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The effectiveness of proprioceptive neuromuscular facilitation in the rehabilitation of patients following total knee arthroplasty: A narrative review

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Abstract

Total knee arthroplasty (TKA) is a widely performed surgical procedure for patients suffering from knee osteoarthritis (OA), with postoperative rehabilitation being vital for restoring function and mobility. Proprioceptive Neuromuscular Facilitation (PNF) emerges as a promising approach in enhancing outcomes post-TKA. This review aims to assess the efficacy of PNF in TKA patients with OA. Through an extensive literature search, five articles encompassing 259 participants were analyzed. Results indicated significant enhancements in gait parameters, balance, range of motion, and pain reduction in intervention groups compared to controls. Notably, PNF exhibited superiority over conventional rehabilitation methods in various aspects of functional recovery. These findings underscore the potential of PNF as an adjunct to TKA rehabilitation, facilitating faster and more comprehensive recovery through its holistic neuromuscular re-education approach. However, further high-quality clinical trials are warranted to validate and broaden these observations.

Keywords: Knee osteoarthritis, total knee arthroplasty, Proprioceptive Neuromuscular Facilitation (PNF), exercise, rehabilitation

Introduction

Knee osteoarthritis is characterized by the gradual degeneration of articular cartilage, leading to friction between the articular surfaces and inflammation of the joint. It is the most common form of arthritis, affecting 13% of women and 10% of men over the age of 60 [1]. The disease manifests gradually and is typically characterized by pain, difficulty in walking, and reduced functionality of the patient [1]. The prevalence of the disease is directly associated with age, as recent research data indicate that the occurrence rate of knee osteoarthritis in individuals over 70 reaches 40% [1], as well as with increased body weight [2]. In advanced stages of the disease, the patient undergoes total knee arthroplasty, replacing the knee joint with an artificial joint. Therapeutic exercise following total knee arthroplasty is an integral part of patient rehabilitation within the framework of physical therapy care, as research has shown it reduces pain, improves knee joint range of motion, enhances strength, and functional ability of the patient [3, 4]. Besides tissue healing post-surgery, joint replacement naturally disrupts proprioceptive inputs, negatively impacting balance [5]. These deficits add to existing ones due to aging and disturbances in gait and movement patterns for an extended period, often resulting from osteoarthritis before the patient undergoes surgery.

Proprioceptive Neuromuscular Facilitation (PNF) is a physical therapy approach through which the therapist attempts to retrain the patient's normal movement by activating proprioceptors and through the processes of motor control and motor learning [6, 7]. PNF exercises are conducted with active patient participation and aim to introduce neural stimuli to muscle proprioceptors (muscle spindles and Golgi tendon organs) [8]. They mainly involve the application of diagonal patterns that mimic daily activities. Mobilizing the patient through PNF diagonal patterns introduces proprioceptive stimuli to the central nervous system, facilitating movement learning and consolidation at the brain level. The combination of different stimuli arising from proprioceptors, along with verbal and visual cues provided by

the therapist during exercises, constitutes the integrated proprioceptive facilitation upon which the PNF mechanism relies [9]. Research has shown that the PNF approach has a positive impact on patients following total knee arthroplasty due to osteoarthritis. However, despite the widespread use of PNF in clinical practice, its effectiveness does not seem to have been thoroughly investigated. The purpose of this review is to examine the effectiveness of the PNF approach in patients after total knee arthroplasty.

Methods

A narrative review was conducted to investigate the effects of PNF in individuals after total knee arthroplasty due to knee osteoarthritis. Separate searches were conducted from

November to December 2023. The PubMed, PEDro, and Science Direct databases were searched using various combinations of the following keywords: knee osteoarthritis, total knee arthroplasty, Proprioceptive Neuromuscular Facilitation (PNF), exercise, rehabilitation. Additional filters applied to the article search included clinical trial design and publication date within the last decade.

Results

Five articles with total sample of 259 were included in this review. The characteristics of the sources included in this review are listed below while Table 1 summarizes the characteristics of each research.

