



Systematic Review

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Proprioceptive neuromuscular facilitation approach for low back pain: A review study

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Abstract

Introduction: Proprioceptive Neuromuscular Facilitation (PNF) is an exercise based on neuromuscular control by stimulation of proprioceptors. The PNF exercise is more popular in the treatment of neurological problems than for musculoskeletal disorders. Numerous research has been done on its application on low back pain (LBP) condition. However, there is not many studies review the application of PNF approach on LBP condition. The aim of this study is to review the PNF approach and explore on its effect on LBP condition. **Method:** This research uses a simple research literature review method. Data were collected through searches on research article databases such as Google Scholar and health research databases, namely PubMed, Cochrane PEDro and other scientific journals databases. **Result:** After searching for articles from the Google Scholar, PubMed, Cochrane and PEDro databases, several research results were obtained on the use of PNF in LBP conditions with the following results. There were 19 researches that has been published provided by the databases. **Conclusions:** All studies have shown that the PNF approach in patients with LBP, whether chronic or not, is sufficient to provide beneficial effects in reducing pain, increasing functional ability, postural control, trunk stability, the flexibility of the lumbar and hip, increasing FEV1 and increasing trunk muscle activity. Furthermore, in general, PNF also appears to be more dominant than other exercises for the management of LBP conditions.

Keywords: Physiotherapy, LBP, Exercise Therapy, PNF, Review.

INTRODUCTION

In physiotherapy practice, low back pain (LBP) is one of the most frequently encountered cases ^[1]. Physiotherapists have several options in the management of LBP ^[2]. According to several clinical guidelines, exercise therapy is one of the most recommended interventions ^[3-5]. Various types of exercise therapy have also proven good results in LBP conditions ^[6]. One type of exercise therapy that is rarely used in LBP conditions but gives good results is Proprioceptive Neuromuscular Facilitation (PNF) ^[7,8].

Proprioceptive Neuromuscular Facilitation (PNF) is an exercise therapy concepts based on neuromuscular control by stimulation of joint proprioceptors and muscle as well as sensory inputs from peripheral organs to influence motor outputs of the central nervous system and promote functional activity of daily living ^[9]. At beginning, PNF was developed by Dr Herman Kabath in the study on neuromuscular dysfunction with paralysis condition with collaboration with Magareth Knot in neuromuscular reeducation ^[10-12]. The main goal of the PNF approach is to facilitate an optimal structural and neuromuscular state. The PNF approach applies the principles of neurophysiological from sensorimotor system to manual evaluation and treatment of dysfunction in both neuromuscular and musculoskeletal problem ^[13].

A study by Westwater-Wood, Adams and Kerry, found that the use of PNF mainly for hemiplegic population that related with stroke condition ^[10]. Another review study also concluded that PNF has been used for many different types of impairments as a comprehensive exercise for rehabilitation, including the LBP condition ^[14]. The review showed that most of study in PNF was conducted in neurological condition such as stroke, gait problems, vital function and face rather than musculoskeletal condition. However, these two review studies only describe about the use of PNF in general condition and identified about the general information of PNF.

The use of PNF approach on LBP condition was started from the development of PNF techniques by Kofotolis & Kellis ^[15]. They were comparing Rhythmical Stabilization (RS) and Combination of Isotonic (COI) for female with chronic LBP (CLBP). The purpose of the previous study was examining the effect of RS and COI o flexibility and functional performance and trunk muscle endurance in subject with CLBP.

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Both techniques used in sitting position, which facilitate the flexion and extension of trunk movement. The RS is the isometric exercise against resistance of alternating movement trunk flexion or extension, with no motion intended for ten seconds. The COI consisted of alternating concentric muscle contraction for five seconds and eccentric contraction of agonist without relaxation for five seconds and resisted eccentric contraction and resisted maintained contraction for five seconds. Both RS and COI were applied for three sets of fifteen repetitions. The rest interval of 30 second was provided in each sets and 60 seconds in each repetition. The treatment regime was done for four weeks with five times in a week. In their study, reported that the RS and COI of PNF techniques defined as static and dynamic training that appropriate for improving the endurance of the trunk muscle and trunk mobility in people with LBP.

The principle of PNF approach on LBP was purposed to stimulate sensory-motor control training, as well as for stimulate the lumbar muscle proprioception [16]. In other previous studies, PNF was shown to have beneficial result compare to manual therapy, core stability exercise and ball exercise for LBP [17-19]. In addition, physiotherapists still have a paradigm that PNF only used for neurological condition. In the past, not many previous studies to review the PNF literature thoroughly addressed the use of the PNF approach for LBP condition. The purpose of this study is to highlight the PNF approach and explore on its effect on LBP condition. Also, in this study, a brief introduction of basic principles and procedure of PNF is reviewed.

METHODOLOGY

This research uses a simple research literature review method. Data were collected through searches on research article databases such as Google Scholar and health research databases, namely PubMed, Cochrane PEDro and other scientific journals. The keywords used in the article search were "Proprioceptive Neuromuscular Facilitation AND/OR Low Back Pain". All articles that have been obtained are then collected and selected only articles published around 2015-2021. The inclusion criteria in the search for articles were the results of research under 2015 and did not use English. The basic search for the principles and philosophy of PNF is also presented as a basic scientific presentation from various books and other scientific sources.

