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Complex rehabilitation treatment after knee arthroplasty

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Knee arthroplasty can significantly improve the quality of life of patients with knee osteoarthritis. About 20 % of patients after knee arthroplasty unsatisfied with surgical treatment results. One of the factors that reduces the unsatisfactory results is the use of new rehabilitation technologies. Objective. Investigate the feasibility and effectiveness of the proposed rehabilitation system within 2–3 months after knee arthroplasty. Methods. A prospective study of two groups of patients with osteoarthritis after knee arthroplasty was conducted. The group БР consisted of 28 patients who did not undergo special rehabilitation treatment. The group P consisted of 30 patients who underwent special rehabilitation treatment in the hospital within 2–3 months after surgery. The groups were comparable in terms of age and body mass index. Flexion and extension angles of the operated knee were measured in patients of both groups within 2–3 and 5–6 months after surgery. The course of special rehabilitation treatment included: massage of the muscles of the lower back, buttocks, thighs, leg and foot on the operated side; performing special physical exercises twice a day for two weeks. Methods of non-parametric statistics were used to process the results. The statistical significance of the differences for unrelated samples was checked using the Mann-Whitney U-test (CMU), for the connected ones, the Wilcoxon test (CV). Results. After a course of rehabilitation, in group P the flexion angle rate increased 1.3 times and amounted to 90° (90°; 100°) (KB, p < 0.01). In group БР during the same period the flexion angle rate underwent a partial regression, amounting 100° (100°; 110°). The rate of extension angle in both groups P did not change. But in group P, in all patients who had a deficiency of extension angle of the operated knee, it disappeared. In group БР, in all patients who had deficiency of extension angle of the operated knee, it decreased slightly, but did not disappear. Conclusions. The use of proposed rehabilitation treatment within 2–3 months after knee arthroplasty restores the volume of movements in the operated knee, reduces the risk of contracture of the operated joint (especially extension contracture) and restores the normal stereotype of walking.

Ендопротезування колінного суглоба дозволяє значно поліпшити якість життя пацієнтів з остеоартритом. Проте близько 20 % із них не задоволені результатами хірургічного лікування. Одним із підходів для зниження відсотка незадовільних результатів є застосування нових технологій реабілітації. Мета. Дослідити доцільність та ефективність використання запропонованої системи реабілітації в терміни 2–3 міс. після ендопротезування колінного суглоба. Методи. Проведено проспективне дослідження пацієнтів після ендопротезування колінного суглоба з приводу остеоартриту. До групи БР увійшли 28 пацієнтів без курсу реабілітації в умовах стаціонару; Р — 30 осіб, які пройшли його через 2–3 міс. після операції. Групи були порівнянні за віком та індексом маси тіла. Оцінювали показники кута згинання та розгинання в оперованому колінному суглобі через 2–3 і 5–6 міс. після операції. Курс реабілітаційного лікування включав: масаж м'язів попереку, сідниць, стегна, гомілки та стопи на оперованій стороні; спеціальні фізичні вправи двічі на день протягом двох тижнів. Для опрацювання результатів використано методи непараметричної статистики. Для визначення статистичної значущості відмінностей незв'язаних вибірок застосовано критерій Манна-Уїтні (КМУ), пов'язаних — Вілкоксона (КВ). Результати. Після курсу реабілітаційних заходів в умовах стаціонару в групі Р показник кута згинання збільшився в 1,3 разу і склав 90° (90°; 100°) (КВ, p < 0,01). У групі БР за цей самий проміжок часу зазначений показник зазнав часткову регресію, склавши 100° (100°; 110°). Показник кута розгинання в групах істотно не змінився. Усі пацієнти групи Р із дефіцитом розгинання колінного суглоба його позбулися, а в групі БР він лише незначно зменшився, але все одно зберігся. Висновки. Використання запропонованої системи реабілітаційного лікування в терміни 2–3 міс. після операції ендопротезування колінного суглоба дає змогу ефективно відновити обсяг рухів у прооперованому суглобі, знизити ризик виникнення контрактури (особливо на розгинання) та відновити нормальний стереотип ходьби. Ключові слова. Реабілітація, ендопротезування колінного суглоба, відновлення функції суглоба, масаж, гімнастика.

