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Assessment of the function of the lower limb and gait of patients after knee replacement using physical therapy

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Abstract

Purpose. To study the dynamics of the function of the lower limb and gait of patients after knee replacement using physical therapy.

Material & Methods. Patients were randomly distributed into groups – control (CG) and study (MG), each group – 12 people (n=24). The groups received a rehabilitation intervention according to the International Classification of Functioning, Disability and Health (ICF) concept. For each person, a categorical profile was created and SMART goals were set. The developed program of physical therapy (PT) for the MG, taking into account short-term goals in a SMART format, included the use of kinesitherapy according to the author's method, hydrokinesitherapy and physiotherapy. Lower limb function and gait were assessed before and after the intervention using the Visual Analogue Pain Scale (VAS), goniometry, Tegner-Lusholm scale and Timed Up and Go (TUG) Test.

Results. VAS pain scores showed significant dynamics in both groups, but without a significant difference between the groups (p>0,05). Indicators of the amplitude of flexion in the operated knee joint approached the normative values; in patients from the MG they improved by 23,51%, and in the CG – by 10,83% (p<0,05). Improvement in indicators on the Tegner-Lusholm scale after the rehabilitation cycle occurred in both groups (p<0,05), but the results of the MG were significantly higher (p<0.05). During the repeated study, 16.66% of the CG showed an "excellent result", in the absence of such a result in the CG. Timed Up and Go (TUG) Test indicators had positive dynamics in both groups (p<0,05), but large changes were observed in the MG (p<0,05).

Conclusions. analysis of the dynamics of indicators of physical functions, range of motion and gait of persons 50-64 years old after total knee replacement confirmed the advantages of the developed physical therapy program for persons in the MG.

Keywords: physical therapy, knee replacement, VAS, goniometry, Tegner-Lusholm scale, Timed Up and Go (TUG) Test.

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Introduction

The problem of joint diseases in recent years has acquired great medical and social importance, this is due to the widespread prevalence of the disease, the rapid development of functional disorders (especially with damage to the joints of the lower extremities), an increase in rates of temporary and permanent disability, and a sharp decrease in the quality of life of patients. Osteoarthritis (OA) affects 240 million people worldwide, approximately 10% of men and 18% of women, especially older patients. OA is the third most common diagnosis made by general practitioners in older patients (Liu et al., 2018; Nelson, 2018; Meenu Singh et al., 2023). More than 500,000 patients with OA are

officially registered in Ukraine. It should be noted that, according to statistics, in Ukraine now every third resident suffers from osteoarthritis of certain joints. Due to aging and obesity, the prevalence of OA is constantly increasing. Lower extremity OA is an important clinical, social, ethical and economic burden from a societal perspective (Cross et al., 2014). Surgery, including joint replacement, is recommended for patients who do not respond adequately to pharmacological treatment or for those with advanced OA. Depending on the extent of the disease, replacement surgery may take the form of a total knee arthroplasty (TKA), partial knee replacement (PKR), or revision knee arthroplasty (RKA). In most developed countries, the number of knee replacements has increased significantly over the past few years, along with increasing costs. By 2030, 1.26 million patients are expected to undergo TKA annually (up 85% from 2014) and 635,000 will undergo PKR (up 71%). The results of surgical treatment are generally considered very satisfactory with an increase in life expectancy. In addition, arthroplasty is a safe and reliable treatment for end-stage arthritis in young adults with good to excellent mid-term results (Neuprez et al., 2020). However, arthroplasty may result in adverse health consequences; Revision surgery is the most problematic. Therefore, it is important to carefully evaluate the patient's benefit from these surgical procedures and implement effective prehabilitation and rehabilitation. (D'Ambrosi et al., 2016).

Rehabilitation is typically offered to patients who undergo arthroplasty to optimize postoperative results, including strength, function, pain reduction, and return to normal activities of daily living. Prehabilitation is increasingly believed to maximize patients' functional status before surgery to improve postoperative outcomes (Beziazychna et al., 2020). The physical therapy program should take into account the individual characteristics and needs of the patient, the intensity of physical activity of the disease and arthroplasty, as well as the methodological approaches of the International Classification of Functioning, Disability and Health when determining the direction of the rehabilitation process; principles of forming individual SMART goals (smart tasks) for a given group of people (Bovend'Eerdt et al., 2009; Hertsyk, 2016, Zviriaka et al., 2022).

