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CASUISTIC PAPER

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Assessment of the effects of Proprioceptive Neuromuscular Facilitation therapy on the improvement of motor function in a patient after total hip replacement – a case study

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ABSTRACT

Hip osteoarthritis is a serious clinical and social problem. The number of patients who suffer from degenerative changes in the hip joints and require endoprosthesis-plasty is constantly increasing. This paper presents physiotherapeutic activities based on Proprioceptive Neuromuscular Facilitation (PNF) which optimize a patient's mobilization using the reserves in their body fully to make improvements in movement and to regain lost functions for achieving beneficial therapeutic effects. The aim of the study was to evaluate the influence of PNF therapy on changes in muscle strength, mobility, and gait pattern in patients after Total Hip Arthroplasty. The case described here regards a 63-year-old woman diagnosed with left hip osteoarthritis who had Total Hip Arthroplasty. The patient was examined twice before and after PNF therapy. The range of mobility of hip joints, level of pain, muscular strength and gait were assessed. Applied PNF therapy, including dynamic (eccentric, concentric) and static muscle training, post-isometric relaxation, stabilization and control in the stance phase, resulted in improved hip joint mobility, muscle strength, gait pattern and pain reduction in the patient. The case study demonstrates that a short (two-week) but intensive (over two hours per day) PNF therapy positively influenced selected motor functions after Total Hip Arthroplasty.
Keywords. hip joint, osteoarthritis, endoprosthesis plasty, PNF method, total hip arthroplasty

Introduction

Osteoarthritis is one of the most common motor disorders in people over 40. According to the World Health Organization, 10% of the world population aged 60 or over have symptoms of osteoarthritis, although only 25% complain of it. Deformities and degenerative changes of the hip joints are caused by congenital and acquired defects, traumas, metabolic diseases, excessive joint overload, being overweight, too little or a lack of physical activity, bad body posture and many others causes.[1,2]

The condition is often accompanied with severe pain in the groin area, sometimes in the buttocks, and pain in the knee might also occur. Pain occurs during gait and on exertion, and when condition progresses, the symptoms occur also at rest, sometimes at night.[3,4]

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The aggravation of the disease limits active and passive range of motion (ROM) in the joint, affects the strength of extensors and abductors. At later stages, muscle atrophy in the lower limb and limping may also appear. The consequence of pathological gait pattern in the elderly are falls, with most frequent complications being fractures in the upper femoral segment. The increasing number of these fractures in elderly people poses a significant medical and social problem and are a heavy burden for institutions taking care of the sick.[5-7]

An effective treatment for hip problems due to degenerative changes or fractures is endoprosthesis plasty (alloplasty), considered one of the greatest advances of medicine during the last century. This surgery allows patients to regain the ability to independently perform activities of daily living, gives independence and significantly improves the quality of life. Endoprosthetic surgery is one of the most common operations on the hip joint.[8-9] According to National Health Fund (NHF) statistics in Poland, 46,685 hip joint endoplasties were performed in 2015, of which 37,126 were total hip endoprosthesis, 8,898 were partial endoprosthesis, and the largest population of patients were people aged 60-69.[10] This procedure is successful in 90-95% of cases and the patient returns to normal functioning after several months. The main aim of the surgery is to relieve pain and restore proper joint function, correct the disturbed joint axis and restore stability, which leads to an improved quality of life for patients. Endoprosthesis plasty is one of the most extensive orthopedic surgeries in which permanent elements of the prosthesis are set to restore, as closely as possible, normal joint function.[11-13] Depending on the type of bone binding, cement and cement-free endoprosthesis can be distinguished. In cement-free endoprosthesis, an acetabular cup is inserted by pressing (Press-fit, Eco-fit) or screwed to the bone, the stem is attached to the femur by means of a wedge. Both elements of the endoprosthesis are metal with a porous surface, which causes the accretion of the prosthesis to the bone of the patient over time. In cemented endoprostheses there is a polyethylene pan, a metal stem and a metal or ceramic head, and the elements are attached to the bone with a bone glue called cement.[14-16]

The Proprioceptive Neuromuscular Facilitation (PNF) concept was used in this study which focuses on proprioception and joint mechanics to facilitate movement similar to natural movements in the activities of daily living. Proprioceptive Neuromuscular Facilitation therapy implies a multi-faceted therapeutic approach, emphasizing the essence of motor control as a determinant of optimal function restoration.[17-18] In the PNF concept, it is important to develop appropriate motor strategies, a positive approach with minimal pain, attainment of tasks, and use of a patient's physical and mental resources and to maintain motivation for further activity. Proprioceptive Neuromuscular Facilitation therapy, through optimal patient mobilization and full use of body reserves, allows for faster and more efficient return of lost functions and thus achieves very good therapeutic effects.[19-21]

The aim of the study was to evaluate the influence of PNF therapy on the change in muscle strength, mobility and gait pattern in the patient after Total Hip Arthroplasty.

