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THE EFFECTS OF PHYSIOTHERAPY USING PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION TECHNIQUES ON THE GAIT OF PATIENTS AFTER HIP AND KNEE ARTHROPLASTY: A CASE REPORT

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Gait disturbances are a major problem for patients after arthroplasty. After the surgery, walking speed, the rhythm of locomotion, and the length of the steps are significantly reduced. One of the therapeutic methods used in gait re-education is proprioceptive neuromuscular facilitation (PNF).

Aim of the study: This study aimed to evaluate the effects of physiotherapy using PNF techniques on the gait of patients after hip and knee arthroplasty.

Case report: A 60-year-old woman with advanced osteoarthritis that received bilateral hip and right knee arthroplasties was examined. Before and after the therapy, the following tests were performed: measurement of the range of motion (ROM) of hip and knees joints in the sagittal plane using a goniometer, assessment of the symmetry of the lower limbs loading using the two scales test, assessment of the risk of falls using the "Timed Up and Go" test, assessment of balance and gait using the Tinetti test, and assessment of pain intensity using the visual analogue scale (VAS). Rehabilitation was comprised of 15 PNF therapies, including scapular and pelvic PNF patterns. The stabilization of the upper and lower trunk, lifting, shifting of the body's weight from one foot to another, gait cycle (the stance phase and the swing phase), walking forward, backward, and sideways, and walking up/down the stairs were also used. After the therapy, the flexion ROM in both hip and knees joints was improved. The lower limb symmetry index decreased from 1.167 to 1.121, and the sum of the points obtained in the Tinetti test increased from 22 to 26. Pain in the joints also decreased from 6 on the VAS scale to 4. However, the result obtained in the "Timed Up and Go" test after the therapy was increased by 0.5 s compared to before the therapy.

Conclusions: After hip and knee arthroplasties, physiotherapy using PNF techniques improved the gait and functional status of the patient. Continuation of this research using a larger number of patients is needed.

KEYWORDS: proprioceptive neuromuscular facilitation, knee arthroplasty, hip arthroplasty, functional gains, gait pattern, physiotherapy

Background

The last decade has seen an exponential rise in the number of arthroplasties performed globally, and a sharp increase in the percentage of young patients hoping to improve their quality of life and return to physically demanding activities [1]. Hip arthroplasty and total knee arthroplasty are safe, and are among the most successful and cost-effective procedures in orthopedics for patients with osteoarthritis [1,2]. Hip and knee replacements are effective treatments for symptomatic, end-stage hip and knee osteoarthritis, aiming to relieve pain and restore joint function. However, their effects on clinical outcome and the rates of implant revision in patients undergoing joint replacement are still unclear [3]. The demand for implants of the large joints of the lower extremities is constantly increasing and the number of total hip and knee replacements will only continue to grow over the next decade. Although hip and knee arthroplasties are considered to be common elective and cost-effective operations, up to one-quarter of patients are not satisfied with the operation [4].

During the implantation of an artificial joint, doctors strive to both minimize the removal of damaged bone elements and install the prosthesis such that the subsequent movements perfectly reflect those that occur physiologically in a properly functioning joint [5, 6]. Degenerative changes in the joints can cause disturbances in the phases of gait, especially in the stance phase and the initial swing. In addition, degenerative changes reduce the range of motion (ROM), including extension, flexion, and abduction of the limb qualified for surgery compared to the second lower limb. This should be taken into account in the physiotherapy plan after surgery [7].

One of the therapeutic methods used in the re-education of the gait is proprioceptive neuromuscular facilitation (PNF). PNF practices promote multiple-plane joint movements, which relieve pain and increase joint ROM. The PNF intervention is also a successful method for relieving the symptoms of knee osteoarthritis. This treatment relieves pain without increasing knee adduction moment, enhances passive ROM, increases active knee flexion ROM, and increases hip adduction moment during stair descent in the elderly with knee osteoarthritis [8].

Aim of the study

The current study aims to evaluate the effects of physiotherapy with PNF on the gait of patients after hip and knee arthroplasty through the presentation of a case report. As the number of patients receiving endoprosthesoplasty of the joints is increasing, it is worth assessing the effectiveness of PNF therapy on the quality of the gait, balance, symmetry of lower limb loading, ROM in hips and knees joints, and pain following surgery.