Purpose of the study to study the dynamics of the function of the lower limb and gait of patients after knee replacement using physical therapy

Material and methods of research

Participants

Under our supervision were 24 people from 50 to 64 years old, on the basis of the medical center for physical rehabilitation and sports medicine "Kinesio" and the Municipal Non-Profit Enterprise of the Kharkiv Regional Council "Regional Clinical Hospital" of Kharkiv. The patients were divided into 2 groups using the random number method – control (CG) and study (MG), with 12 people in each group. The average age in the main group was 59.00±1.23, and in the control group – 57.41±1.17 years. Inclusion criteria: persons after total knee replacement (cause: osteoarthritis). Exclusion criteria: repeated prosthetics, severe concomitant diseases. In terms of general characteristics and the presence of concomitant pathology, the study and control groups were homogeneous.

Methods

Assessment of subjective pain using a visual analog pain scale. To assess pain, the Quadruple Visual Analogue Scale (VAS) was used (Von Korff et al., 1993; Trč, & Bohmová, 2011). When assessing pain intensity using VAS, the patient subjectively determines the intensity of his pain by pointing to a certain mark located on a straight line 10 centimeters long (Figure 1). The beginning of the line on the left corresponds to the absence of pain, the end of the segment on the right side corresponds to unbearable pain (Aicher et al., 2012).

Goniometry. Goniometry is a widely used meth-

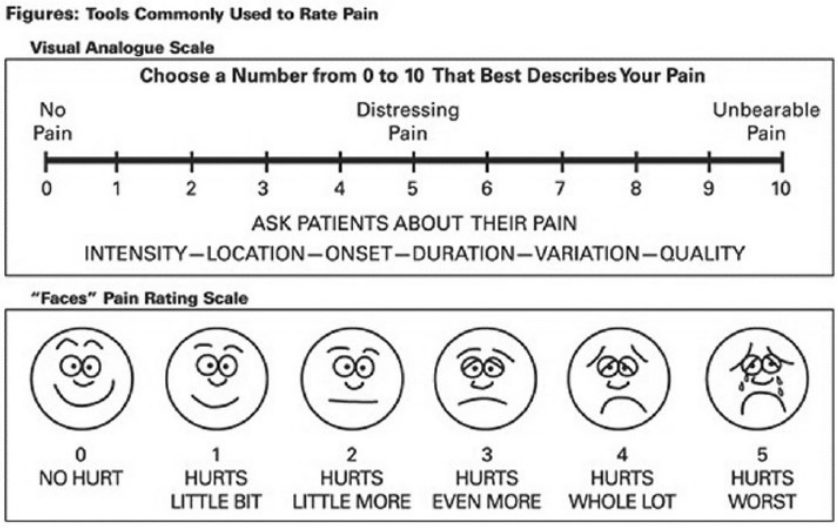

Figure 1. 10-point pain intensity rating scale (Ghaderi et al., 2013)

od to assess range of motion in the joints of the lower extremities (Bhamare et al., 2017; Hancock et al., 2018; Victoria et al., 2021). Knee mobility was assessed using a goniometer using the classical method (Norkin & White, 2017; Hancock et al., 2018).

The goniometer consisted of a rod with a brush attached perpendicular to its end; the second brush was attached to a frame sliding along the rod. There are millimeter marks on the rod. On the side opposite to the legs of the caliper, a goniometer is attached using a retractable hinge, which can be moved in different planes. The goniometer consisted of a base, a body and a arrow freely rotating around its axis. The scale has marks from 0 to 360 degrees, the measurement accuracy is 2 degrees.

The range of motion available to patients in movements such as flexion and extension was assessed. Normal range of motion in the knee joint: extension/flexion 0°/140°.

The measurement was carried out in the standard position of the patient in the initial position, lying on his stomach. The thigh of the limb on which the measurements were made and the lumbar spine were fixed. A fixed brace was installed on the thigh on the lateral condyle of the femur, movable on the lateral malleolus of the ankle joint. When measuring the position of the hip and the patient's body do not change.

Assess the functional status of the knee joint using the Tegner-Lusholm (1982) scale, which is a form of subjective assessment of the knee joint - pain, instability, joint locking, stair walking, limping, extra support, swelling and squatting.