Case study

The presented case concerns a 63-year-old woman who was diagnosed with left hip osteoarthritis in 2008. In July 2015, she had left hip arthroplasty with EcoFit endoprosthesis with posterio-lateral approach and subarachnoid anaesthesia (up to 2 hours). On the second day after the operation, a hip joint X-ray was performed which indicated that the components of the prosthesis were correctly positioned in the joint. A drain was also visible in this area. The operation went without complications and medication was administered according to recommendations. Rehabilitation was implemented starting from the first day after surgery and included respiratory exercises to improve lung ventilation, isometric exercises to strengthen the muscles of the operated limb, and safely sitting on the bed with legs down. On the second day after the procedure, the patient stood with the assistance of a walker and took her first steps. After rehabilitation, the patient walked with crutches without loading the operated limb. She was discharged in good general and local condition on the fourth day after the surgery. Due to the condition of the patient, she was referred for home rehabilitation, which took place in September 2015, two months after the surgery.

The rehabilitation program included PNF training aimed at improving the range of motion in the joint, muscle strength, pain reduction, and gait training. The patient was given two weeks of PNF therapy in the following areas: 1) a combination of isotonics, using dynamic (eccentric, concentric) and static muscle contraction to improve muscle coordination, strength and endurance; 2) hold relax post-isometric muscle relaxation - using the phenomenon of muscle relaxation after tension to improve ROM, reduce pain and promote relaxation (Photo 1, Photo 3); 3) stabilizing reversal and rhythmic stabilization – to promote stability, balance, and to increase muscle strength by pelvis control while sitting (sagittal plane) and standing (frontal plane); 4) trunk stabilization through shoulder and pelvic girdle (Photo 2, Photo 3, Photo 4) gait training with pelvis and trunk control (Photo 3) and walking with high knee lift and training for control in the support phase of the lower limb using approximation - to improve stability, facilitate balance reactions, muscle stimulation and irradiation (the spread of the response to stimulation)

Photo 1. Post-isometric relaxation of the iliopsoas

Photo 2. The control of pelvis position in sitting (sagittal plane)

Photo 3. Stabilization of the pelvis in standing (frontal plane) in the phase of support on the operated lower limb

Photo 4. The training of the phase of support on the operated lower limb using the phenomenon of approximation and irradiation through the upper limbs

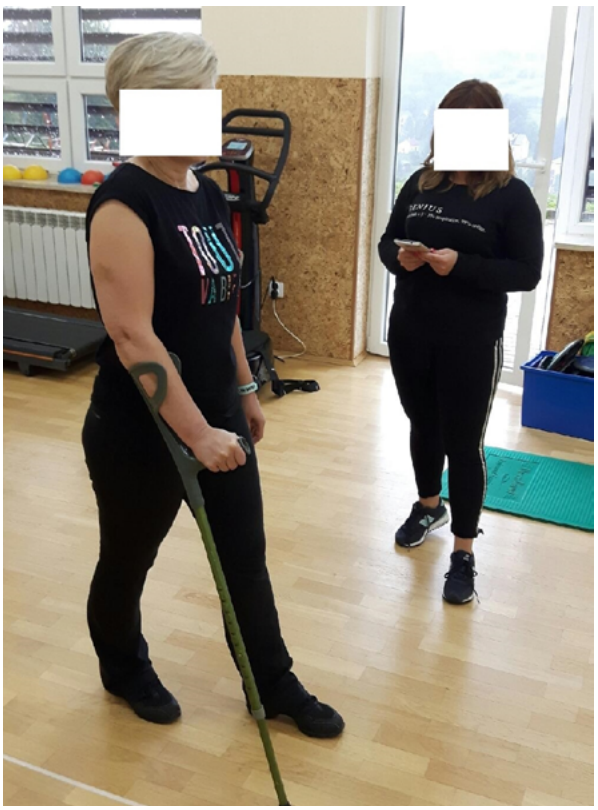

Photo 5. Gait assessment using the patient's walk test

through the upper limbs (Photo 4). The rehabilitation program was implemented two months after the operation. In the first week, the focus was mainly on dynamic and static muscle work, pain reduction and pelvic control, while in the second week on regaining a normal gait pattern. The training was performed daily in the afternoon, the time of therapy was more than 2 hours a day. The patient had no other physiotherapeutic treatment during two week training program.