Key words. Rehabilitation, knee arthroplasty, restore joint function, massage, physical exercises

Introduction

Osteoarthritis of the knee joint is a quite frequent disorder, which significantly impairs the quality of life and ultimately requires surgical treatment. Knee arthroplasty is one of the most common operations that can significantly improve the quality of life of such patients. In Great Britain alone, more than a million such interventions are performed per year [1] and their number will continue to grow [2].

Knee arthroplasty can reduce pain and restore function even in patients at late stages of osteoarthritis. However, about 20 % of people remain dissatisfied with the results of surgical treatment [3]. Often, such patients are found to have a deficiency of *m. quadriceps femoris* strength after surgery, contractures of the knee joint, reduction of walking distance and speed of movement on stairs compared to healthy people, impairment of walking stereotype [4, 5]. Presumably, this is due to the insufficient restoration of the functional capabilities of the locomotor system under the conditions of using the existing rehabilitation systems. Some researchers believe that rehabilitation after endoprosthetic repair does not have any advantages in the long term [4, 6]. They are sure that more intensive rehabilitation using exercises with increasing resistance and aimed to increase muscle strength can significantly improve the functional condition of the patient without harming the operated joint [7–9].

T. Myers has recently suggested the hypothesis of «muscle chains»about the functional and structural relationship of various muscles and ligaments that have common attachment sites [10]. Based on it, we assumed that the use of physical exercises and massage to affect not only the muscles and ligaments that directly perform movements in the knee joint, but also the «muscle chains» will be effective in such patients, especially for restoring range of motion on extension when even a few degrees matter. The return of the knee joint extension function is very important for restoring the vertical position of the body and the stereotype of walking [4, 5].

Purpose: to investigate the expediency and effectiveness of using the proposed rehabilitation system within 2–3 months after knee arthroplasty.

Material and methods

The materials of the study were discussed and approved at the meeting of the Bioethics Committee at the State Institution «Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Sciences of Ukraine» (Protocol No. 164 of 18.04.2017).

A prospective study involved two groups of patients who underwent knee arthroplasty for osteoarthritis at the Orthopedic Arthrology and Endoprosthetics Clinic of the State Institution «Professor M. I. Sytenko Institute of Spine and Joint Pathology of the National Academy of Sciences of Ukraine». Group I (WR) included 28 patients without rehabilitation treatment in the inpatient conditions of the institute; 30 patients who underwent a rehabilitation course were assigned to Group II (R) 2–3 months after surgery. The groups were comparable in terms of age and body mass index (BMI): in the WR group the patients' age was 60 (52; 64) years, BMI 34.9 (31.6; 37.9) kg/m2; R — 60.9 (54; 67) years and 34.4 (32.4; 38.7) kg/m2, respectively.

After surgical treatment, patients of both groups were taught a set of therapeutic exercises to perform at home every day independently. At the control examination 2–3 months after surgery, patients who were identified as having a risk of developing knee joint contracture were offered a course of rehabilitation treatment in hospital conditions.

Rehabilitation treatment included:

– massage of the muscles of the lower back, buttocks, thigh, lower leg and foot on the operated side. Attention was paid to techniques aimed at stretching the attachment points of the following muscles and ligaments: *m. tibialis anterior, m. fibularis longus, longus plantar ligament, m. quadriceps femoris, m. biceps femoris, mm. adductor brevis, longus, magnus, m. fascia latae* [10];

– physical exercises twice a day for two weeks (Tables 1–4), aimed at restoring the volume of movements, increasing muscle strength and endurance: *m. quadriceps femoris, m. biceps femoris, m. soleus, m. gastrocnemius, mm. adductor brevis, longus, magnus, m. erector spinae, mm. gluteus medius, maximus, m. iliopsoas, m. quadratus lumborum, m. transversus abdominis*.

Not only the muscles involved in bending and extending the knee joint were trained, but also those that ensure stable vertical standing (two-legged and one-legged) and correct walking pattern in all phases of the step [11]. Our complex includes exercises that restore neuromuscular control and coordinated muscle contraction, necessary for vertical one- and two-legged standing and uniform loading of hip and knee joints [12, 13].