The Tegner-Lysholm Knee Scoring Scale was proposed by Lysholm and Gillquist in 1982 (Tegner & Lysholm, 1985; Briggs et al., 2009; Beziazychna, et al., 2020). Overall scoring results classified as "unsatisfactory – less than 64 points", "satisfactory – 65-83 points", "good – 84-94 points", or "excellent – 95-100 points". A completely healthy knee joint corresponds to a score of 100 points. Score 84 score is considered the lower limit of excellent/good results (Table 1).

The Tegner-Lysholm scale was downloaded electronically to the patients' appropriate gadgets, and during the process of physical rehabilitation, patients suffered independently within the

Table 1. Scale for assessing the functional state of the knee joint Tegner-Lysholm (The Tegner-Lysholm Knee Scoring Scale)

Indicator	Evaluation by indicator
Limp (5 points)	I have no limp when I walk. (5) I have a slight or periodical limp when I walk. (3) I have a severe and constant limp when I walk. (0)
Using cane or crutches (5 points)	I do not use a cane or crutches. (5) I use a cane or crutches with some weight-bearing. (2) Putting weight on my hurt leg is impossible. (0)
Locking sensation in the knee (15 points)	I have no locking and no catching sensation in my knee. (15) I have catching sensation but no locking sensation in my knee. (10) My knee locks occasionally. (6) My knee locks frequently. (2) My knee feels locked at this moment. (0)
Giving way sensation from the knee (25 points)	My knee gives way. (25) My knee rarely gives way, only during athletics or vigorous activity. (20) My knee frequently gives way during athletics or other vigorous activities. In turn I am unable to participate in these activities. (15) My knee frequently gives way during daily activities. (10) My knee often gives way during daily activities. (5) My knee gives way every step I take. (0)
Pain (25 points)	I have no pain in my knee. (25) I have intermittent or slight pain in my knee during vigorous activities. (20) I have marked pain in my knee during vigorous activities. (15) I have marked pain in my knee during or after walking more than 1 mile. (10) I have marked pain in my knee during or after walking less than 1 mile. (5) I have constant pain in my knee. (0)
Swelling (10 points)	I have swelling in my knee. (10) I have swelling in my knee only after vigorous activities. (6) I have swelling in my knee after ordinary activities. (2) I have swelling constantly in my knee. (0)
Climbing stairs (10 points)	I have no problems climbing stairs. (l0) I have slight problems climbing stairs. (6) I can climb stairs only one at a time. (2) Climbing stairs is impossible for me. (0)
Squatting (5 points)	I have no problems squatting. (5) I have slight problems squatting. (4) I cannot squat beyond a 90° bend in my knee. (1) Squatting is impossible because of my knee. (0)
Result	
Excellent: 95-100 Good: 84-94 Fair: 65-83 Poor: < or = 64	

specified time frame; they were tested according to the physical rehabilitation program, and the data was sent to the coordinator. This approach objectifies the analysis of results and completely eliminates the subjective influence of the rehabilitation therapist on the results of physical rehabilitation and allows remote preliminary assessment of the quality of the developed physical rehabilitation program for people with knee joint pathology.

The patient was asked to independently choose the level that coincided with his capabilities at the time of examination.

The Timed Up and Go (TUG) Test was used to evaluate gait. (Large et al., 2006; Bennell et al., 2011; Herman et al., 2011; Beauchet et al., 2011; Zasadzka et al., 2015).

The patient must, from a sitting position (in a chair with armrests), stand on his feet, walk 3 meters forward, turn around, go to his place and sit down again. The patient should wear their usual shoes and use aids if they usually do so.

On the "Forward" command, the patient should try to quickly do the following:

1. Get up from the chair
2. Walk 3 meters forward
3. Turn around
4. Walk 3 meters back
5. Sit down

The recording of time in seconds begins after the patient begins to rise and sits in the chair using the "Forward" command. The patient is given 1 attempt for training and 3 real attempts. The average time of three real attempts is taken into account. When walking, you should pay attention to balance, stepping, step length and arm movements (Table 2).

Procedure

At the preliminary study stage, examination data from 24 people after total knee replacement in the long-term period were analyzed and systematized.

The algorithm for the rehabilitation examination of individuals involved the use of scientifically evidence-based techniques and methods of clinical and instrumental diagnostics. The primary rehabilitation examination was carried out 2 months after surgery (on 68,35±0,49 days), the second examination was carried out after 3 months of the rehabilitation cycle.

Based on the results of the study, ICF categories specific to patients after knee replacement were selected (Table 3)

These categories were significant for all persons from the MG and CG without exception.