Table 1: Characteristics of the included studies

Author, Year	Number of participants	Intervention duration	Intervention type	Outcome measures	Conclusions
Fetlis <i>et al.</i> [5]	54	8 weeks	Control group: Conventional treatment Intervention group: Conventional treatment + PNF	BBS Postural sway	Statistically significant improvement in intervention group both in BBS score and center of mass displacement.
Alaca <i>et al.</i> [10]	30	8 weeks	Group 1: Conventional treatment + CPM Group 2: Conventional treatment + PNF	NRPS Knee ROM BDI Time of functional milestone Peak Torque MVC	Participants in the PNF group reached functional milestones earlier, while no differences were observed in torque and strength parameters between groups.
Jaczevska-bogacka & Stolarczyk [11]	48	3 weeks	Group 1: PNF Group 2: Conventional home-based exercise	Kinematic characteristics VAS pain	Improvement was observed in participants of the intervention group in all gait kinematic characteristics compared to controls, including reduced stance phase time, cycle time, and double support time, as well as increased swing phase velocity, step length, and pain reduction.
Park, [12]	10	2 weeks	Group 1: PNF + CPM Group 2: Conventional exercise + CPM	Kinematic characteristics	Statistically significant improvement in all gait parameters in the intervention group compared to controls.
Chow & Ng, [13]	117	3 weeks	Group 1: Self-stretching Group 2: Stretching with external weight Group 3: Physiotherapist-led stretching	Knee ROM	Researchers concluded that all three types of stretches equally improve active and passive range of motion.

BBS, Berg Balance Scale; BDI, Beck Depression Inventory; CPM, Continuous Passive Movement; MVC, Maximum Voluntary Contraction; NPRS, Numeric Pain Rating Scale; PNF, Proprioceptive Neuromuscular Facilitation; ROM, Range of Motion; VAS, Visual Analog Scale

Literature review

In a Greek study [5], the effect of adding a PNF-based exercise program to a standard physical therapy rehabilitation program was examined. Fifty-four older adults who underwent the same surgical technique for total knee arthroplasty participated in the study. The participants were divided into two groups (intervention and control). The first group (control group) received standard therapy, while the second group (intervention group) received the same standard therapy plus a PNF exercise program. Both programs lasted for 8 weeks. Static and dynamic balance were assessed using the Berg Balance Scale (BBS), and postural sway was evaluated before and after the intervention. The results of this study showed that participants in the intervention group exhibited statistically significant improvement in both BBS scores and postural sway compared to those in the control group ($p < .001$). The researchers attributed these improvements to the

addition of PNF exercises to the standard rehabilitation program.

In another study [10], the effectiveness of PNF was compared with the application of Continuous Passive Movement (CPM). Thirty participants after total knee arthroplasty were randomly divided into two intervention groups. All participants followed a standard 8-week rehabilitation program after surgery. Participants in one intervention group concurrently followed a PNF-based exercise program alongside the rehabilitation program, while participants in the other group followed a CPM program concurrently. Knee range of motion using a goniometer, pain intensity using the Numerical Pain Rating Scale (NPRS), functional recovery days using diary recordings, depression levels using the Beck Depression Scale, maximum torque, and maximum isometric strength of knee flexors and extensors using an isokinetic dynamometer were assessed before and after the intervention. The results

showed that participants in the PNF group achieved functional goals earlier ($p < .05$), while no differences were observed in torque and strength parameters between the groups ($p > .05$). The researchers concluded that PNF exercises can positively influence patients' functional recovery, providing better long-term outcomes.

In another study ^[11], the effectiveness of an individualized PNF-based program was compared to a conventional home-based program in middle-aged and older adult patients who underwent total knee arthroplasty due to knee osteoarthritis. In this study, forty-eight patients were enrolled and divided into two groups (intervention and control). Participants in the intervention group followed a PNF-based program consisting of 10 sessions over three weeks, with each session lasting 75 minutes for a total of 10 sessions, while the control group followed a conventional home exercise program. Kinematic gait characteristics and pain using the Visual Analog Scale (VAS) were assessed one day before surgery and at 1- and 6-months post-surgery. The results of the study showed statistically significant improvement in all gait kinematic characteristics in the intervention group compared to the control group. This improvement included a reduction in stance phase time, swing phase time, double support time, an increase in swing phase velocity and step length, and a reduction in pain ($p < .05$). The researchers concluded that the PNF program used was much more effective than the conventional home exercise program in improving gait kinematic characteristics and reducing pain.

In another pilot study ^[12], 10 older adults who underwent total knee arthroplasty due to knee osteoarthritis participated. The study investigated the effectiveness of PNF compared to a conventional strengthening exercise program. Participants were divided into two groups (intervention and control). Participants in the intervention group followed a program for two weeks, five times a week, lasting a total of 45 minutes, which included a 15-minute PNF application and 30 minutes of passive knee mobilization with a CPM device. In contrast, the control group followed a similar duration and frequency program, which included 15 minutes of conventional strengthening exercises and 30 minutes of passive knee mobilization with a CPM device. Gait kinematic characteristics were assessed before and after the intervention using a gait analysis system. The results demonstrated statistically significant improvements in all examined gait parameters in the intervention group compared to the control group ($p < .05$). Therefore, the researchers concluded that the application of lower limb exercises with PNF patterns effectively improves gait parameters in older adult patients after total knee arthroplasty.

