

SHORT THESIS FOR THE DEGREE OF DOCTOR OF (PHD)

**Development of a new patient pathway for patients undergoing
hip and knee arthroplasty in the preoperative period**

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1 Introduction

1.1 Osteoarthrosis epidemiology

Osteoarthrosis (OA) is the most common musculoskeletal disorder, defined as a chronic disease affecting all components of the joint, leading to pain and progressive deterioration of motor function. The main pathomorphological abnormalities are deterioration, fragmentation and thinning of the articular cartilage structure, sclerosis of the subchondral bone, accompanying chronic synovitis and soft tissue inflammation and isomatrophy. All these together lead to pain, instability and deterioration of functional status. (1) It has a prevalence of 6% in 20-30 year olds, while it affects more than one third of the adult population and its prevalence increases with age, with a prevalence rate of almost 80-90% in people over 80 years of age. (2) According to 2019 statistics, OA is the third most common chronic disease in Hungary. In the total population, 15% of the population (13% of men and 17% of women) live with articular cartilage disease. (3) With the increase in global life expectancy, both the incidence and prevalence of the disease are increasing.

OA is the third most common cause of disability in Hungary and the second most common cause of disability in the United States. The cost to the health system of treating a patient with OA is 30% more than for other diseases. Because of OA as an underlying disease, and also because of the development of these comorbidities, 60% of patients need the help of others (2)

1.2 Classification of arthrosis

As mentioned above, hip joint OA (also known as coxarthrosis) can also be primary or secondary, the latter being caused in the vast majority of cases by congenital hip disease, femoral head blood supply disturbance, inflammation or mechanical factors. If an inflammatory component accompanies the progression of OA, the synovial membrane becomes inflamed, which may lead to an accumulation of synovial fluid, with associated capsular strain and pain. Deterioration of cartilage quality and partial or complete loss of cartilage cover increases friction and can also cause mechanical pain. In advanced cases, deformity of the femoral head can further increase pain and functional impairment (5).

1.3 Therapy options

Future potential options include treatments to regenerate cartilage tissue, reduce inflammation, ageing cartilage cells and eliminate pain. These treatments are not widely available to patients and therefore the analysis of these methods was not the subject of my research, which will be followed by a description of the treatment options currently used in everyday practice.

1.3.1 Pharmacotherapy

The first step in drug therapy is local treatment (hyperaemic rubs, topical non-steroidal anti-inflammatory ointments and transdermal patches). If these are ineffective, paracetamol may be

used, followed by ibuprofen at analgesic doses (maximum 1200 mg per day) and then weak opiates (most commonly tramadol, codeine or dextrapropoxyphene). In the case of inflammatory symptoms, full doses of systemic NSAIDs may be justified, and in refractory cases, the use of the tramadol-paracetamol-NSAID triad in various combinations as part of multimodal analgesia has become increasingly common.

1.3.2 Physiotherapy treatments

Among the treatments for osteoarthritis, physiotherapy options play a very important role in addition to drug therapy. Among the various movement therapy professionals, physiotherapists, electrotherapists and physiotherapeutic massage therapists are the most involved in the treatment of patients with osteoarthritis.

The role of a physiotherapist

Physical exercise should be performed at all stages of the arthrosis process. If the arthrosis is so advanced that there is a restriction of movement in the joint, stretching and dynamic exercises should be given priority. This can be done with active exercise. The patient is fully active in the exercise programme or, if the contracture is already so severe, the physiotherapist himself performs the joint stretching with the patient's help, either actively guided or with the patient being a passive participant in the therapy and the physiotherapist passively moving the joint to the point of movement and pain. Manual soft tissue techniques may also be used. In case of muscle weakness, mainly isometric exercises should be dictated to the patient. Here the patient is an active participant in the treatment. The active exercises can be made more difficult by changing the body position and by using different devices such as rubber bands, small and large balls, Velcro to attach weights of different kilograms to the body. If the patient's condition allows, they can also undergo underwater throat training or ride an indoor bike to achieve better results. For the physiotherapist there are various contracture release techniques e.g. PNF, PIR. (8)

The role of the electrotherapy assistant

The aim of electrotherapy treatments in arthrosis is to relieve pain. This is particularly important for physiotherapy, because if the movement is less painful, the patient can participate more actively in the exercise programme and the contracture will be easier to stretch. In many cases, it is not only the pain from the joint itself that prevents the patient from moving, but also the pain from the tightness and binding of the muscles surrounding the joint. We have distinguished several forms of treatment within electrotherapy. (2)

- High frequency treatment: the deeper area is heated, so the joint and surrounding muscles relax, pain is reduced and movement becomes easier.

- Low frequency treatment:
 - Diadynamic current: it can be used for its analgesic effect, it dilates the blood vessels, thus increasing the circulation and the metabolism of the muscles, which causes relaxation in the muscles.
 - Tens: its analgesic effect is beneficial for the most important muscles surrounding the joint, which will reduce the pain when the joint moves.
- Ultrasound treatment: used to relax and relieve pain in the muscles surrounding the joints. This treatment can also be used to apply ointments and fluids containing medications.

The role of the medical masseur

Massage can release stiff muscles, which can reduce pain and increase joint movement. Within balneotherapy, mud wraps can also be used by medical masseurs, the idea being that the heat loosens the soft tissues, loosens the contracture and reduces the constriction of the joint movement. Anti-inflammatory wraps are applied to inflamed joints to reduce the patient's need for medication. During the spa treatments, it is also possible to apply weight baths and tangentor treatments.

1.4 Surgical solutions

In the last stage of arthrosis, when conservative and drug treatments are no longer effective, the implantation of a prosthesis is the last resort.