Case report

Patient characteristics

The patient was a 60-year-old woman with advanced osteoarthritis that had received bilateral hip and right knee arthroplasty surgery. The woman gave written consent for the publication of rehabilitation results and photos, and the research was approved by the Bioethic Commission of the Opole Medical School in Opole, Poland (consent no.: KB/204/Fi/2019).

At the time of the study, the arthroplasty of the left hip joint was carried out eight years earlier, and the right four years earlier. In both hips joints, uncemented fixation was used. Arthroplasty of the knee joint took place a year before the described rehabilitation. For the treatment of the knee joint, endoprosthesis elements with a cemented fixation was used. After these procedures, the patient went through rehabilitation and then independently performed isometric exercises, exercises using flexible tapes, and rode a stationary bicycle regularly. Despite performing these exercises, the functional condition was not satisfactory.

Diagnostics before and after therapy

Before the therapeutic intervention, an examination was carried out that started with completing the examination card recommended by International Proprioceptive Neuromuscular Facilitation Association (IPNFA). The patient examination was documented in accordance with the International Classification Guidelines, Disability and Health (ICF). The history of the current disease and co-existing diseases were recorded. The patient's limitations in everyday functioning and the main goal of the patient were determined.

The main problem for the patient was pain in both hip joints and the right knee joint during long walks, walking up/down the stairs, and when lifting heavy objects (e.g., heavier shopping bags). In other activities of everyday life, such as personal hygiene, dressing, cooking, and cleaning, the patient was independent. Together with the patient, an analysis of facilitators and barriers among both personal and environmental factors, as well as opportunities and limitations in the level of participation and activity, was performed. For the personal factors, the main facilitators were the patient's motivation and relatively young age for people receiving arthroplasty,

The main facilitating environmental factors were installed handrails at the stairs and in the bathroom, and the possession of a stationary bicycle for exercise. The main barriers were the inactive lifestyle of the patient, even before the endoprosthesis procedures, the large number of stairs at home, and the lack of a shower.

Both before and after therapy the following tests were performed:

1. *Measurement of the ROM in the sagittal plane for the hip and knee joints using a goniometer*. For the hip joints, the range of active extension was measured in the supine position, the axis of rotation of the goniometer was the greater trochanter, the fixed arm ran parallel to the ground, and the movable arm along the long axis of the measured thigh. In the supine position, the range of active flexion in the right and left hip joints was measured, with the position of the goniometer as in the extension measurement. In the knee joints, the extent of active knee flexion was measured in the supine position with the lower limbs straightened. For this measurement, the axis of rotation of the goniometer was the lateral epicondyle of the femur, the fixed arm ran along the long axis of the thigh, and the movable arm along the long axis of the lower leg. There was no hyperextension in both knee joints. The obtained results were recorded using the adopted SFTR system. The name of this method is derived from first letters of the planes of movement that are measured (S – Sagittal, F – Frontal, T – Transverse, R – Rotation). In the sagittal plane (S – sagittal), the extension movement is recorded first, the starting position second, and the flexion movements third [9].

2. *Assessment of the symmetry of lower limb loading using the two scales test*. The patient was examined in a standing position, with the feet placed at an equal distance on two scales standing next to each other, the upper limbs lowered along the trunk, and the eyes directed straight ahead. The measurement was performed on a scale with an accuracy of 0.1 kg. On the basis of the obtained data, the loading symmetry index of the lower limbs was calculated as the quotient of the greater value to the lower value. This indicator should be in the range of 1.0–1.15 [10].

3. *Assessment of the risk of falling using the "Timed Up and Go" test*. The patient starts in a seated position, stands up upon therapist's command, walks 3 meters, turns around (180°), walks back to the chair, and sits down. The result of the test is the time it takes to perform these actions [11]. The interpretation of the results is based on the following values: < 10 seconds – normal, functional efficiency correct; 10–19 seconds – within normal limits for frail elderly and disabled patients, the patient can go outside on their own, does not need auxiliary walking equipment, patient is independent in most everyday activities, but an in-depth assessment of the risk of falls is recommended (e.g., using the Tinetti test); 20–29 seconds – the person needs assistance outside and indicates further examination and intervention, functional ability partially limited; ≥30 seconds – significantly reduced functional capacity, auxiliary equipment for walking is commissioned.

