intervention can be adapted to home-based rehabilitation. This makes it possible to ensure continuity of care and to reduce the risk of functional regression after hospital discharge. The introduction of telemonitoring systems or remote supervision (for example, video instructions or mobile applications) may further enhance recovery effectiveness.

Another important aspect is improving the level of training of physical therapy specialists working with this patient population. Standardisation of educational programmes in higher medical institutions, along with the inclusion of personalised approaches and psycho-emotional support components in the curriculum, will help to prepare professionals capable of implementing comprehensive programmes in practice. Improving professional competence will contribute not only to better rehabilitation outcomes but also to increased patient trust in the therapeutic process.

Conclusions

The programme, based on the principles of individual approach, adaptation and continuity, proved to be not only clinically appropriate but also economically justified, as it reduced the duration of rehabilitation. A particularly important advantage is the ability to combine inpatient and outpatient rehabilitation stages with the use of remote monitoring and motivational support for patients. The programme contributed to improving the functional status of patients, reducing pain levels, increasing endurance and overall quality of life.

A comparative analysis of the results of the experimental and control groups revealed significant advantages of the individualised programme over the standard one. In particular, improvements were recorded in the 6-minute walk test, VO_2max, anaerobic threshold, and quality of life according to the SF-36 scale. The results obtained suggest that the use of a personalised, step-by-step approach to physical therapy allows for better clinical outcomes in the postoperative period. In patients in the experimental group, this indicator increased from 14.8 mL/kg/min to 17.2 mL/kg/min, i.e. by 2.4 mL/kg/min, or 16%, indicating a significant improvement in the functional capabilities of the cardiovascular system. At the same time, in the control group VO_2max increased only to 15.3 mL/kg/min, with a gain of about 0.8 mL/kg/min or 5%, which represents minimal positive dynamics. Indicators of the anaerobic threshold, reflecting the patient's ability to perform prolonged physical activity without increasing fatigue, improved in patients of the experimental group to 11.5 mL/kg/min.

This is 1.6 mL/kg/min higher than before the start of therapy and almost 1.5 mL/kg/min higher than in the control group, where the increase was only 0.4 mL/kg/min.

This approach is appropriate from both a medical and socio-economic point of view, as it helps to reduce the duration of rehabilitation and the risk of rehospitalisation. The technique is adaptable to the individual characteristics of the patient, convenient for implementation in various medical institutions, and can be integrated into the practice of physical therapists. Thus, the results of the study confirmed the effectiveness of an individualised physical therapy programme after arthroplasty as an alternative to typical rehabilitation approaches. It can become the basis for the formation of national protocols for physical therapy in the postoperative period.

A promising area for future research is the analysis of the programme's impact on patients' cognitive functions, as active rehabilitation in old age has the potential to positively influence not only physical but also neuropsychological indicators. It is also important to investigate how cultural, social and educational factors influence patients' adherence to recommendations and the overall effectiveness of the programme. The introduction of implementation science assessment tools will improve the adaptation of the programme to specific clinical conditions.

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Conflict of Interest
None.

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Побудова програми фізичної терапії для пацієнтів після ендопротезування кульшового суглобу внаслідок коксартрозу

Катерина Сатановська
Магістрант
Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського»
03056, просп. Берестейський, 37, м. Київ, Україна
https://orcid.org/0009-0006-6266-7697
Юлія Антонова-Рафі
Кандидат технічних наук, доцент
Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського»
03056, просп. Берестейський, 37, м. Київ, Україна
https://orcid.org/0000-0002-9518-4492

Анотація. Актуальність дослідження зумовлена зростанням кількості пацієнтів із коксартрозом, які потребують ендопротезування кульшового суглоба, а також необхідністю створення ефективних програм відновлення для підвищення їхньої якості життя. Метою дослідження стало обґрунтування та впровадження індивідуалізованої програми фізичної терапії, яка забезпечує поетапне відновлення функцій опорно-рухового апарату після ендопротезування кульшового суглоба. У статті представлено результати застосування комплексної програми фізичної терапії, що включала ранній, проміжний, пізній та довготривалий етапи, адаптовані відповідно до функціонального стану пацієнтів. Програма базувалася на поєднанні лікувальної гімнастики, вправ для розвитку координації, рівноваги та витривалості, елементів дихальної гімнастики, поступового розширення рухового режиму та психологічної підтримки. Її особливістю була поетапність із поступовим підвищенням навантаження, а також можливість інтеграції стаціонарного, амбулаторного та дистанційного форматів реабілітації. Оцінювання результатів здійснювалося за допомогою шестихвилинного тесту ходьби, опитувальників для визначення рівня болю та функціональних обмежень, анкетування якості життя за міжнародною шкалою, вимірювання максимального споживання кисню, визначення анаеробного порогу, а також госпітальної шкали тривожності й депресії. Результати підтвердили достовірне покращення фізичних і психоемоційних показників, зменшення болю, зростання функціональної активності та прихильності до терапії. Показники анаеробного порогу, що відображають здатність пацієнта виконувати тривале фізичне навантаження без наростання втоми, покращилися у пацієнтів основної групи до 11,5 мл/кг/хв. Це на 1,6 мл/кг/хв. більше, ніж до початку терапії, і майже на 1,5 мл/кг/хв. більше, ніж у контрольній групі, де приріст становив лише 0,4 мл/кг/хв. Запропонована програма продемонструвала клінічну ефективність, економічну доцільність і перспективність стандартизації як моделі для практики фізичних терапевтів, що відповідає сучасним тенденціям доказової реабілітації

Ключові слова: реабілітація; функціональне відновлення; якість життя; індивідуалізована терапія; остеоартроз кульшового суглобу