1.5 Prehabilitation

In many countries, it is becoming common practice for patients to undergo so-called "prehabilitation" before endoprosthesis surgery. The aim of prehabilitation is to reduce post-operative recovery time and the number of days spent in hospital after surgery. The theory of prehabilitation is based on the idea that patients with better functional abilities and a higher level of knowledge are better able to tolerate surgical procedures. Research has shown that patients with higher levels of fitness have lower rates of post-operative complications and better functional and psychosocial outcomes. Several studies have been conducted to evaluate the effectiveness of preoperative exercise in patients undergoing knee or hip replacement surgery. Jungae An and colleagues investigated the effect of preoperative telerehabilitation in patients undergoing knee replacement surgery. The programme looked at knee range of motion (ROM) and the functional status of the patients. (24) The intervention lasted for 3 weeks and the patients underwent movement therapy in their homes with the help of physiotherapists. The results

showed that the programme improved muscle strength, ROM and preoperative functional outcomes, which in turn contributed to better functional recovery after arthroplasty. (24) Oosting E. and colleagues investigated the effectiveness of exercise programmes prior to hip replacement surgery on functional movement and walking ability. Their postoperative results showed significant improvements compared to the control group in the 6-minute walk test and the time to stand up from a chair test. (25) Majid and colleagues summarised research published between 2003 and 2013 on the effectiveness of patient education in patients awaiting orthopaedic surgery. They looked at length of hospital stay, patient satisfaction, pain levels, cost of care, knowledge, anxiety and changes in quality of life and functional ability. The study found that preoperative patient education along the lines described above had a markedly positive impact on the success of the rehabilitation programme. (26) Rajrishi Sharma and colleagues used Medline, PubMed, Embase, Central, Cinahl and Ageline to review articles that examined the importance of prehabilitation for patients undergoing unicondylar knee replacement surgery. (27) The aim of the study by Pascale Gränicher and colleagues was to assess the impact of preoperative physiotherapy on functional, subjective and socioeconomic parameters after total knee replacement. (28) Jones et al and Huang et al found positive changes in costs and length of hospital stay after prehabilitation. (29,30) Huifen Chen and colleagues also investigated how prehabilitation exercises affect hospital length of stay following rehabilitation and improvement in knee range of motion (ROM). (31) Robert Topp's colleagues also support the conclusion that prehabilitation is important. (32) Swank and colleagues found positive results in a trial of a 4-8 week functional improvement prehabilitation programme. (33)

1.6 Patient education

"Patient education is defined as all educational activities directed towards patients, including therapeutic information, health education and clinical health promotion". (35)

An adequate level of patient education and information is essential for increasingly high quality patient care. In 2015, the World Health Organization published a global strategy calling for people-centred and integrated health services. (4,35) In the current context, health policy aims to achieve the best possible health outcomes, taking into account cost-effectiveness. High quality patient education is essential for all health professionals. Literature has shown that the outcome of planned treatments and operations can be positively influenced by the prior preparation of patients. This is also very important in the preventive phase, in order to avoid the development of diseases. Even in the case of established diseases, the higher the level of knowledge, the more an individual can do for himself, thus speeding up the time of his own treatment. It is important that the educational material available to acquire knowledge is safe and that the source of information is credible and science-based.

If the patient knows and understands the process of his or her own care, he or she can prepare for the difficulties and problems ahead and become an active participant in the intervention. In this case, both the patient and the care system can expect a more successful outcome and higher health gains. According to Marc O' Reilly and colleagues, patient education prior to hip and knee replacement surgery reduces length of hospital stay, improves positive outcomes for

patients post-operatively, and even shows cost-effectiveness. Midlands Regional Hospital, Tullamore, introduced a pre-operative 'joint school' in 2012 and it has been running successfully ever since. The lectures consisted of a series of integrated talks (4 sessions) (a combination of PowerPoint presentations, instructional videos and model demonstrations) with multidisciplinary team members: nurse, anaesthetist, surgeon, physiotherapist, occupational therapist. The average length of the presentations was 90 minutes. Each patient was given a written educational handout on all aspects of the surgery on admission to the programme, and patients were encouraged to ask questions at any stage of the session. At the end there was time for further discussion. There was also an opportunity for family members to attend the sessions, reducing anxiety and thus helping to understand and retain information more accurately. Their aim was to gauge their understanding of their patients and to ensure a sustained high level of patient care and quality assurance. They compared the data recorded at the first and last visit in relation to patients' knowledge. They found a significant result based on patient responses to the post-preparation session survey ($p < 0.001$). (36) In their summary paper, Pierluigi Sinatti and colleagues investigated the impact of patient education on pain and hip and knee joint function. In 84% of the clinical trials they reviewed, appropriate patient education significantly reduced joint pain in patients undergoing knee and hip surgery. (37)

One of the principles of patient education is to tailor health-related educational materials to the reading and comprehension skills of the patient. Stenquist and colleagues examined previous patient education materials and found that, although they required only an eighth-grade reading level, they were not suitable for conveying new information. Therefore, they developed a new patient education material that required no more than a fifth-grade reading level and was therefore effective in helping patients absorb new information. Many healthcare facility management recommended that patient education materials should not exceed a reading level of sixth to eighth grade. It should also be mentioned here that the requirement for the information to be comprehensible to all also reduces the depth and amount of accurate and relevant information that can be conveyed. Patients' health-related knowledge is influenced by their basic literacy and knowledge of the health care system. It is important to note that poorer health literacy increases the frequency of emergency care use. Inadequate patient information also has a significant economic impact, as the health care costs of patients with limited literacy are approximately four times higher than those with adequate health literacy. Poor communication between doctors and patients can increase the chances of medical malpractice. While effective communication can reduce patient anxiety and improve adjustment, it can also positively affect clinical outcomes. According to the Hungarian Standard for Health Care (MEES), which came into force on 31.01.2007, there must be professionals in the health care institutions involved in inpatient care who are authorised to inform patients, obtain patient consent and document this. Patient education can take different forms. Patients can receive a DVD, information booklet, brochure. Patients request the creation of pre-operative counselling groups, and also benefit from being able to talk to a fellow patient who has already undergone the operation or treatment and ask questions about the medical procedure. They are more accepting of information from a fellow patient as it is perceived as more realistic and authentic. Many people also use the internet to search for educational material. And men even prefer to watch operations, while women expressly reject the latter. (28, 29, 48, 49)

1.7 Working hypotheses, objectives

Working hypotheses

We assumed that the patient information leaflet we edited would contain a large amount of new information for patients, would be easy to understand and use for older people.

We hypothesised that the impact of the leaflet would reduce patients' fear of surgery.