4. *Assessment of balance and gait using the Tinetti test*. The scale consists of two parts to assess balance and gait. The first part consists of 9 tasks. During the test, balance is assessed when sitting, standing up, immediately after getting up, while standing, while trying to nudge with eyes open and closed, turning 360°, and sitting down [12]. In the gait section, 7 elements are assessed: gait initiation, stride length and height (left and right feet), stride symmetry, gait continuity, walking path, swaying, and heel position when walking. For the individual tasks, 0, 1 or 2 points can be obtained, depending on the degree of irregularity found. The balance portion of the test can receive a maximum of 16 points, and the gait part 12 points. The interpretation of the results is based on the following values: 26–28 points – no risk of falls; <26 points – there is a risk of falls; <19 points – the risk of falls increases fivefold.

5. *Assessment of pain intensity using the Visual Analogue Scale (VAS)*. This scale enables assessment of the pain level on a scale from 0 to 10, where 0 is no pain at all and 10 is the maximum imaginable [13].

Therapy applied

The patient's rehabilitation consisted of 15 PNF treatments. Each physiotherapy session lasted 45 minutes. There were two days off between the sessions, during which the patient performed homework (exercises) ordered by the therapist. The therapy was individually matched to the patient's skills and well-being, as well as pain symptoms on a given day. During the physiotherapeutic process, elements of the PNF techniques were performed (Table 1).

The patient did homework once a day for at least 20 minutes. This task included two exercises. The first included exercises on bathroom scales, where the patient stood on two bathroom scales (one foot on one scale) and tried to evenly load her lower limbs. The difficulty in this exercise was closing the eyes. In this case, in order to control the load distribution, the patient used the help of a third party. The second exercise involved touching a step with the foot, with independent repetition of the gait phases learned during the therapy, and paying particular attention to the correct body posture. In order to exclude compensation by the trunk of the body, this exercise was performed in front of a mirror. A 20 cm high step was used.

Table 1. Elements of the proprioceptive neuromuscular facilitation (PNF) techniques used in patient therapy

Elements of therapy	Facilitation methods
Pelvic patterns: anterior elevation, posterior depression, posterior elevation, anterior depression (Figure 1)	Rhythmic Initiation
Symmetrical reciprocating exercises: scapula anterior elevation, pelvic posterior depression	Rhythmic Initiation
Stabilization of the upper trunk	Stabilizing Reversals
Lifting: exercise in a sitting position, one lower limb in contact with the ground	Replication
Mat exercises: glute bridge, stabilization/rotation of the lower trunk	Combination of Isotonics
Shifting of the body's weight from one foot to another	Rhythmic Initiation Rhythmic Stabilization
Exercise in gait support phase: initial contact, loading response, mid stance, terminal stance	
Facilitation of swing phase: pre swing, initial swing, mid swing, terminal swing (Figure 2)	
Walking forward, backward, and sideways Walking up/down the stairs (Figures 3–5)	Replication Repeated Stretch from Beginning of Range, Repeated Stretch through Range

Figure 1. Pelvic patterns – Rhythmic Initiation

Figure 2. Facilitation of Swing Phase

Figure 3. Gait training – Walking forward

Figure 4. Gait training – Walking backward

Figure 5. Walking sideways

Results of the therapy

The patient's results before and after the therapy are presented in Table 2. After the therapy, the range of flexion motion in both hip and knee joints improved. The greatest difference was seen in the flexion movement of the left hip joint and amounted to 13°.

Table 2. Results of the patient's tests before and after the therapy.

Variables	Before therapy	After therapy
Range of Motion: Left hip joint Right hip joint Left knee joint Right knee joint	 S 10°-0°-70° S 10°-0°-80° S 0°-0°-95° S 0°-0°-83°	 S 10°-0°-83° S 10°-0°-85° S 0°-0°-97° S 0°-0°-90°
Two Scales Test – lower limb loading symmetry index	1.167	1.121
"Timed Up and Go" Test	12.64 [s]	13.14 [s]
Tinetti Test	22	26
Visual Analogue Scale (VAS)	6	4

The lower limb loading symmetry index before the therapy amounted to 1.167 and pointed to asymmetry, with the patient putting a greater load on the right lower limb. After the therapy, the index decreased to 1.12 and was within the normal range. The obtained result indicates that the asymmetry of lower limb loading was reduced.