Exercises with a balancing hemisphere, a fitness rubber bands and a stand are aimed at training the coordinated contraction of the muscles that stabilize the vertical position of the body and restoring the correct walking pattern [13] (Table 2).

Table 1

Rehabilitation complex exercises with a fitness ball to restore neuromuscular control and coordinated muscle contraction

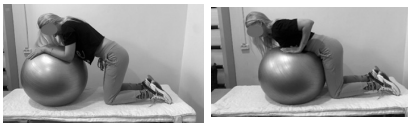
Image	Description
	1. Starting position (SP) lying on the back, feet on the ball and arms along the body. Raise the pelvis up, trying to straighten the body. Perform 5–10 times. The exercise is aimed at increasing the angle of extension in the knee joint, training *m. quadriceps femoris, m. biceps femoris, m. soleus, m. gastrocnemius, mm. gluteus medius, maximus, m. erector spinae*
	2. SP lying on the back, feet on the ball, arms along the body. Raise the pelvis up, and keep it in this position throughout the exercise. Raise the right leg to 50°. Return to SP. Do the same with the left leg. Perform 5–10 times. The exercise is aimed at training *m. quadriceps femoris, m. biceps femoris, m. soleus, m. gastrocnemius, mm. gluteus medius, maximus, m. erector spinae, mm. adductor brevis, longus, magnus*
	3. SP lying on the back, feet on the ball, arms along the body. Roll the ball to the buttocks, bending the legs at the knee joints. Perform 5–10 times. The exercise is aimed at training *m. quadriceps femoris, m. biceps femoris, m. soleus, m. gastrocnemius, mm. gluteus medius, maximus, m. transversus abdominis*
	4. SP standing on the knees, resting forearms on the ball. Roll the ball up to the knee joints. Perform 5–10 times. Aimed at training *m. erector spinae, mm. gluteus medius, maximus, m. quadratus lumborum,* and an increase in the bending angle in the knee joint
	5. SP lying with the back on the ball, legs bent at the knee joints. Roll the ball back and forth, left and right. Perform 5–10 times. Aimed at training *m. quadratus lumborum, m. erector spinae, mm. gluteus medius, maximus, m. quadriceps femoris, m. biceps femoris*
	6. SP lying on the stomach on the ball. Alternately lift the right and left legs. Perform 8–10 times. Aimed at increasing the angle of extension in the knee joint and axial stability of the body
	7. SP lying on the stomach on the ball. Raise the right and left hands alternately 8–10 times. The exercise is aimed at increasing the angle of extension in the knee joint and the axial stability of the trunk
	8. SP lying on the stomach on the ball, raise the right leg and arm at the same time. Return to SP. Do the same with the left leg and hand. Perform 8–10 times. The exercise is aimed at strengthening *m. quadriceps femoris, m. biceps femoris, m. soleus, m. gastrocnemius, m. erector spinae, mm. gluteus medius, maximus*

Table 3 shows rehabilitation exercises performed in bed aimed at training *m. quadratus lumborum, m. quadriceps femoris, m. biceps femoris*, etc.

Table 4 presents rehabilitation exercises performed while standing and aimed at restoring the stereotype of walking.

The indicators of the angle of flexion and extension in the operated knee joint were evaluated 2–3 and 5–6 months after surgery.

Non-parametric statistics methods of the STATISTICA general-purpose software package (License Number: 139-956-866) were used to process the findings. To determine the statistical significance of the differences between unrelated samples, the Mann-Whitney test (MWT) was used, and the Wilcoxon test (WT) was used for related samples.

Numerical indicators are presented in the form of Me (LQ; UQ), where Me is the median, LQ is the lower quartile, UQ is the upper one.

Results and their discussion

At the time of the beginning of the rehabilitation treatment, the index of bending angle of the operated knee in Group R was 70° (70°; 80°), WR — 110° (90°; 110°).