We hypothesised that as a result of the prehabilitation programme, patients who receive the intervention will, over the same period of time, have better functional abilities than patients who undergo prosthetics in the traditional care setting (only after surgery and then enter the rehabilitation programme).

We hypothesised that the information material developed would be effective in helping all participants to return to their daily lives and thus improve their quality of life.

It was assumed that the prehabilitation programme would result in shorter periods of postoperative rehabilitation institutionalisation for patients participating in the intervention.

Objectives

The main objective of our study was to develop a new "patient pathway" for patients undergoing knee and hip replacement, including prehabilitation interventions. Secondly, we aimed to investigate the effectiveness and benefits of this new patient pathway in a hospital setting. To this end, we created a paper-based patient information leaflet for patients undergoing knee (TKA) and hip arthroplasty (THA), which we incorporated into the new patient pathway system to assess the feasibility and effectiveness of using the leaflet in this format and to collect data on the effectiveness of prehabilitation

2. Methodology

In May 2018, we developed a completely new patient pathway for patients undergoing knee and hip replacement surgery at the Kenézy Gyula Hospital of the University of Debrecen. This new option for the patients was discussed and approved by the Medical Director of the Hospital, the Head of the Department of Rehabilitation and the Head of the Department of Traumatology and Hand Surgery and was implemented as a new institute protocol. The first phase of the new patient pathway was the coordination of the surgical appointment and the end was the completion of post-operative rehabilitation. The novelty of the programme was the inclusion of a prehabilitation programme for patients undergoing knee and hip replacement surgery in the 6-5 weeks prior to surgery, which was delivered in one of the departments of the Rehabilitation Unit.

At the same time, we also introduced a new paper-based patient information leaflet for knee and hip replacement patients, which we edited, containing new information about the surgery, pre- and post-operative rehabilitation and lifestyle advice for patients post-operatively.

2.1 Target group

The target group of our study were patients of the DE KEK Department of Traumatology and Hand Surgery, who were scheduled for knee or hip endoprosthesis surgery. Data collection took place between May 2018 and November 2019, and between February 2023 and 2023. The intervention group included those who agreed to participate in a prehabilitation programme before surgery and agreed to complete the overall questionnaire. The control group consisted of patients who did not agree to participate in the programme or to complete the questionnaire and who were not sure that they would spend their postoperative rehabilitation period in the Rehabilitation Unit.

The inclusion criteria for the patients included in our study were:

They undertook to:

- DE KEK Department of Traumatology and Hand Surgery performs your knee or hip endoprosthesis surgery
- will spend their post-operative rehabilitation at the Rehabilitation Department of Kenézy Gyula Hospital
- read and study the patient information leaflet given to them at the beginning of the trial and complete an assessment questionnaire at the end of the post-operative rehabilitation programme

Patients who agreed to participate in the intervention group beyond the inclusion criteria were:

- participate in the new prehabilitation programme under the pilot protocol
- completion of a fear of surgery questionnaire at the beginning and end of the preoperative rehabilitation programme

The control group consisted of patients who met the inclusion criteria but did not participate in the prehabilitation programme.

The exclusion criteria for our study were:

- Rejection of our leaflet
- After surgery, you want to participate in post-operative rehabilitation in a non-hospital setting.
- a co-morbidity of previous limb amputation, paralysis of central or peripheral origin, or chronic arthritis not involving the operated joint.
- lack or poor cooperation with the rehabilitation team and lack of rehabilitation goals, assessed on the basis of a personal interview.

2.2 Detailed description of the research

The process started with an appointment with the patient, on the basis of which the specialist set the date of the surgery, discussed surgical techniques and the type of prosthesis. At this meeting, the members of the intervention team were given the patient information booklet that we had prepared. We recruited 180 participants for our study. 44 patients did not receive an educational booklet, they became members of control group 1. 136 patients received a patient information booklet, they became members of the intervention group $n=44$ and members of control group 2 $n=92$. The prehabilitation programme took place in a department of the Rehabilitation Unit during the 6th and 5th week before surgery. If the patient agreed to participate, a consultation with the rehabilitation specialist took place in the outpatient department of the Rehabilitation Unit and it was decided together which department would be the most suitable for the patient to undergo the prehabilitation programme. There were two options for patients to choose from: 1. outpatient care 2. inpatient care. There were also two options within inpatient care. One was care requiring full ward admission and the other was of the day hospital type. If the patient preferred day hospital care, he/she received only a hospital bed and one meal a day for the duration of treatment, and thus did not use the full inpatient hospital service. Inpatient care was only recommended by the rehabilitation specialists in consultation with the patient if the patient was unable to make daily visits to the hospital. Whichever option was chosen, patients received the same high quality of physiotherapy care in all cases. During the prehabilitation programme, patients had the opportunity to ask questions to the rehabilitation team members (doctor, physiotherapist, nurse, psychologist, occupational therapist) in addition to the physiotherapy. After knee and hip replacement operations, patients returned to the Rehabilitation Unit for the post-operative rehabilitation period. The patients in our study underwent questionnaire and physical examination in the prehabilitation and postrehabilitation period. The Surgical Fear Questionnaire-SFQ and the Oxford Hip and Knee Score questionnaires were used in the prehabilitation programme participants. For the members of the intervention group, we measured knee and hip joint movements and walking distance during the physical examination. The SFQ was assessed before and after prehabilitation for the intervention group. Patients prepared for surgery individually at home after medical consultation and prehabilitation, with or without the help of the educational material or with knowledge acquired in prehabilitation rehabilitation. In order to increase the effectiveness of the patient information material, we added another measure to our study. A subset of the control group (control group 1) was also administered the SFQ questionnaire at bedtime the day before surgery. In the post-operative period, both the intervention and control groups were assessed with a questionnaire, a physical assessment and the number of days spent in hospital. The Oxford Hip and Knee Score and a questionnaire measuring the effectiveness and usability of a self-reported patient information leaflet were included as questionnaire measures. Physical status was assessed by back-testing, knee and hip joint movements and walking with an assistive device.