The result obtained in the "Timed Up and Go" test after the therapy was increased by 0.5 s compared to before the therapy. However, it was observed that the patient walked during the test without noticeably swinging her entire torso, and the duration of the support phase on each lower limb was similar. The results of the "Timed Up and Go" test before and after the therapy were within the range of 10–19 s, which shows that the patient was able to go outside on her own and was independent in everyday activities.

The sum of the points obtained in the Tinetti test before the therapy was 22, and after the therapy it was 26. Both results show that there was a risk of falling. After the therapy, the results indicated that the patient could get up and sit down on her own without using the upper limbs. In addition, there was a reduction in pronounced swaying.

Physiotherapy with the PNF method also had a positive effect on the symmetry of the gait. In contrast to the patient's steps before treatment, the steps performed by both the left and right foot after therapy were of comparable length. The support phase of the gait after therapy was correct in terms of initial contact, loading response, and mid stance. The support phase of gait on the left and right foot also lasted a similar amount of time. The element that did not change after the applied rehabilitation was the patient's condition on a broad basis in order to maintain balance. An additional positive effect of the therapy was a reduction in pain from the joints. Before the therapy, the patient assessed her pain as 6 on the VAS, and after therapy as 4 (Table 2).

Discussion

The aim of this study was to assess the gait, balance, symmetry of lower limb loading, ROM in the hip and knee joints, and pain before and after PNF therapy in a patient with bilateral hip and right knee arthroplasty. After the therapy, the ROM of the hips and knee joints in the sagittal plane improved, the asymmetry of the lower limb loading decreased, and balance measured with the Tinetti test improved. Although the time of "Timed Up and Go" test increased slightly, the test results indicated that the patient was in the group of people who are independent in their daily activities. In addition, the swaying of the entire trunk of the body during walking was reduced and the symmetry of the gait improved. Pain was also reduced, which was extremely important for the patient.

The techniques used in the PNF method are often used in the treatment of orthopedic patients. Rhythmic initiation of movement is a technique that is helpful in learning appropriate movement patterns at the beginning of rehabilitation. The replication technique also allows the patient to be taught the final position of movement. The combination of isotonic contractions on healthy limbs and trunk causes irradiation within the synergistic muscles of the exercised limb. Rhythmic stabilization is used to stabilize the newly achieved position by the patient (e.g., one-legged knee on the affected lower limb, standing, midstance phase on the affected limb), to approximate the affected lower limb, and to improve balance and overall endurance. Stabilizing reversals are also used to stabilize the newly achieved position by the patient, to improve balance in problematic positions, and to improve overall endurance. Repeated stretch applied to healthy limbs will also strengthen the irradiation to synergistic muscles on the exercised limb [14].

Many studies have analyzed the functional efficiency, structures, and activity of patients before and after lower limb arthroplasty. However, there are few reports on the effectiveness of the PNF method in patients with endoprosthesis. Jaczewska-Bogacka et al. investigated the effectiveness of PNF physiotherapy in patients after knee replacement prosthesis. After 4 days of standard postoperative rehabilitation, the group of patients underwent a 3-week rehabilitation using the PNF method. After the therapy, the patient's gait kinematics improved, including shortening the stance phases, gait cycle duration, and double support phase, and prolonging swing phase veloc-

ity, gait velocity, cadence, step length, and gait cycle length. Moreover, walking speed and stride length improved, and postoperative pain decreased [15]. Alaca et al. also conducted studies of patients after total knee arthroplasty. Apart from the standard rehabilitation program, the first group underwent PNF therapy and the second group received passive motion therapy. In both groups, the time needed to achieve the required ROM was similar. On the other hand, in the PNF group, there was an earlier improvement in the functional indicators of gait [16]. Other studies have examined the effectiveness of preoperative physiotherapy, including PNF therapy, on functional parameters after total knee replacement surgery. In the group that used preoperative physiotherapy, an increase in the level of physical activity was found after surgery compared to those who did not receive preoperative physiotherapy [17].

The current therapeutic results for the described patient confirm the effectiveness of the PNF method in the rehabilitation of patients after arthroplasty of the hip and knee joints. Due to the fact that the number of people receiving arthroplasty continues to increase, more research is needed on the effectiveness of various methods of rehabilitation following these surgeries.

Conclusions

The number of total hip and knee replacements will increase in the next decade. Physiotherapy with the PNF method improved the gait and functional status of the patient after hip and knee arthroplasty. A continuation of this research with a larger number of patients is needed.

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