The patient was assessed twice, before and after PNF therapy, under the same conditions and with the same tests. Measurements used in the patient were: assessment of ROM with a goniometer, pain assessment using the Laitinen scale, assessment of muscle strength using the Lovett scale, and evaluation of patient's gait with a patient's walk test. Assessment of ROM was performed in both hip joints according to the principles established by Skolimowski, [22] without measuring adduction and external rotation in the operated joint due to the risk of dislocation of the prosthesis. Laitinen Scale (The Laitinen Modified Questionnaire Indicators of Pain) is a subjective and point-based tool for assessing the level of pain, based on the interpretation of specific factors directly related to pain. The scale provides information about both the quality of the pain and its intensity. Patient had four indicators assessed including pain intensity, pain frequency, frequency of analgesia, and restriction of motor activity. Each indicator was assigned a score from 0 to 4, where 0 means no problem, and 4 is the most problematic . The maximum score for a patient is 16, which is a very negative result, and the lower the score in Laitinen scale, the higher the improvement recorded in rehabilitation.[23,24] A detailed description of the score is presented in Table 1.

The patient's muscle strength was measured with Lovett's scale in terms of extensors (gluteus maximus and muscles co-working when knee is in extension:

Table 1. The Laitinen scale - detailed scoring system

Indicator	Problem assessment	Score
Intensity	Painless	0
	Mild	1
	Moderate	2
	Severe	3
	Unbearable	4
Pain frequency	Absence	0
	Infrequent	1
	Frequent	2
	Very frequent	3
	Constant pain	4
Analgesics	Not applied	0
	Sporadically	1
	Regularly – little	2
	Regularly - lots	3
	Regularly - huge	4
Motor activity limitation	None	0
	Partial	1
	Limitation in professional activity	2
	Preventing professional activity	3
	Preventing independent existence	4

semimembranosus, semitendinosus and biceps femoris), flexors (iliopsoas and rectus femoris of quadriceps), and abductors (gluteus medius and tensor fasciae latae) in the operated hip joint.[25] The adductor test was omitted due to the risk of dislocation of the prosthesis. The gait test was performed using a walk test developed by the author (Photo 5). To perform the test, a stopwatch, tape to determine the starting point of the distance and a meter stick to measure the distance covered by the patient were used. The test consisted of going forward 10 steps at the patient's own pace. The patient normally used a crutch in her daily life, so it was also used for the test (before and after therapy). The time and the distance were measured for quantity assessment. Qualitative assessment included pelvic alignment, pelvic balance during movement, symmetry, step lengths, equal loading of each limb in the support phase (Trendelenburg sign +), and proper coordination of the upper limbs and the trunk with the lower limbs.

Discussion

The analysis of the obtained results showed that after the therapy there was an increase in ROM in all the planes both in the left hip (operated) and the right (normal) hip. The greatest improvement was observed in a 12° increase in flexion and a 9° increase in abduction in the operated hip joint. Extension improved by 4°, while internal rotation increased by 3°. A detailed comparison of ROM in both hip joints before and after the treatment is presented in Table 2.

Comparing the results of the pre-treatment and post-treatment assessment of pain in the subjective Laitinen scale, it occurred that the first and third indicator of this scale remained unchanged. In the second and fourth indicators regarding the frequency of pain and limitations in motor activity a decrease was found by 1 pt (Table 3).

The analysis of the results in terms of muscle strength in the Lovett's scale, showed improvement after treatment in each of the muscular groups of the oper-

Table 2. A comparison of ROM in the hip joints before and after the treatment

Type of movement	Test I	Test II	Difference
Extension in the operated hip joint	7	11	4
Extension in the other (normal) hip joint	11	12	1
Flexion in the operated hip joint	77	89	12
Flexion in the other (normal) hip joint	87	91	4
Abduction in the operated hip joint	20	29	9
Abduction in the other (normal) hip joint	30	33	3
Adduction in the operated hip joint	----------	- ----------	----------
Adduction in the other (normal) hip joint	23	26	3
External rotation in the operated hip joint	----------	- ----------	----------
External rotation in the other (normal) hip joint	28	30	2
Internal rotation in the operated hip joint	16	19	3
Internal rotation in the other (normal) hip joint	26	28	2

Table 3. Comparison of assessment of pain in the Laitinen scale before and after the therapy

Indicator [pts]	Test I	Test II	Difference
Intensity	1	1	0
Pain frequency	1	0	1
Analgesics	0	0	0
Motor activity limitation	1	0	1

Table 4. Comparison of obtained values of muscle strength in the operated hip in the Lovett's scale before and after the therapy

Lovett's scale	Test I	Test II	Difference
Flexion	4.5	5	0.5
Extension	3.5	4	0.5
Abduction	3.5	4.5	1.5

Table 5. Comparison of distance and time in the walk test before and after the therapy

Walk test	Test I	Test II	Difference
Distance [m]	5.6	6.4	0.8
Time [s]	31	27	4

ated hip joint. The greatest increase in muscle strength was found in the abductors by as much as 1.5 degrees. Flexors and extensors improved by 0.5 degree. The obtained values of muscle strength before and after the therapy are presented in Table 4.