2.3 Patient Guide

The implantation of a total hip or knee endoprosthesis is preceded by a long painful process, characterised by difficulty in walking, problems with using the stairs, and limitations in everyday life. In many cases, well-chosen mobility therapy postpones the surgery date, but in most cases the definitive solution to alleviate symptoms is implantation of the prosthesis. The surgery also provides long-term pain relief and improved function. We have produced a written patient information leaflet for each type of prosthesis separately for patients undergoing lower limb prosthesis. Our aim in creating the educational material was to familiarise patients with the hip and knee replacement surgery process, what patients should do before and after surgery, and to help them develop a good lifestyle after surgery. The patient education material did not include a diagram, we preferred the text based guide.

The guide covered four main areas:

1. The first part described knee and hip prosthesis types, the expected lifetime of replacements, and the factors that affect their lifetime.
2. The second part focused on the importance of pre-operative programmes. In order to avoid pain, patients load their healthy side more, resulting in a changed posture. Patients do not use the appropriate muscles while walking, which results in a decrease in muscle strength and muscle tone on the painful side, which in turn makes post-operative rehabilitation longer and more difficult. In this part we also informed patients that pre-operative exercises under the supervision of a physiotherapist could help strengthen, or, if necessary, relax the affected muscles around the joint to be re-placed, which may shorten the rehabilitation period after surgery. They can also learn exercises that we deem important to start immediately after the surgery. Patients were also informed about the walking aids that they would have to use after surgery if they decided to participate in our program. The patient material also included information on where our preoperative program would be available for patients waiting for hip and knee arthroplasty surgeries.
3. In the third part our patients received useful advice on lifestyle, such as how to get out of bed after surgery and how to use a high bed and chair after surgery. The information also highlighted the use of a burlap or elastic bandage. The leaflet also described the near and far aids to use after surgery. It also explained how to transport patients to their homes immediately after surgery or from post-operative rehabilitation. They also described options for patients to continue regular exercise and sports activities (swimming, cycling, or driving) after the post-operative rehabilitation period.

The information leaflet for hip replacements also recommends putting a firm, long, large pillow between the knees after the operation.

Patients waiting for a hip replacement should be made aware that before the operation they should find out about the movements that should not be used at all after the operation (forbidden movements):

- Intensive stretching of the hip, leaning forward (if it is necessary to bend down, slide your operated leg backwards extended, and bend your healthy leg)
- Crossing legs in any posture
- Supination and pronation of the operated leg with straight legs
- Twisting the torso standing with straight legs (the leg must be moved in the direction of the rotation in sync with the body).

4. The fourth part offered a general description of post-operative rehabilitation, which is further divided into two stages: early and late rehabilitation. The former begins on the day the operation at the Department of Traumatology. Based on the recommendations of the surgeon in terms of load, a physiotherapist teaches patients how to do tailored exercises and how to use their mobility aids. In the late rehabilitation stage, when a patient has left the department where the operation was performed, rehabilitation may be continued either at the Department of Rehabilitation or in the home of the patient in the form of home patient care, based on the recommendation of the specialist who performed the surgery. The first phase of late rehabilitation can be carried out more efficiently in a hospital setting because of the availability of equipment there that supports the restoration of joint functionality and facilitates quicker recovery.

The first three pages of the 4-page, A5-size guide provided patients with new information, while for those patients who did not understand something (patients with learning difficulties) about the patient education material, contact details were provided: the physiotherapists of the department, the investigator in charge of the study, so that any questions about the patient information leaflet could be answered for patients.

2.4 Prehabilitation, preoperative programme

During the prehabilitation programme we developed, patients received education, physiotherapy, electrotherapy and drug therapy.

During the preoperative education, patients met with a doctor, physiotherapist, physiotherapy assistant, physiotherapist and, if the team deemed it necessary, a psychologist. The main part of the complex physiotherapy programme for the target group was the exercise programme. Exercise focused on improving functional status and breaking down muscle imbalances in the lower limbs using various physiotherapy techniques. The exercises were performed gradually according to the patients' individual abilities. Patients participated in 30 minutes of individual exercise every day for two weeks. In addition to the exercise programme, the intervention included electrotherapy and massage treatments to reduce pain and provide targeted muscle relaxation. The programme included education of patients on the correct use of post-operative equipment. Together, doctors and physiotherapists provide patients with advice on lifestyle changes that patients can use after discharge from hospital, helping them to cope with everyday life.

During the prehabilitation program for hip and knee joints daily exercise lasted for 30 minutes. It consisted of 4 parts:

I. Introduction

Patients were in a relaxed state, resulting in reduced muscle tension caused by pain. We increased circulation in the lower extremities using leg presses and ankle circles. We asked patients to perform breathing exercises, mobilizing the upper extremities and the chest. The aim of these exercises was to prepare the cardio-vascular system for physical load, to support tissue oxygenization and to achieve psychological stress relief.

II. Increasing range of motion in the affected hip or knee joint:

1. Hip joint:

- At first, improvement of flexion was performed by patients in the supine position and pas-sive/assisted active movements guided by a physiotherapist, starting with short lever arm followed later by active movements also with short as well as long lever arm. In the lateral position we had patients practise active flexion movements only.
- Abduction and adduction movements were carried out by patients in the supine and lateral positions. At first abduction was performed against gravity and then, to increase re-sistance, smaller ankle weights (0.5 kg) or flexible rubber bands were used to make the agonist-antagonist reflex muscle relief effect more effective.
- Extension movements were performed in the supine position using isometric exercises, mainly through activation of the gluteal muscles, and in the lateral position, through active movements, and finally, for a short period of time (5-10 min max) with the patients positioned in the prone position.
- A síkok mozgásainak gyakorlása közben, nagy hangsúlyt fektettünk a korrigált rotációs középhelyzet megtartására.
- During practising plane movements, great emphasis was placed on keeping the corrected rotation middle position.

2 Knee joint:

- During increase of the range of flexion–extension movement all three positions were used (supine, prone, and lateral), using only active relaxation and stretching techniques (post isometric relaxation; reciprocal innervation; contract-relax pnf stretching). In case of extension particular attention was paid to practising while keeping full range of motion.