Some individuals reported difficulties in the following categories:

- body functions – b7150 Stability of one joint, b7300 Strength of isolated muscles and muscle groups, 7400 Endurance of isolated muscles;
- activity and participation – d470 Use of vehicles, d850 Highly paid work and d920 Rest and leisure.

For patients, their needs were taken into account when creating a physical therapy program, but these categories were not represented in our study.

The level of structure and function according to the ICF was determined using a visual analogue scale and goniometry. The level of activity and participation was determined using the Tegner-Lysholm scale, the Timed Up and Go test.

Each of the categories was assessed on the appropriate scale (Table 4).

Table 2. Evaluation of results on the Timed Up and Go test (TUG)

Time (seconds)	Evaluation
<10 s	free ability to move
10-20 s	predominantly independent ability to move
>20 s	impaired ability to move

Table 3. ICF categories for patients after total knee replacement

Body functions	Body structures	Activity and participation
b28015 Pain in lower limb	**s75011** Structure of the knee joint	**d450** Walking
b28016 Joint pain		**d460** Moving from place to place
b7100 Mobility of a single joint		
b770 Walking pattern functions		

Table 4. Rating scales for ICF categories

ICF categories	Measurement tool
b 28015 Pain in lower limb	Visual analog pain scale
b 28016 Joint pain	Visual analog pain scale
b 7100 Mobility of a single joint	Goniometry
b 770 Gait pattern functions	Visual observation, Get up and walk test
d 450 Walking	Get Up and Walk Test, Tegner-Lysholm Scale
d 460 Moving from place to place	Get Up and Walk Test, Tegner-Lysholm Scale

The basis for constructing the developed physical therapy program was based on the conceptual provisions of international rehabilitation protocols and the international classification of functioning, disability and health.

The developed program for the MG included the use of kinesitherapy according to the author's methodology, hydrokinesitherapy and physiotherapy, taking into account short-term goals in the SMART format.

Table 5 shows the correspondence of the means of rehabilitation intervention to the goals.

The complex of *kinesitherapy* exercises included the following: static, dynamic, dynamic exercises on a balancing basis and on a balancing disk, stretching exercises and post-isometric relaxation, balancing exercises, proprioceptive and functional TRX training, exercises for gait training (imitation, standing and walking on uneven surfaces). Kinesiotherapy was carried out 3 times a week for 40-60 minutes.

Correct adjustment of TRX straps allows you to exercise with the desired level of load (from 5 to 100%), which is adjusted by different stabilization coefficients and allows you to obtain any desired workout intensity.

Hydrokinesitherapy. When performing physical exercises in a pool, due to the physical and mechanical properties of water (Feroyan & Parulava, 2022), the speed component of the exercises decreases and the strength component increases, which is very important for strengthening the strength endurance of the quadriceps femoris muscle and the muscles of the operated lower leg. In water, various variations of walking, running, jumping, and imitation exercises for various sports were used: imitation of striking a ball with different parts of the foot, running with a high rise of the hips, with an overlap of the shin, etc.; swimming in different styles at an average or fast pace, with "support", "without hands" (Becker, 2009; Azizi et al., 2019, Pidhaina, 2022). Classes in the pool were held 2 times a week. The duration of each lesson ranged from 45 to 60 minutes. Number of procedures: 10-12 times.

Physiotherapy: electromyosimulation of the quadriceps femoris muscle (25-24 mAm) on the device for electromyostimulation "Miorhythm 040" (with the frequency and time of the procedure changed individually according to the muscle response to stimulation). Number of procedures: 10-12 procedures every other day (Mintken et al., 2007; Meenu et al., 2023).

The physical therapy program for persons in the CG included the following activities.

Kinesitherapy included the use of general developmental, breathing and corrective exercises, special exercises to strengthen the muscles of the damaged lower limb and restore the range of motion in the knee joint: static tension of the quadriceps femoris muscle (6-8 s), exercises with counteraction, exercises on simulators (exercise bike), exercises to restore walking (varieties, walking on stairs, through objects)

Kinesiotherapy was carried out 4-5 times a week for 40-60 minutes.

Physiotherapy: electromyosimulation of the quadriceps femoris muscle (25-24 mAm) on the device for electromyostimulation "Miorhythm 040" (with the frequency and time of the procedure changed individually according to the muscle response to stimulation). Number of procedures 10-12 procedures, every other day.