Regarding the isolated application of PNF patterns compared to other stretching methods for increasing knee range of motion, in a study ^[13], the effectiveness of three different stretching protocols was investigated in 117 patients (average age 68.43 years) who underwent total knee arthroplasty due to knee osteoarthritis. The participants in this study were divided into three different groups. The first group followed a self-stretching program from a supine position using a suspension strap, which the patient controlled. With the help of this strap, the patient performed ballistic stretches. The second group followed a passive stretching program from the same position and using the same suspension unit, with the difference that, by shifting the position of the hip and using a weight placed on the ankle joint, the stretch was passively induced by gravity. The third group followed a PNF stretching program, administered by a physical therapist. All stretching programs

lasted for 3 weeks. The active and passive range of motion of the knee joint was assessed immediately after the first session and at the end of the 3-week intervention. The results of this study did not show statistically significant differences between the groups. The researchers concluded that all three types of stretching protocols equally improved the active and passive range of motion of the knee joint.

Discussion

From all the aforementioned studies, it emerges that the PNF approach has positive effects on the rehabilitation of patients undergoing total knee arthroplasty. In two of the studies, it was found that adding PNF to a conventional strength training program as part of postoperative rehabilitation further improves static and dynamic balance, reduces pain and depression, and contributes to faster functional recovery of patients ^[5, 10]. Moreover, the positive effects of PNF were evident when compared to conventional home-based exercise programs, both in the short and long term, as applying PNF for 3 weeks improved gait kinematics up to 6 months post-intervention ^[1]. This beneficial impact of the PNF approach on gait kinematics was also confirmed by another study that combined PNF exercises with CPM application ^[11]. This beneficial impact of the PNF approach on gait kinematics was also confirmed by another study that combined PNF exercises with CPM application ^[12].

According to research data, the positive effects of the PNF approach stem from its underlying philosophy rather than just the isolated application of its individual techniques ^[6, 14].

The PNF approach to musculoskeletal rehabilitation (and beyond) is based on retraining normal movement patterns at the brain level through motor learning and motor control, rather than merely applying strengthening exercises, which promote these mechanisms more indirectly and less targetedly ^[6]. Additionally, PNF exercises within the framework of brain retraining for the restoration of normal movement exploit the properties of the central nervous system to benefit the patient through reciprocal and autogenic inhibition, as well as through metriority relaxation ^[7]. For all these reasons, it is important for clinical physical therapists to apply PNF under the prism of an "integrated approach" rather than solely as a stretching technique ^[6].

Regarding the rehabilitation of total knee arthroplasty, these effects of PNF seem logical and can be interpreted as follows: As it is normal to replace a joint with an artificial one, and the impairment of proprioceptive receptors due to the long-term degenerative effects of osteoarthritis on the knee joint until the patient undergoes surgery, it leads to a disturbance in knee proprioception, which can also affect balance ^[5]. The application of PNF exercises aims to retrain these mechanisms, thus representing a more targeted approach to functional rehabilitation of patients after total knee arthroplasty compared to simply applying isolated strengthening exercises or range-of-motion exercises. This may be why the superiority of the PNF approach over other techniques is not demonstrated in cases where isolated PNF techniques are applied (e.g., as a stretching technique) rather than the PNF approach as a whole ^[6, 13].

Finally, it is worth noting that most of the above-mentioned studies were not considered high-quality clinical trials, as they had weaknesses regarding research design and the small number of participants. Therefore, the implementation of more clinical studies in the future is needed to investigate the effects of the PNF approach on patients with knee osteoarthritis after total knee arthroplasty.

Conclusions

The PNF approach significantly contributes to the rehabilitation of patients after total knee arthroplasty due to osteoarthritis. From the results of this review, it appears that PNF accelerates patients' functional recovery, improves balance and gait parameters, enhances the range of motion of the knee joint, and reduces pain. All these positive effects are attributed to the holistic approach of PNF. Therefore, physical therapists should apply it correctly in clinical practice rather than using isolated techniques. More research is needed in the future to explore the effects of PNF, both short-term and long-term, in these patients.

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