III. Increasing muscle strength:

Here emphasis was on strengthening the extensor and abductor muscles as well as m. quadriceps. In case of the hip joint, our aim was to correct the muscle imbalance caused by typical flexion and abduction contracture. To this end, the most frequently used positions were the classical horizontal positions (supine, prone, lateral, and all fours) and the alternative variants of these, e.g. when the patient is lying on the therapy bed in the prone position hip height and the two lower extremities are positioned on the floor, hanging from the end of the bed. In this position concentric and eccentric movement of the hip extensors can be easily performed and the effectiveness of the training can be further increased using less resistance. In addition, if the patients' general condition made this possible, they performed muscle strengthening exercises using wall bars. During these exercises, concentric and eccentric strengthening of the abductors performed in a corrected position was mainly practised using different sizes of resistance.

A further aim of our study was to strengthen the quadriceps muscles, which are characterised by considerable weakening in degenerative diseases of both the hip and the knee joints. Typically, strengthening was carried out with patients in the supine position, in the affected leg, using extended hip joint in starting position, working with short and long lever arm. We increased load gradually by increasing the number of repetitions of the exercises, using gravity only or in some cases weaker rubber bands as resistance. In order to avoid paracoordination or compensatory movements, the pelvis was always stabilized by positioning the other lower leg, or, if necessary, manual fixing by the physiotherapist.

The intensity and strength of the exercises, as well as the number of repetitions were determined in every case by the current condition of the patient; we made sure we were not causing or increasing pain during the movements.

The tools used during the exercise program helped maintain patients' interest and made the exercises more varied. Soft Balls, rubber bands of different strengths, Dynair cushions, and Fit Balls were used.

IV. Cooldown:

The last stage of the exercise program featured gradual load decrease as well as relaxing exercises, active stretching and breathing exercises to restore circulation.

During the prehabilitation program members of the intervention group also received electrotherapy and therapist massage in addition to the exercises. Electrotherapy treatments were meant to reduce pain in the given area, improve circulation and activate and strengthen the muscles around the joints. To this end, interferential therapy, the application of selective stimulation, and electromagnetic therapies were also incorporated in the program.

In using classical therapist massage we intended to increase range of motion of the joint, improve circulation and relaxing painful, adhesions.

2.5 Physical examinations

To describe patients' functional status, we measured the active and passive ranges of motion of the hip (flexion, extension, abduction) and knee (flexion, extension) joints and walking distance without rest.

2.5.1 Motion range tests

Active and passive ranges of motion of the joints were measured using a goniometer. Measurements were performed at the beginning and end of both the preoperative and postoperative exercise program in the intervention group, and at the beginning and end of postoperative rehabilitation in the control group. Measurements were made three times and averaged

2.5.2 Measuring walking distance

The data were recorded in a normal hospital corridor with a physiotherapist present. The patient was asked to walk on a flat surface with an assistive device appropriate to his/her physical condition and also at a recorded speed selected according to his/her condition, without rest until the onset of pain. We used this method because it allowed us to visualise the situation of everyday life. Inge van den Akker -Scheek and colleagues have also measured walking distance in hip prosthesis patients before and after surgery, also using a normal living situation. The distance walked was proportional to the functional status of the patient. When measuring walking distance, patients were divided into three categories based on their performance. The first category was 0-50 metres, the second category was 51-200 metres and the third category was longer than 200 metres.

2.6 Questionnaire

2.6.1 Surgical Fear Questionnaire (SFQ)

The Fear of Surgical Intervention is a ten-question questionnaire validated in Hungarian and used since 2011. Patients were asked to mark their level of fear between zero and ten. Zero meant they were not afraid at all and ten meant they were very afraid. This gives a total score of between 0 and 100. The lower the score obtained, the less fearful the patient was of the likely complications of the surgery to be performed. Patients completed the questionnaire before the prehabilitation programme started and after the programme was completed. For some of the control group, it was only taken at the time of admission before surgery. The results suggest that the content of the paper-based "Patient Information Leaflet", which was given to the

patients beforehand, was able to reduce their anxiety about the surgical procedure they were about to undergo.

2.6.2 Oxford Hip and Knee Score

The changes in patients' quality of life were evaluated using a questionnaire method. The internationally used, validated Oxford Knee and Hip Score quality of life scale was used for data collection. The intervention group completed the questionnaires after both the preoperative and postoperative rehabilitation programs, while the control group did so only after the postoperative program. Completed by patients, the Oxford Hip and Knee Score contains 12 questions about pain and functional ability over the previous four weeks. Questions are scored with numbers between 1 and 5, with 5 meaning normal function and 1 meaning severe difficulty. Scores are summed to give a total score between 12 and 60. A lower score indicates a more severe condition

2.6.3 Self-designed questionnaire to measure the effectiveness and usability of Patient Information Leaflet

We used a questionnaire of our own design to assess the usability and comprehensibility of the leaflet. It included 12 closed-ended questions and one open-ended question related to the four sections of the guide. Based on the answers we gathered information on the amount of new information provided by the Leaflet, its comprehensibility, and usability.

Patients had three options to choose from with every question, and could give a maximum of 12 points, which meant that the guide was easy to understand and provided new information.

Patients completed the questionnaire at the end of the post-operative rehabilitation programme on a voluntary basis.

We helped patients understand the questions when necessary.

2.7 Postoperative rehabilitation programme

On the 8th to 10th day after surgery, after suture removal, patients were transferred to the rehabilitation ward for a medical consultation and functional status assessment on the same day. Hip flexors and extensors were strengthened in the supine and lateral recumbent position with isometric and isotonic exercises, with great attention to gradual loading. This was followed by increasing the range of motion of the hip joint with guided active and active exercises. In patients undergoing knee replacement surgery, the main objective was to strengthen the knee flexors and extensors and increase range of motion. CPM was used to increase the range of motion, while electrotherapy devices were used to strengthen the muscles. Occupational therapy was another important component of the postoperative programme to improve functional movement and self-care.

3. Results

3.1 Demographical data

A total of 103 patients participated in our study. Of the total number of patients, 60 patients were waiting for hip replacement surgery, 41 women and 19 men; the median age was 71 years, and 43 patients were waiting for knee replacement surgery, 31 women and 12 men; the median age was 70 years. There was no significant difference between the THA and TKA groups in terms of gender ($p=0.682$). There was no significant difference between the median age of men and women in the TKA group ($p=0.085$), but a significant difference was observed in the THA group ($p\leq 0.05$).