The study was carried out in accordance with the research plan "Theoretical and methodological foundations of physical therapy and occupational therapy for organic and functional disorders of the organs and systems of the human body in healthcare practice", 2021-2025 (state registration number 0121U110141).

Statistical analysis

For mathematical processing of digital data of research materials, the Windows XP operating system and the Statistica 6.0 program were used. The critical level of significance when testing statistical hypotheses was taken $\alpha=0,05$ ($p<0,05$). The Kolmogorov-Smirnov criterion was used to assess the normality of sample distributions. If normality was established, parametric statistical methods were employed. In cases where the distribution differed from normal, the Wilcoxon signed-rank test was utilized for paired samples, and the Mann-Whitney U test was used to independent samples.

Table 5. Example of compliance with the aims and means of an intervention

Intervention goals	Means of intervention
reduction of pain in the lower limb to a value of 1-2 points according to VAS after 1.5 months	stretching exercises and post-isometric muscle relaxation, hydrokinesitherapy
restoration of the active flexion amplitude in the operated knee joint to 120° after 2 months.	proprioceptive and functional training TRX, hydrokinesitherapy
restoration of normal walking on stairs without additional support after 2 months (climb to the 5th floor independently)	proprioceptive and functional TRX training, dynamic exercises on a balancing base and on a balancing disc, gait training exercises, electromyostimulation of the quadriceps femoris muscle
return to the initial level of vital activity after 2 months (walks 2-4 times a week in the park for 30-40 minutes with a normal walking pattern)	proprioceptive and functional training TRX, dynamic exercises on a balancing base and on a balancing plate

Results of the study

During the initial study, the results of the VAS examination showed the presence of pain at a level of 5,16±0,94 points in the MG and 5,00±0,85 points with a maximum value of 10 points. According to the interviews, it was established that complaints of pain during active movements were observed in 79,16%, during passive movements – in 62,50%, at rest – in 33,33% of patients.

Indicators of the range of motion when flexing the affected limb in the knee joint are significantly reduced - with a normal range of motion equal to 140° in people after knee replacement, it was 92,08±7,98° in the MG, which is 47,92° less than normal and corresponds to 65,77% of the normal range of motion, and in the CG it is 95,41±6,66, which is 44,59° less than normal and corresponds to 68,15% of the normal range of motion. As for the available range of motion when performing extension in the knee joint of the operated limb, the registered indicators of individuals are close to the norm (no statistically significant difference in the studied indicators was observed).

During the initial study, the assessment of knee joint function on the Lysholm scale in the MG was 65,50±4,44 points, and in the CG – 63,33±4,31 points; no statistically significant difference in the studied parameters was observed. In the MG, "unsatisfactory" results were observed in 29,17%, "satisfactory" – in 70,83%, and in the CG – 37,50% and 62,50%, respectively.

The results of the initial examination of individuals based on the results of the "Timed Up and Go" test showed a predominantly independent ability to move in 75,00% of people in the MG, 83,33% in the CG; impaired ability to move was found in 25,00% of individuals in the MG, and in 16,67% in the CG.

The average characteristics of the clinical and functional state of the lower extremities of individuals from both groups are presented in Table 6.

During the repeated study, VAS pain scores in the MG decreased by 3,58±0,13 points, and in the CG – 2,42±0,10 points.

The presented dynamics of VAS scores under the influence of physical therapy programs indicated a significant decrease in pain in both groups, but there were no significant differences between the groups (p<0,05).

During a repeated study in individuals from the MG and CG, the average statistical indicators of the available range of motion when flexing the affected limb in the knee joint improved significantly and amounted to 125,00±5,22° in the MG and 110,58±4,52° in the CG. The difference between the indicators of MG and CG patients is statistically significant at p<0,05 (Table 3). Thus, the indicators of normal range of motion in the knee joint of patients in the OG exceeded the corresponding indicators in the CG by 11,53%. The difference between the knee joint flexion indices of the MG and CG patients is statistically significant at p<0,05.