Table 2

Rehabilitation complex exercises with a balancing hemisphere, a fitness rubber band and a stand

Image	Description
	1. SP standing on the hemisphere, maintain balance for 5 minutes
	2. SP standing on the hemisphere, squat to an angle of 145°–150°. Return to SP. Repeat 5–10 times
	3. SP standing with one foot on the hemisphere, the other on the stand, maintain balance. Gradually transfer the weight of the body from one leg to the other. Perform 8–10 times, then repeat on the other side
	4. SP standing on the stand, take a step to the side, leaning on the right leg to the right of the stand. Return to SP. Do the same in the other direction. Perform the exercise 8–10 times
	5. SP with legs fixed using a fitness rubber band. Walk in front of the mirror, imitating a wide gait, with half-bent knees. Perform 5–10 min

Thus, the initial status of Group WR in terms of the flexion angle of the operated knee was significantly higher than that of the Group R. The differences were statistically significant (MWT, $p < 0.01$).

Regarding the initial values of the extension angle indicator, no statistically significant differences between the groups were found: Group R — 0° (0°; 0°), Group WR — 0° (0°; 5°), but in both groups there were patients with an extension deficiency of the operated knee.

After a course of rehabilitation measures in hospital conditions, in Group R, the index of the bending angle increased 1.3-fold (WT, $p < 0.01$) (Figure), and in Group WR, the index underwent a partial regression, reaching 100° (100°; 110°) (statistically insignificant changes).

The indicator of the extension angle in Group R was 0° (0°; 0°), and 3° (0°; 3°) in Group WR. That is, we can note that there were almost no statistical changes.

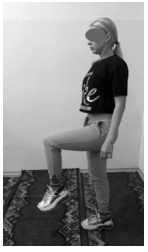
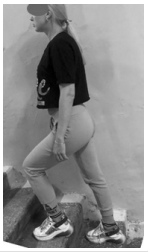
Table 3

Rehabilitation complex exercises on the bed

Image	Description
	1. SP lying on the right side, put the right hand under the head, bend the right leg at the knee. Take the left leg up by 30°. Return to SP Perform 8–10 times, then repeat on the other side. The exercise is aimed at training *m. quadratus lumborum, m. quadriceps femoris, m. biceps femoris, mm. adductor brevis, longus, magnus, m. iliopsoas*
	2. SP lying on the side, legs bent at the knee joints. Move the left leg to the side 50 times. Repeat the same on the other side.

Table 4

Rehabilitation exercises in a standing position

Image	Description	Image	Description
	1. SP standing, take a step back with the left leg and bend it at the knee joint. Return to SP. Repeat with the other leg. Perform 10 times		6. Standing in front of the mirror, bend the right leg in the knee joint to an angle of 90°. Maintain balance for 30 seconds. Repeat with the left leg
	2. SP standing in front of the mirror. Move the leg to the side by 30°. Return to SP, repeat with the other leg. Perform 10 times		7. Standing in front of the mirror, move the left leg to the side to an angle of 30°, maintaining balance, then forward and backward. Perform 6 times. Repeat with the right leg
	3. SP standing with the right side next to the wall. Raise the knee of the right leg at an angle of 30° and press the thigh against the wall for 10 seconds. Return to SP, repeat with the other leg. Perform 10 times		8. Walk along the line for 5–8 minutes
	4. SP standing in front of the mirror. Transfer the weight of the body to one leg, bend the other as much as possible in the knee joint. Return to SP, repeat with the other leg. Perform 10 times		9. Walk with the maximum lifting of the legs, bending at the knee joints 5–8 min
	5. SP standing in front of the mirror. Squat to a 90° angle in the knee joints. Return to SP. Repeat 10 times		10. Walk up the stairs 3–10 min

But it should be mentioned that knee extension deficiency observed in Group R patients before rehabilitation, was eliminated; and in Group WR it only slightly decreased.

Discussion

A significant loss of functional capabilities, strength, and muscle endurance occurs in the first month after knee arthroplasty, and early rehabilitation measures can prevent this [4, 5].

The high-intensity rehabilitation program is based on a number of studies [7, 8] and consists of blocks of exercises: 1) warm-up; 2) aimed at the plantar flexors, popliteal and abductor muscles of the thigh, flexors and extensors of the knee joint; 3) aimed at training stability and balance during two-legged standing. All exercises should be performed in 2 sets of 8 repetitions each. All patients should adhere to a walking program (as part of home exercise) and increase its duration to 30 minutes per day, 5 days per week. After that, the patient is allowed cardiovascular exercises, such as swimming, cycling, walking on an elliptical trainer.