3.2 Range of motion of hip and knee joints

For both hip and knee joint movements, the intervention group achieved better results by the end of the postoperative period. When determining flexion in hip surgery patients, we measured a significantly better value in the intervention group after the operation compared to the control group (median 75° (IQR $70-80^\circ$), $n=27$ vs median 60° (IQR $50-70^\circ$), $n=30$). In knee surgery patients, flexion showed a significant difference compared to controls only at the endpoint of rehabilitation (median 100° (IQR $95-100^\circ$), $n=14$ vs median 90° (IQR $90-90^\circ$), $n=28$). Extension values in both hip and knee surgery patients tended to be better in the intervention groups compared to control patients, but they failed to reach statistical significance. Regarding hip abduction values, patients in the intervention group showed better results; however, neither at the beginning nor at the end of the rehabilitation were we able to show a significant difference between the intervention and the control groups.

3.3 Walking distance

In the case of hip replacement surgery, 84% members of the intervention group were able to walk less than 50m and 16% more than 50m at the beginning of postoperative re-habilitation. In comparison, however, only 7% of the members of the control group were able to walk more than 50m at the beginning of rehabilitation. At the end of rehabilitation, 68% of the intervention group belonged to the second (51-200m) and third ($>200m$) categories; 14 patients performed between 50m and 200m, while 3 patients were able to walk more than 200m without rest. In the control group, the proportion of patients falling into the second and third categories was only 50%.

In the case of knee endoprosthesis surgery, at the start of the rehabilitation program only 7% of patients could walk more than 50m in the control group, while in the intervention group all the patients belonged to the first category. At the end of rehabilitation 61% and 57% of the control and intervention patients could walk more than 50m without rest, respectively.

3.4 Surgical Fear Questionnaire (SFQ)

This questionnaire is informative if completed by the patient in the preoperative period, so it was only possible to include patients undergoing prehabilitation at the beginning. The questionnaire was completed at entry to the programme (prehabilitation) and after prehabilitation. The questionnaire was completed by 44 patients: 68% female, mean age 67.9 ± 11.3 .

For patients undergoing knee replacement ($n=14$, 22% male, mean age 71.5 ± 7.33), we found that fear of intervention and rehabilitation was significantly lower at the end of the preoperative programme (median 20.00, IQR 16.25-24.00 points) than at the beginning of the programme (median 26, (IQR 30.75-39.75 points) ($p < 0.01$, Cohen's $d = 1.76$). Similar results were also recorded for patients undergoing hip prosthesis with reduced fear at the end of prehabilitation compared to the beginning of prehabilitation ($n=30$, 36% male, mean age 66.23 ± 12.5 , median 34.50 IQR 28.00-42.00 vs. median 20.00 IQR 16.00-22.00 points, $p < 0.01$ Cohen's $d = 1.76$). We also examined fear of surgery among men under 70 and men over 70 at the end of the prehabilitation exercise programme. We found that fear levels were significantly reduced in both age groups ($p < 0.01$).

We complemented our study with another comparison, where we administered the SFQ questionnaire to the control group immediately before surgery and compared this with the SFQ measures of the intervention group after prehabilitation. The results demonstrate the extent to which face-to-face education and repeated review of printed patient education material reduces fear of surgery. The SFQ score was significantly ($p < 0.001$, Cohen's $d = 1.76$) lower in the intervention group (TKA and THA, $n=44$) (median 20.00 IQR 16.00-24.00, median 20.00 IQR 16.00-22.00) than in the control group (TKA and THA, $n=44$) (median 64.50 IQR 54.00-82.00, median 73.00 IQR 56.00-81.00).

3.5 Oxford Hip and Knee Score

In the patients with hip endoprosthesis surgery the Oxford Hip and Knee Score in the intervention group was significantly ($p < 0.001$) higher than in the control group (median 33 (IQR 31.5-35), $n=27$ vs. median 25 (IQR 25-30), $n=30$). In knee endoprosthesis surgery patients the Oxford Hip and Knee Score was also significantly ($p < 0.05$) higher in the intervention group than in the control group (median 35 (IQR 33-35), $n=14$ vs. median 30.5 (IQR 30-35), $n=28$).

3.6 Effectiveness of patient information

Of the 136 people who met the inclusion criteria, 29 were no longer in post-operative rehabilitation care and were discharged to their homes immediately after surgery, so they were not able to complete the follow-up questionnaire. Thus, 107 patients (hip and knee replacement combined) completed the questionnaire, of which 103 were finally processed. Four people were excluded from the analysis because they did not complete the questionnaire correctly.

The evaluated questionnaires were distributed according to surgery type, age and gender as follows: 72% of patients who underwent knee replacement surgery ($n= 43$) were female; mean age 70.49 ± 7.34 , 68% of patients who underwent hip replacement surgery ($n= 60$) were female; mean age 68.93 ± 10.88 .

Evaluation questions

In the evaluation of the newly introduced patient information leaflet, we found that all participants (n=103) scored a median of 12 out of 12 (IQR 11.00-12.00) on the question of how well they understood parts of the leaflet. For the question on the content of the new information, respondents scored a median of 12 out of 12 points (IQR 11.00-12.00), and for the question on use and application in postoperative rehabilitation, respondents scored a median of 12 out of 12 points (IQR 11.00-12.00).

The results by prosthesis type and age were as follows:

Patients awaiting knee replacement (n=43, 31% female, mean age 70.49±7.34) scored a median of 12 out of 12 points (IQR 11.00-12.00) on the question of how well they understood parts of the newly introduced patient information leaflet. Those aged under 70 scored better compared to those aged 70 or over (median 12 (IQR 12.00-12.00) vs median 12 (IQR 11.00-12.00)).

The same group scored a median of 12 (IQR 11.00-12.00) for new information content. Our patient education booklet provided more novelty to the 70+ age group (median 12 (IQR 11.00-12.00) vs median 11 (IQR 11.00-12.00)).

In post-operative rehabilitation, patients gave a median score of 12 (IQR 11.00-12.00) for use and application. Again, a difference by age group was observed for patients under 70 years (median IQR 12 (11.75-12.00) points) and patients aged 70 years and over (median IQR 12 (11.00-12.00) points).