Analysis of the data obtained in a repeated study using the Lysholm scale showed a "satisfactory result" in 41,67% of people, "good" in 41,67% and "excellent" in 16,66% of patients in the MG. In CG patients, 58,33% of individuals had a satisfactory result, a good result was observed in 41,67% of individuals (Table 7). Improved results after the

Table 6. Indicators of the clinical and functional state of the lower extremities during the initial study, M±SD

Indicators		MG, n=12	CG, n=12	t	p
		M±SD	M±SD		
VAS, points		5,16±0,94	5,00±0,85		>0,05*
Range of movements in the knee joint	Bending (normally – 140°), deflection angle, deg.	92,08±7,98	95,41±6,66	1,11	>0,05
	Extension (normally 5-10°), deflection angle, deg.	6,08±3,11	5,90±2,50	0,14	>0,05
Lysholm scale, points		65,50±4,44	63,33±4,31	1,21	>0,05
Test «Get up and go», s		15,00±4,41	15,16±4,15		>0,05*

* – Mann-Whitney U Test was used.

Table 7. Indicators of the clinical and functional state of the lower extremities during repeated examination, M±SD

Indicators		MG, n=12	CG, n=12	t	p
		M±SD	M±SD		
VAS, points		1,58±0,51	2,58±0,51		>0,05*
Range of movements in the knee joint	Bending (normally – 140°), deflection angle, deg.	125,00±5,22	110,58±4,52	7,22	<0,05
	Extension (normally 5-10°), deflection angle, deg.	7,08±2,02	6,90±1,97	0,20	>0,05
Lysholm scale, points		86,25±7,03	80,25±6,46	2,17	<0,05
Test «Get up and go», s		10,00±1,70	12,58±3,31		<0,05*

* – Mann-Whitney U Test was used.

rehabilitation course occurred in both groups. It should be noted that there is no "excellent" rating in patients from the CG, while in the MG such patients it is 16,66%.

When re-examining individuals using the "Get up and Walk" test, a predominantly independent ability to move was established in 66,67% of people in the MG, 83,33% in the CG; free ability to move in the MG in 33,33%, and in the CG – in 16,67% of people; impaired ability to move was not observed in both groups. The average indicators of this test are presented in Table 3. The difference between these indicators of MG and CG patients is statistically significant at $p<0,05$.

The dynamics of the studied characteristics of the clinical and functional state of the lower extremities of individuals of both groups under the influence of physical therapy programs are presented in Table 8.

The use of physical therapy programs after knee replacement allowed to improve the range of motion in the joint, the functional state of the lower limb and the quality of gait, but significantly better indicators were obtained in the MG ($p<0,05$).

Discussion

According to Glinyana et al. (2020) rehabilitation treatment after surgery on the knee joint is divided into 4 periods: the early postoperative period, during which the patient is recommended bed rest, immobilization, cold, and quadriceps muscle training; this period can take from several hours to 3 days; the period of initial loading, during which kinesiotherapy, passive development of the knee joint, and walking with crutches are recommended; long-term period, during which kinesiotherapy, exercises with increased load on the muscles, mechanotherapy, walking with crutches with partial load on the limb are recommended. Depending on individual characteristics, the duration of each period may vary, but at least partially the main provisions are present in each specific case.

There are other approaches to rehabilitation that divide it into the following phases (Meier et al., 2008; Arnold et al., 2016): Phase I: up to 2-3 weeks after surgery (patient education: about pain, pain management, importance of home exercises; establishing rehabilitation goals and expectations; achieving active and passive knee flexion to 90 degrees and full knee extension, reducing pain and swelling, achieving full load on the limb, independence in movement and daily activities); Phase II: 4-6 weeks after surgery (quadriceps exercises, achieving 105 degrees of active knee flexion, full knee extension, pain and swelling reduction); Phase III: 6-8 weeks after surgery (strengthening exercises, improvement of neuromuscular control, functional lower extremity exercises, balance and proprioception training); Phase IV: 8-12 weeks to 1 year after surgery (training and self-exercise, strength training, balance and proprioception exercises, introducing behavior change strategies to increase overall physical activity.

Most patients begin physical therapy during their hospital stay within 24 hours of surgery. Typically, dynamic and strengthening exercises, cryotherapy, gait training are started, and a home exercise program is prescribed before discharge from the hospital. There is limited evidence that accelerated physiotherapy regimens reduce length of hospital stay (Henderson, et al., 2018). Patients are typically discharged after a few days of hospital stay and receive further physical therapy in an outpatient or home setting for 1 week after discharge.