Observational assessment of the patient's gait before the therapy showed significant deviations from the normal pattern. The patient's gait pattern was characterized by limping, a positive Trendelenburg sign, abnormal upper limbs and trunk rotations combined with lower limbs, patient's steps were short. Due to excessive caution and fear of pain, the patient limited the load on the operated limb and fixed the pelvis in an abnormal position. In the quantitative test after the therapy, the gait length improved by 80 cm while the time decreased by 4 seconds (Table 5). After treatment, it was also observed that the patient's gait became more confident, more symmetrical, and steps became longer.

The results suggest that short but intensive PNF therapy, including eccentric, concentric, static muscle training, post-isometric muscle relaxation and stabilization, positively influenced hip mobility, muscle strength, and gait. Numerous studies are available in the literature, among different patient groups, which also indicate beneficial effects of PNF.[17,18,26-28] Kabat and Knott were the first to describe the method as successful for in rehabilitating patients with paresis in Polio.[17] Song et al. reported that PNF method significantly increases flexibility, mobility, muscle strength and self-care in the elderly.[26] Ribeiro et al. demonstrated that PNF training improved motor function and functional efficiency in patients with hemiparesis after stroke.[27] Areas et al. reported that PNF therapy was also effective in increasing muscle volume and inducing muscle fibre modification,[18] therefore, this method is widely used in physiotherapeutical and sport training.[28]

Our studies showed that extension in the operated hip joint prior to PNF therapy was the most restricted. It can be assumed that this was due to the fixation of pathological pre-operation gait pattern. The observation of gait showed that the patient's pattern of gait was typical for the elderly, and that the patient's posture indicated a positive Trendelenburg sign. Weakening of the gluteus medius and minimus caused the pelvis to drop on the unloaded side. The patient's gait was cautious, uncertain with the small steps and flexion in the hips. The patient was anxious to load the operated leg, so she shortened the support phase on the operated limb, resulting in improper pelvic alignment and lack of upper and lower limb work. Likewise, Wrzosek et al. reported that the most common problems encountered in the gait after hip replacement surgery are fear to contact with the ground of the operated limb, the inclination to flexion body posture and incorrect work of the crutches and limbs.[29] Limitation of muscle function after hip arthroplasty involves i.e. hip flexors. This group includes the iliopsoas and quadriceps femoris, while the contracture of the quadriceps also leads to problems in ROM in the knee joint. As a consequence of the late implementation of rehabilitation, there may be flexion contracture and consequently an abnormal gait pattern.[30] Therefore, the patient had relaxation techniques of post-isometric muscle relaxation, using the phenomenon of muscle relaxation after their work under tension, to treat pain.[20] The PNF training program presented in this study had a positive effect on the improvement of ROM on the hip joints, increased muscle strength, reduced pain and improved the gait of the patient. O'Hora et al. stated that even a single session of PNF stretching technique is beneficial because it is based on active involvement and active participation of the patient in therapy.[31] It can, therefore, be assumed that the relaxation technique of post-isometric muscle relaxation is beneficial to reduce the tension of the contracted muscle groups, resulting in an improvement in ROM in the patient's operated hip joint. We found that ROM in the operated hip joint increased by as much as 9° after therapy. Also, Popławski et al. demonstrated that after applied therapy, the greatest improvement in mobility was observed in abduction of the operated hip joint, which was probably due to the fact that the muscles responsible for this movement were strengthened by resistance exercises using a Theraband.[32] Ridan et al. pointed to the usefulness of relaxation applied on the contracted muscles and increasing muscle strength in the patients after arthroplasty of the hip joint. [30] Our studies showed the greatest increase in muscle strength was in the abductors group, which may be due to eccentric, concentric and static muscle work, using a combination of isotonic technique to strengthen the weakened abductors and extensors of the hip joint. An important part of the therapy were muscular coordination exercises and stabilization using stabilization reversal, rhythmic stabilization and combination of isotonics. These exercises were mainly based on the control of pelvis position in the sagittal and frontal plane, and the stabilization of the trunk. Training of the phase of support on the operated lower limb was also performed using approximation and irradiation, to improve stability, facilitate balance reactions, and stimulate the lower limb muscles. After PNF therapy concentrating on work on a stable trunk and pelvis alignment as well as adjusting the height of the crutches, we observed that the patient's gait became more confident and symmetrical with longer steps.

Conclusion

Applied PNF therapy, including dynamic (eccentric, concentric) and static muscle training, post-isometric relaxation, stabilization and control in stance phase, has resulted in improved mobility of the operated hip joint,

muscle strength, gait pattern and pain reduction in the patient. The case study demonstrated that a short (two-week) but intensive (over two hours per day) PNF therapy positively influenced selected motor functions after Total Hip Arthroplasty. A greater study group with more tests are required to draw far-reaching conclusions.

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