
PHYSICAL THERAPY OF PATIENTS WITH POST-TRAUMATIC GONARTHROSIS WITH IMBALANCE OF OSTEO-ASSOCIATED MACRONUTRIENTS**ФІЗИЧНА ТЕРАПІЯ ХВОРИХ З ПОСТТРАВМАТИЧНИМ ГОНАРТРОЗОМ У РАЗІ ДИСБАЛАНСУ ОСТЕОАСОЦІЙОВАНИХ МАКРОЕЛЕМЕНТІВ**

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Summaries

According to modern concepts, bone remodeling disorders that are directly dependent on the imbalance of osteo-associated trace elements play a key role in the pathogenesis of OA. Therefore, the purpose of our study is to develop the program of physical rehabilitation of patients with post-traumatic gonarthrosis and to investigate its effect on the composition of osteoassociated macronutrients.

To determine the metabolic function of bone tissue there were the results of the study of mineral homeostasis by the level in the peripheral blood of phosphorus and magnesium, total calcium and its ionized form, as well as the amount of urinary calcium excretion. The processes of bone formation were evaluated by the content of bone isoenzyme of alkaline phosphatase, bone resorption was evaluated by the level of tartrate-resistant acid phosphatase. 42 patients with post-traumatic osteoarthritis of the knee joints of I–II stages according to Kellgren-Lowrence were observed.

The complex of physical therapy included the educational program, medical gymnastics and massage. The theoretical part of the program included 6 topics covering the main issues related to the risk factors and prognosis for the disease, the main mechanisms of its progression, as well as the basics of different physical therapy use. The practical part of the program was carried out in a small-group way and included the gradual application of static, dynamic, active and proprioceptive neuromuscular stretching using the exercises with elastic bands and metered loading. As for the massage technology a combination of segmental massage with Swedish technique was used in the program. The total duration of the complex program was 9 months, after which patients were advised to perform independent classes. The application of the developed program of physical rehabilitation had a positive effect on the processes of bone remodeling, and allowed to reduce the number of exacerbations during the year.

Key words: physical therapy, osteoarthritis, knee joint, bone formation.

Натепер розробки технологій фізичної терапії для профілактики інвалідності внаслідок захворювань і травм опорно-рухового апарату не досить ефективні, що негативно відбивається на якості життя контингенту пацієнтів, їхньому соціальному статусі і економічному стані країни загалом. За сучасними уявленнями, ключову роль у патогенезі остеоартриту відіграють розлади кісткового ремоделювання, що прямо залежать від дисбалансу остеоасоційованих мікроелементів. Тому мета нашого дослідження – розробити програму фізичної реабілітації хворих з посттравматичним гонартрозом і дослідити її вплив на склад остеоасоційованих макроелементів.

Для визначення метаболічної функції кісткової тканини були результати дослідження мінерального гомеостазу за рівнем у периферичній крові фосфору і магнію, загального кальцію та іонізованої його форми, а також величиною екскреції із сечею кальцію. Процеси кісткового формування оцінювалися за вмістом кісткового ізоферменту лужної фосфатази, кісткова резорбція – за рівнем тартрат-резистентної кислоти фосфатази. Під спостереженням перебували 42 хворих з посттравматичним остеоартритом колінних суглобів I–II стадій за Kellgren-Lowrence.

Комплекс фізичної терапії включав освітню програму, лікувальну гімнастику і масаж. Теоретична частина програми включала 6 тем, що охоплюють основні питання, що стосуються чинників ризику і прогнозу такого захворювання, основних механізмів його прогресування, а також основ застосування різних засобів фізичної терапії. Практична частина програми здійснювалася малогруповим способом і включала поетапне застосування статичного, динамічного, активного і пропріоцептивного нервово-м'язового стретчингу з використанням вправ з пружними стрічками і дозованим обтяженням. З масажних технологій у програмі використовувалося поєднання сегментарного масажу зі шведською технікою. Загальна тривалість комплексної програми становила 9 місяців, після чого хворим надавалися рекомендації щодо виконання самостійних занять. Застосування розробленої програми фізичної реабілітації позитивно вплинуло на процеси ремоделювання кісткової тканини, дозволило зменшити кількість загострень протягом року.