Patients waiting for hip replacement (n=60, 32% male, mean age 68.93±10.88) gave a median score of 12 (IQR 11.00-12.00) for the clarity of the information. A higher score was obtained for those under 70 years (median 12 (IQR 12.00-12.00) vs median 11 (IQR 11.00-12.00)).

For new information content, the THA group scored a median IQR of 12 (11.00-12.00). For this questionnaire, we were able to provide more new information for those under 70 (median 11 (IQR 11.00-12.00) vs median 12 (IQR 10.75-12.00)).

The extent to which they were able to use and apply the patient information leaflet was rated at a median of 11 (IQR 11.00-12.00). The results by age group show that the younger age group was better able to use the information, with a median score of 12 (IQR 11.75-12.00) for those under 70 and a median score of 11 (IQR 11.00-12.00) for those aged 70 or over.

3.7 Days spent in hospital and healthcare costs

In patients with hip prosthesis implantation the postoperative hospital stay was significantly ($p < 0.01$) shorter in the intervention group than in the control group (median 31.5 (IQR 26.5-32.5) n=27 vs. median 28 (IQR 21-28.5), n = 30). In the intervention group, the number of inpatient days after surgery decreased, resulting in a reduction of postoperative costs of approximately 26%. Another favourable outcome of preoperative preparation was that 5 patients did not require postoperative rehabilitation in a hospital setting. They used the in-home physiotherapy service in their own home, in their family environment, further reducing the cost of hospital care.

Among patients with knee prosthesis implantation postoperative hospital stay was significantly ($p < 0.05$) shorter in the intervention group than in the control group (median 36.5 (IQR 28-42) $n=14$ vs. median 29 (IQR 26-32.5) $n=28$). Similar to hip prosthesis patients, a reduction in postoperative costs of approximately 16% was observed in those who underwent knee surgery due to shorter hospitalization.

4 Discussion

A new patient pathway for patients waiting for hip and knee replacement at the Kenézy Gyula Hospital of the University of Debrecen has been developed, which has been extended with two new elements compared to the previous one. On the one hand, participants had the opportunity to participate in a prehabilitation, pre-operative physiotherapy programme, and were also given a printed patient information booklet to study and consult with the specialist staff during the pre-operative period. In our research, we looked at the positive effects of this new patient pathway, both for patients and for the care system.

This programme has allowed patients to improve the functionality of the hip and knee joint, thereby improving the effectiveness of surgery. Prehabilitation was achieved through the use of a personalised gymnastics programme and other physiotherapy treatments, and during the prehabilitation programme, the patients were introduced to the gymnastic exercises to be performed in the postoperative period, the prohibited postoperative movements and the aids to be used immediately after surgery and in the postoperative period. Another positive impact of the intervention programme was that patients were able to meet the team members with whom they would work in the post-operative period in the Rehabilitation Unit. Prehabilitation took place in the 6-5 weeks before surgery. We had to plan the timing of the prehabilitation programme carefully, as it had to be far enough away from the surgery date to fit in the mandatory tests (goitre, anaesthesia), but not too close to the surgery date, because if the patient gets an iatrogenic infection during the programme, the surgery has to be postponed.

Our research has shown that a patient who has undergone prehabilitation will have better functional abilities in the postoperative period in a shorter time.

Based on the analysis of the data collected in our study, we found that the intervention programme had a positive effect on both physical and mental health in our patients.

Based on the analysis of the evaluation questionnaires, the patient information leaflet we prepared proved to be effective, it contained new information, was understandable and usable for the patients, 44 of whom preferred the prehabilitation part of the newly designed patient pathway.

Our results also showed that the patient information booklet we designed significantly reduced fear of surgery and rehabilitation among patients undergoing total knee and hip endoprosthesis during the prehabilitation programme.

A surprising result of the data analysis by age group was that we were able to provide more new information for those under 70 years of age among those who underwent hip replacement, although we would have expected them to have more knowledge about all the details of the expected intervention.

We can say that the educational material we prepared met the expectations of the literature, as patients understood and could use the information contained in the leaflet. Similar to the results of Kennedy et al, the participants in our study also liked the written material very much. They did not have to memorize the information immediately once they had read it, but could take out the printed leaflet at any time and reread what had been written. (4) In general, developing appropriate leaflet materials is an important part of patient education. This is particularly important in the patient population under study, as the proportion of elderly people in the population is increasing with the rise in the average age and, in parallel, the number of elderly people undergoing lower limb arthroplasty is increasing (58)

For physical status, the results of the range of motion measurements showed that the intervention group was able to achieve better functional abilities during postoperative rehabilitation despite a shorter hospital stay.

This result was also confirmed by data from the quality of life scales. The efficacy of our prehabilitation programme was further confirmed by the fact that three of our hip replacement surgery patients did not need hospital rehabilitation at all due to their favourable functional status, but were able to continue their movement rehabilitation in the form of home-based specialist care in their own homes after the surgery.

In our study, patients who participated in the prehabilitation programme were able to leave the hospital an average of 7.5 days earlier than patients in the control group during the postoperative rehabilitation process. The shorter hospital stay reduced the cost of hospital care, resulting in financial savings for the healthcare system. In our study, the postoperative costs of hip and knee replacement implants were reduced by 26% (THA) and 16% (TKA), respectively.

Our results are consistent with those of other researchers. In their review, Widmer and colleagues compared two forms of prehabilitation: exercise therapy and patient education in patients undergoing hip arthroplasty. (59) They concluded that in the postoperative period, patients treated with exercise-based prehabilitation had better functional test scores than patients without prehabilitation. (59, 60) The same was confirmed by Gränicher P and Plenge et al. (28, 61) Myers et al. also found in their study that if patients are admitted to surgery in better general and physical-functional condition, they have better postoperative outcomes and fewer surgical complications. (62) Moyer and colleagues also found in their systematic meta-analysis that prehabilitation of patients undergoing total hip and knee replacement surgery significantly improved postoperative function and reduced length of hospital stay. (64) A similar conclusion has been reached independently by several working groups (Dlott et al, Sharma et al, Jones et al, Huang et al, and Butler, Konnyu et al. (63, 27,29, 30, 64,65)

As can be seen, several previous studies and synthesis reports have examined the effectiveness of prehabilitation in hip and knee replacement patients.(61,63) However, the results are inconclusive, probably due to differences in the types of interventions used during prehabilitation and the length of the prehabilitation period. The importance of the timing of prehabilitation has been highlighted by Widmer P et al. The efficacy of prehabilitation is strongly associated with the length of intervention and the intensity of therapies (59). It is important to investigate whether the efficacy of prehabilitation is influenced by sociodemographic factors (e.g. age, gender). However, the role of these factors has not been demonstrated in hip replacement patients (59).