Pain management at this stage may include appropriate use of pain medications, cryotherapy, and elevation of the operated limb. There is evidence that cryotherapy improves knee range of

Table 8. Dynamics of indicators of the clinical and functional state of the lower extremities of patients in the MG and CG under the influence of physical therapy programs, M±SD

Indicators		Primary study	Repeated study	t	p
		M±SD	M±SD		
Main group, n=12					
VAS, points		5,16±0,94	1,58±0,51		<0,002*
Range of movements in the knee joint	Bending (normally – 140°), deflection angle, deg.	92,08±7,98	125,00±5,22	10,77	<0,05
	Extension (normally 5-10°), deflection angle, deg.	6,08±3,11	7,08±2,02	1,04	>0,05
Lysholm scale, points		65,50±4,44	86,25±7,03	8,11	<0,05
Test «Get up and go», s		15,00±4,41	10,00±1,70		<0,05*
Control group, n=12					
VAS, points		5,00±0,85	2,58±0,51		<0,002*
Range of movements in the knee joint	Bending (normally – 140°), deflection angle, deg.	95,41±6,66	110,58±4,52	6,12	<0,05
	Extension (normally 5-10°), deflection angle, deg.	5,90±2,50	6,90±1,97	1,50	>0,05
Lysholm scale, points		63,33±4,31	80,25±6,46	7,07	<0,05
Test «Get up and go», s		15,16±4,15	12,58±3,31		<0,05*

* - Wilcoxon signed-rank test was used

motion and pain in the short term. Post-exercise cryotherapy may be beneficial, but low-quality evidence makes it difficult to make specific recommendations on the use of cryotherapy (Bech, et al., 2015). Patients should be advised to avoid prolonged periods with a bolster under the knee as this may lead to contracture. It is important to review a patient's home exercise program during the first physical therapy session, as home exercises are an important component of the update. At an early stage, patients need to be taught to walk on stairs, with the non-operated leg stepping on the step first when going up, and the operated leg when going down. Key exercises for this stage: plantar/dorsiflexion of the foot, strengthening the quadriceps and improving range of motion in the knee using a pillow or rolled towel under the knee, isometric exercises for the hips and buttocks, flexion/extension of the knee and hip joint, hip abduction/adduction.

In the next phase, physical therapy sessions can be scheduled once or twice a week. This frequency may increase or decrease depending on progression. Achieving full knee extension is important for functional tasks such as walking and climbing stairs. Knee flexion range of motion is necessary for comfortable walking (65 degrees), climbing stairs (85 degrees), sitting and standing (95 degrees). During this phase, tissue mobilization techniques can be used to improve scar mobility.

The importance of proprioceptive training has been emphasized in the literature (Moutzouri et al., 2016). Balance exercises may include balancing with one leg, stepping over objects, lateral raises, and standing on uneven surfaces. Postoperative balance and proprioceptive training, including standing on one limb, can begin when adequate knee control is achieved on the operated limb, usually occurring approximately 8 weeks after TKA.

Individualized rehabilitation programs that include strengthening and intensive functional exercises conducted in the gym or aquatic can progress as clinical and strength milestones are achieved (Husby et al., 2017).

Physical therapists may use transcutaneous electrical neurostimulation and neuromuscular electrical stimulation (NMES) for patients undergoing TKA to improve quadriceps strength, gait, and subjective outcomes throughout all phases of rehabilitation. Using NMES in the quadriceps muscle during the first month after TKA may help reduce strength loss in this muscle (Jette et al., 2020).

Current rehabilitation strategies for patients after TKA typically focus on range of motion exercises and do not place enough emphasis on resistance training or functional training. A recent study demonstrated that a more intensive rehabilitation program that included resistance training and functional training may lead to better results. (Petterson et al., 2009).

Conclusion

The results of the study showed impairment of physical functions, namely: pain and decreased range of motion in the knee joint and gait disturbance in persons 50-64 years old after knee replacement. A physical therapy program was developed taking into account short-term goals in a SMART format, which included kinesitherapy according to the author's method, hydrokinesitherapy and physiotherapy. Analysis of the dynamics of the studied indicators confirmed the advantages of the developed program.

Author's contribution

Conceptualization, O.S. and S.K.; methodology, O.S. and S.A.; check, O.S. and S.P.; formal analysis, S.P. and O.R.; investigation, O.S.; data curation, A.R., O.S.; writing – rough preparation, A.R. and O.R.; writing – review and editing, O.S. and S.K.; supervision, O.S.; project administration, O.S. All authors have read and agreed with the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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