Ключові слова: фізична терапія, остеоартрит, колінний суглоб, кісткове формування.

На сьогоднішній день разработки технологий физической терапии для профилактики инвалидности вследствие заболеваний и травм опорно-двигательного аппарата недостаточно эффективны, что негативно отражается на качестве жизни контингента пациентов, их социальном статусе и экономическом положении страны в целом. По современным представлениям, ключевую роль в патогенезе ОА играют расстройства костного ремоделирования, прямо зависящие от дисбаланса остеоассоциированных микроэлементов. Поэтому цель нашего исследования – разработать программу физической реабилитации больных с посттравматическим гонартрозом и исследовать ее влияние на состав остеоассоциированных макроэлементов.

Для определения метаболической функции костной ткани применялись результаты исследования минерального гомеостаза по уровню в периферической крови фосфора и магния, общего кальция и ионизированной его формы, а также величине экскреции с мочой кальция. Процессы костного формирования оценивались по содержанию костного изофермента щелочной фосфатазы, костная резорбция – по уровню тартрат-резистентной кислой фосфатазы. Под наблюдением находились 42 больных с посттравматическим остеоартритом коленных суставов I–II стадии по Kellgren-Lowrence.

Комплекс физической терапии включал в себя образовательную программу, лечебную гимнастику и массаж. Теоретическая часть программы включала 6 тем, охватывающих основные вопросы, касающиеся факторов риска и прогноза данного заболевания, основных механизмов его прогрессирования, а также основ применения различных средств физической терапии. Практическая часть программы осуществлялась малогрупповым способом и включала поэтапное применение статического, динамического, активного и проприоцептивного нервно-мышечного стретчинга с использованием упражнений с упругими лентами и дозированным отягощением. Из массажных технологий в программе использовалось сочетание сегментарного массажа со шведской техникой. Длительность комплексной программы составила 9 месяцев, после чего больным предоставлялись рекомендации по выполнению самостоятельных занятий. Применение разработанной программы физической реабилитации оказало положительное влияние на процессы ремоделирования костной ткани, позволило уменьшить количество обострений в течение года.

Ключевые слова: физическая терапия, остеоартрит, коленный сустав, костное формирование.

Introduction. At the present stage of development of rehabilitation technologies for the prevention of disability due to diseases and injuries of the musculoskeletal system physical therapy methods have not been effective enough, which negatively affects the quality of life of this patient population, their social status and economic status of the country as a whole [4; 5; 6; 8].

In recent years, there has been a tendency to increase the incidence of knee osteoarthritis (OA) among young able-bodied people [14]. This is greatly facilitated by joint injuries, recurrent

injuries, inflammatory processes that lead to progressive degeneration of cartilage, deterioration of the musculoskeletal system, and decreased physical activity [1; 11; 13; 14]. Post-traumatic gonarthrosis, which is the most severe of the long-term complications of knee injury, often leads to disability and reduced quality of life [11].

According to the World Health Organization, OA has been the cause of disability in 10 % of the population and in the next 10–15 years it will become the fourth major cause of disability for women and the eighth one for men [7].

According to modern concepts, bone remodeling disorders, which are directly dependent on the imbalance of osteo-associated macronutrients, play a key role in the pathogenesis of OA [2; 3; 8; 10; 12].

However, in recent years, this issue has not been addressed in the development of physical rehabilitation technologies.

The purpose of the study is to develop a program of physical rehabilitation of patients with post-traumatic gonarthrosis and to investigate its effect on the composition of osteoassociated macronutrients.

Research materials and methods. The processes of bone formation were analyzed for the content of alkaline phosphatase (KShF) bone isoenzyme, bone resorption was evaluated by the level of tartrate-resistant acid phosphatase (TrKF). Mineral homeostasis was evaluated by the level of total calcium in the peripheral blood and its ionized form (Ca^{++}), phosphorus, magnesium, as well as by the amount of urinary excretion of calcium. The results of biochemical studies were compared with those of 20 people (40.6 ± 1.7 years old) who had no pathology of the musculoskeletal system and were considered healthy according to the indicators of clinical and laboratory studies.