In the literature, it has been found that increased stress and anxiety result in poorer physical performance, which may impair the success of surgery. Cerasola D and colleagues have highlighted in their research that in patients with chronic disease, frequent anxiety and stressful situations can lead to an increased inactivity state. (66)

In our study, we also processed the results by type of prosthesis and by age (the under-70 and over-70 age groups). We chose the age of 70 because in Hungary, according to the current law, workers retire at 65, but due to the socio-economic situation, many retired people are still actively working full or part-time on a daily basis until the age of 70. (67, 68) Thus, it may be of great importance whether and how soon the still working retired people will be able to continue working after the surgery.

Rohringer et al. have previously found that patients' own health literacy levels play a key role in patient education as part of total knee or total hip arthroplasty rehabilitation (TKA/THA).(69) Bitzer et al. have described how patient education in an institutional setting can be effective in increasing health literacy levels, enabling patients to take a greater role in their own rehabilitation process. (70) Rackwitz et al. conclude that comprehensive information and education in the pre-operative period of hip and knee endoprosthesis surgery plays a central role in preparing for surgery and affects recovery in the postoperative period. It has been postulated that preoperative education can help to reduce patients' fear of surgery and minimise the need to take analgesics in the postoperative period.(71) Clarius et al. found similar results regarding the importance of patient education.(72)

5 Limitations

- Estimating and accurately determining the financing of patient care

In our study, we focused on the number of days patients spent in the rehabilitation ward after surgery when examining the costs of hospital care. One of the main questions of the study is whether the prehabilitation programme will reduce the length of postoperative hospital stay. This has been achieved and proven. However, if we take into account the fact that the patients who benefited from the prehabilitation programme also chose inpatient hospital care, it is clear that the cost of their care increased with this time and that the reduction in funding was therefore no longer fully justified. The best cost-effectiveness could be achieved if patients chose inpatient or maximum day hospitalisation during prehabilitation.

Another distorting factor in terms of funding is that the patients we studied stayed longer in the rehabilitation ward than in other European countries. There are several reasons for this. In Hungary, the physiotherapy treatments provided in home care are underfunded, which means that providers cannot employ sufficient numbers of rehabilitation specialists and physiotherapists. This results in long waiting lists, which in turn leads to delays in starting therapy. Patients therefore find it safer to spend their rehabilitation period in hospital, where they can be assisted 24 hours a day by the Rehabilitation Unit staff (nurses, physiotherapists and doctors). This is enabled and funded by the health care system.

- The small size of the intervention team

The number of patients in the intervention group was limited by the presence of exclusion criteria. Many did not wish to participate in any form of prehabilitation programme or simply did not agree to complete the questionnaires.

- The high age of participants

The median age of patients undergoing endoprosthesis surgery in our study was 70 years. These patients were particularly distressed by being away from their families and therefore refused the option of a preoperative hospital stay, and were unable to manage outpatient care on a day-to-day basis, so they were also excluded from the intervention group.

- Cooperation with the doctors performing the surgery

The surgeons feared that prehabilitation in hospital could lead to an increased risk of nosocomial infections, which in turn could result in the planned surgery being postponed. Therefore, for patients who were already at high risk of surgical complications, preoperative hospitalisation was not recommended for inclusion in the programme.

- Limitations in completing the fear of surgery questionnaire

Patients undergoing knee and hip replacement in the pre-operative programme were only able to complete the fear of surgery questionnaire because the questionnaire was only taken in the pre-operative period. Thus, for patients who arrived at the hospital only in the afternoon before the surgery or on the day of the surgery, we were not able to collect the questionnaire because of the surgical preparations.

6. Summary

6.1. New results, main findings

Our research confirmed that:

- Prehabilitation is effective in helping to restore functional ability in the postoperative period, mainly through significant improvements in hip and knee movements.
- Quality of life scales show significantly better outcomes in the postoperative period in both intervention groups.
- The provision of patient education and patient information material adapted to the target group prior to total hip and knee replacement surgery reduced fear of surgery and had a positive impact on the postoperative period.

- As a result of the prehabilitation programme before total hip and knee replacement surgery, the length of hospital stay after surgery was significantly reduced, which influenced the reduction of patient care costs.

6.2. Conclusions

On this basis, the importance of physical and psychological preparation before elective lower limb prosthesis surgery cannot be overemphasised. This process should be integrated into the preoperative period according to a carefully defined timing. The use of traditional paper-based documents is of considerable help in psychological preparation (taking into account the advanced age of the patients). All these can help to reduce the patient's anxiety about surgery and post-operative rehabilitation time, and to improve functional status.

We are committed to continuing and incorporating the new patient pathway we have developed into the care protocol of the Rehabilitation Clinic of the University of Debrecen Clinical Centre, further increasing the efficiency of the institution and the level of patient satisfaction.

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8 Publication list



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Registry number: DEENK/437/2023.PL
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Doctoral School: Doctoral School of Health Sciences

List of publications related to the dissertation

1. **Szilágyiné Lakatos, T.**, Lukács, B., Nagy, A. C., Jenei, Z., Veres-Balajti, I.: Efficiency of Printed Patient Information Leaflets Written for Total Knee and Hip Arthroplasty Patients to Reduce Their Fear of Surgery.
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2. **Szilágyiné Lakatos, T.**, Lukács, B., Veres-Balajti, I.: Cost-Effective Healthcare in Rehabilitation: Physiotherapy for Total Endoprosthesis Surgeries from Prehabilitation to Function Restoration.
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