Low-intensity refers to rehabilitation built on the basis of the time elapsed after endoprosthesis surgery [14–16]. The key difference of this program is its initial focus on performing isometric exercises to increase the range of motion in the first 4 weeks after surgery with a gradual transition to more intensive bodyweight training. It does not include exercises with resistance and rubber bands; there should be limited activity in everyday life during the first 4 weeks (walking outside, work-out on an exercise bike).

After analyzing the results of endoprosthesis and restorative therapy of 102 patients, the authors concluded that both rehabilitation protocols (high- and low-intensity) were effective in restoring knee joint function [17].

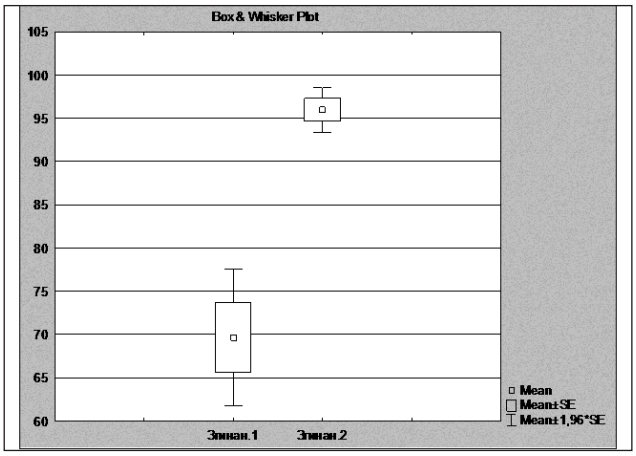


Figure. The time course of the bending angle index in Group R: Bending. 1 — before rehabilitation measures, bending. 2 — after rehabilitation measures

Immediately after surgery, our patients performed most of the exercises that belong to the high-intensity rehabilitation protocol. After surgical treatment, the patients of both groups were taught a complex of therapeutic exercises, which they had to perform at home every day independently. At the control examination 2–3 months after the operation, persons who were found to be at risk of developing knee joint contracture were offered a course of rehabilitation treatment in hospital conditions. Proprietary rehabilitation system has a number of fundamental differences. In particular, the complex includes training of the pelvic stabilizer muscles, the sacroiliac joint and the vertical position of the body, as well as exercises to restore the functional balance of these muscles. Their implementation makes it possible to restore two- and one-legged standing and sagittal spine-pelvic balance parameters [11, 13, 18]. R. Irwin [19] believes that these factors have an impact on the restoration of the function of the joints of the lower extremities.

Performing exercises on an unstable platform enables training of the neuromuscular control system and coordinated muscle contraction. This is very important for restoring vertical one- and two-legged standing and correct walking pattern [12, 13]. These exercises allow the patients to include in the process of developing the range of motion in the knee joint not only muscles and ligaments that directly perform movements in the knee joint, but also «muscle chains», which consist of muscles with common attachment points with stabilizers of the knee joint [10]. By performing exercises and walking in front of a mirror, the patient can visualize errors and adequately train coordinated muscle contraction. This is especially important when restoring range of motion in the knee joint to extension, when even a few degrees matter.

According to the hypothesis of T. Myers, the inclusion in the rehabilitation system of massage aimed at «muscle chains» involved not only in the stabilization of the knee joint, but also in the stabilization of the entire lower limb as part of the locomotor system, allows to significantly speed up the rehabilitation process [10, 20].

The use of the proposed rehabilitation system made it possible to eliminate the deficiency of the angle of extension in the operated knee joint in all patients, which is important for restoring vertical one- and two-legged standing and walking stereotype.

Conclusions

The use of the proposed system of rehabilitation treatment 2–3 months after surgery and endoprosthetic repair of the knee joint makes it possible to effectively restore the range of motion in the operated joint, reducing the risk of contracture (especially on extension) and restoring the normal walking pattern.

Conflict of interest. The authors declare no conflict of interest.

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COMPLEX REHABILITATION TREATMENT AFTER KNEE ARTHROPLASTY

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