The level of total calcium in the blood of the control group was (2.42 ± 0.03) mmol/l, its ionized form – (1.08 ± 0.02) mmol/l, phosphorus – (0.96 ± 0.05) mmol/l, magnesium – (0.91 ± 0.03) mmol/l. Urinary calcium excretion was (2.92 ± 0.37) mmol/l. The concentration of CSF is (68.3 ± 4.8) mmol/l, TrKF is (53.2 ± 2.4) mmol/l.

Statistical processing of the results of the study was carried out by the methods of variational statistics using the standard package of applications SPSS 13.0 for Windows. A comparative analysis of the differences between the mean values was evaluated by Student's-test. Spearman correlation analysis was performed.

Deontological and legal problems of research have been solved within the framework of existing International Conventions and legislation of Ukraine and the principles of bioethics in medical research [15].

We observed 42 patients with post-traumatic osteoarthritis of the knee joints of I–II stages according to Kellgren-Lowrence. The diagnosis was made taking into account the anamnesis, clinical symptoms, radiological examination and magnetic resonance imaging of the joints. The patients' age ranged from 24 to 54 (40.2 ± 1.4) years old, with male predominance (64.3 %). The duration of the disease in patients ranged from 1 to 14 (7.1 ± 0.6) years. The number of exacerbations of the disease reached (2.95 ± 0.19) per 1 year.

Results of the study and their discussion.

The study of bone formation parameters showed a 71.4 % decrease in CSF level 1.3 times to (57.0 ± 0.29) mmol/l ($p < 0.05$), with an increase in TrKF in 47.6 % of patients with 10.7 % ($p < 0.01$) to (59.6 ± 0.45) mmol/L.

In the analysis of the content of macronutrients in peripheral blood, 45.2 % of patients showed a decrease in the level of total calcium fraction by 9.9 % (2.18 ± 0.03) mmol/l ($p < 0.001$), in 81.0 % of patients – its ionized form by 11.1 % (0.96 ± 0.01) mmol/l ($p < 0.001$). Moreover, the concentration of Ca^{++} decreased with the increasing of patients' body weight ($r = -0.623$; $p = 0.001$). The excretion of calcium thus increased 1.6 times, to (4.64 ± 0.07) mmol/l ($p < 0.001$) in 73.8 % of patients. The concentration of phosphorus in the blood of 83.3 % of patients increased 1.4 times to (1.37 ± 0.02) mmol/l ($p < 0.001$) and directly correlated with the body weight of patients ($r = 0.726$; $p = 0.001$).

Changes in magnesium content were observed in 71.4 % of patients. In this case, 43.3 % of them had hypermagnesemia (1.34 ± 0.03) mmol/l ($p < 0.001$) with an increase of magnesium concentration 1.5 times, 56.7 % had the decreased concentration by 14.3 % to (0.78 ± 0.01) mmol/l ($p < 0.001$). Moreover, as the body weight of the patients increased, the content of this macronutrient decreased ($r = -0.420$; $p = 0.005$). The role of the imbalance of osteo-associated macronutrients in changes in bone remodeling processes is confirmed by the direct correlation between the KSHF level and the total calcium fraction ($r = 0.542$; $p = 0.001$), Ca^{++} ($r = 0.895$; $p = 0.001$). A negative correlation was found

between CSF and urinary calcium excretion ($r=-0.953$; $p=0.001$), as well as blood phosphorus ($r=-0.909$; $p=0.001$).

The complex of physical therapy included an educational program, medical gymnastics and massage.

The theoretical part of the program lasted 8 weeks in a group way, three times a month, included 6 topics covering the main issues related to the risk factors and prognosis of the disease, the main mechanisms of its progression, as well as the basics of the use of various physical therapy methods. Part of the time during the implementation of the theoretical program was devoted to the development of the patient elements of exercises that are planned for use in the practical part of the program.

The practical part of the program was carried out in a small group way and included the gradual application of static (2 weeks), dynamic (6 weeks), active (8 weeks) and proprioceptive neuromuscular (12 weeks) stretching with the use of exercises with elastic bands and metered loading. In addition to stretching, the complex of medical gymnastics included equilibrium and walking exercises on knees, sides, back, etc.

For massage technology, the program used a combination of segmental massage with Swedish technique, which involves the combination of classic massage techniques with joint movement. The massage was performed every other day for two months in two stages, with a break for 2 weeks between them. Segmental massage was performed with influence on the reflexogenic zone of the lower extremities at the level of the spinal segments Th-9-S-5, as well as on the sites of localization of reflex changes in the area of the affected limb. When using the massage by the Swedish method, the massage area covered the upper third of the lower leg and thigh. Special impact on the joints was performed from the third procedure, starting from the places where the pain was less expressed.

The total duration of the complex program was 9 months, after which patients were advised to perform independent classes.

To study the effectiveness of the program, all the patients were divided into 2 groups: I – 22 patients who completed the entire course of the developed program, II – 20 patients, who used the complexes of therapeutic gymnastics and segmental massage twice a year for 10 days.

Repeated control study was conducted after 12 months.

As a result of the program, the level of total calcium fraction (2.42 ± 0.005) mmol/l was normalized in all patients of group I, the content of its ionized form (1.08 ± 0.004) mmol/l was restored in 95.5 % of patients. The number of patients with normal calcium excretion (2.94 ± 0.05) mmol/l increased by 4 times ($\chi^2=18.2$; $p=2.04E-05$).

The number of patients with high phosphorus content decreased by 4.7 times ($\chi^2=17.9$; $p=2.38E-05$).

Changes in magnesium content were observed less than by 3.2 times ($\chi^2=9.1$; $p=0.003$). In this case, hypermagnesemia occurred in 9.1 % of patients, the lack of this macroelements – in 13.6 %.

The application of the developed program had a positive effect on the processes of bone remodeling. Thus, the number of patients with normal bone formation increased by 2.3 times ($\chi^2=4.5$; $p=0.03$), normal resorption – by 1.7 times ($\chi^2=9.1$; $p=0.003$). Enhanced resorption decreased by 3.7 times ($\chi^2=5.1$; $p=0.02$).

It should be noted that no negative dynamics in changes of indicators were found in either case. During the year, the number of exacerbations decreased to (0.73 ± 0.17), with 45.4 % of patients without any exacerbation during this period.

In group II, the content of total calcium fraction was normalized only in 5.0 % of patients, its ionized form – in 30.0 % of patients. An increase in the number of patients with normal calcium excretion was observed ($\chi^2=0.94$; $p=0.33$). The number of patients with high phosphorus content decreased by 2.8 times ($\chi^2=3.84$; $p=0.05$).

The tendency to the changes' decrease in the magnesium content was detected ($\chi^2=0.99$; $p=0.32$). In this case, hypermagnesemia was observed in 25.0 % of patients, lack of this macronutrient – in 30.0 %.

In contrast to the patients of group I, 15.0 % of patients of group II experienced unsatisfactory results of the rehabilitation measures, which was confirmed by the progressive decrease in the level of magnesium and ionized calcium fraction, increase in the concentration of phosphorus.

No significant positive changes in bone remodeling indicators were observed in patients of group II. In contrast to patients in group I, 25.0 % of patients in group II experienced a progressive decrease in bone formation, and 20.0 % of patients experienced the increase of bone resorption.

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Conclusions. 1. Rehabilitation measures for patients with post-traumatic gonarthrosis should be constructed taking into account the state of metabolic function of bone tissue, in particular, osteo-associated macronutrients.

2. The application of the developed program of physical rehabilitation had a positive effect on the processes of bone remodeling, which allowed to reduce the number of exacerbations during the year.

Conflict of interests. The authors declare that there is no conflict of interests.

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