RESULT AND DISCUSSION

PNF Basic Philosophy and Principles

In order to treat the patient, PNF have some aims to get the therapeutic result. The PNF approach is based on a facilitation procedure which provides tools for the therapist to help the patient gain efficient motor function and increased motor control [10]. The effectiveness of PNF does not depend on having the conscious cooperation of the patient. The basic procedures of PNF were used to improve the patient's movement or stability, guide the motion by proper grips and optimal resistance, help the patient to get coordinated motion through timing and improve the patient's stamina and avoid tiredness [14]. Adler, Beckers and Buck described that the basic philosophy of PNF were positive approach with no pain and achievable task, highest functional level approach include the treatment of impairments and activity level, mobilize potential by intensive active training, consider the total human being and use motor control and motor learning principles [9]. Those principles is an essential part of the approach and provides the basis for developing consistency throughout the evaluation and treatment process [13].

Motor Control and Motor Learning Principles

As the main principles, motor control and motor learning are the things that underlie the concepts and principles of implementing PNF. These principles will greatly assist the application of PNF by physiotherapists

to improve the patient's ability to achieve optimal results [9]. In motor control there are four underlying phases, namely mobility, stability, controlled mobility or mobility in stability and the last is skill. The four phases of motor control are adapted in several procedures and techniques in PNF so that patients can respond well to return to activities [20].

Whereas in motor learning, it is how physiotherapists prepare treatment plans for patients by providing movement learning with specific tasks and with specific goals [9]. The tasks assigned by physiotherapists to patients will vary according to each end goal of the treatment given by taking into account biomechanical, psychological and neurophysiological factors [20,21]. The workings of the motor control and motor learning system refers to a neurophysiological principle called Reciprocal Innervative, namely the contraction reflex activity is facilitated when the contraction of the antagonist muscles suddenly stops [20]. The stronger the antagonist's contraction, the greater the facilitation effect. The reciprocal innervative mechanism is carried out by Proprioceptive, namely golgy tendon organs and muscle spindles. Thus, PNF uses proprioceptive stimulation based on motor control and motor learning to get the ultimate goal of the patient being treated [9].

PNF Basic Procedures

PNF have some basic procedures that were used to treat the patient, the basic procedures will guide the therapist to perform maximal response from patient. The basic procedures consist of ten elements [9,14]. The first procedure is resistance, which is used to facilitate muscle contraction and motor control, to increase strength and aid motor learning. Second, Irradiation and reinforcement, that is spreading of the response to stimulation. The third is manual contact, which is used to increase the power of the movement and guide motion with grip and pressure. Forth, body position and body mechanics, used for guidance and control of motion or stability. Fifth, verbal commands, use of words and the appropriate volume of physiotherapist vocal command to direct the patient. Sixth, vision, which is use of vision to guide motion and increase force. Seventh, traction or approximation is the elongation or compression of the limbs and trunk to facilitate motion and stability. Eighth, stretch, which is the use of elongation of the muscle and stimulate the stretch reflex to facilitate contraction and decrease muscle fatigue. Ninth, timing, which is to promote normal timing and increase muscle contraction through "timing for emphasis". Tenth, patterns, are the synergistic mass movements or the components of functional normal motion.

There are some PNF patterns can be applied to treat the patient. The pattern is based on normal function motion that composed of mass movement pattern of the limb and synergistic trunk muscles. Based on the diagonal movement, the PNF pattern combines of three planes those are sagittal plane for flexion and extension, frontal plane for abduction and adduction of limbs or lateral flexion of the spine, and transverse plane for rotation [14,15].

PNF Techniques

In general, when preparing to treat the patient, the right techniques should be chosen depending on the type of treatment the patients require [10,14]. There are ten techniques of PNF that can be used to treat the patient. The techniques are rhythmical initiation, combination of isotonic, dynamic reversal, stabilizing reversal, rhythmical stabilization training, repeated stretch from beginning of range, repeated stretch through range, contract-relax, hold-relax and replications. In order, choose the techniques, combination of two or more techniques to be used [9]. The PNF exercise should be combine the basic procedure and the techniques when applied to the patient [14].

Research Review of PNF on Low Back Pain

After searching for articles from the Google Scholar, PubMed, Cochrane and PEDro databases, several research results were obtained on the use of PNF in LBP conditions with the following results. There were 19 research that has been published provided by the databases.

Author (Year)	Type of Study	PNF Approach	Comparison	Types of LBP	Result and Conclusion
Jadeja, (2015) ^[22]	Randomised controlled trial	RS and COI on Trunk Pattern combined with conventional back exercise	Conventional Back Exercise	Chronic non-specific LBP	The PNF approach to the back is effective in reducing pain and improving core muscle strength.
Young et al., (2015) ^[23]	Quasi-experimental study	PNF integration pattern (PIP) (PNF-applied cross training program)	Swiss ball exercise	Chronic Non-specific LBP	The PNF integration pattern showed that improved the balance ability of elderly patients with LBP
Kumar & Moitra, (2015) ^[24]	Quasi-experimental study	PNF Stretching	Muscle Energy Techniques Static Stretching	Chronic non-specific LBP	This study showed that the MET, PNF and static stretching can be used as an effective therapeutic combination to decrease pain, and improve ROM of the tight hamstring in LBP condition
Mavromoustakos et al. (2015) ^[25]	Randomized controlled trial was	Consist of 11 using PNF techniques used with 11 form of exercise from seated, supine, and standing or waking.	General Exercise Group	Chronic non-specific LBP	The PNF approach is more effective to reduce pain and increase the functional ability.
Areeudomwong et al. (2017) ^[26]	Randomised control trial study	RS and COI on Trunk pattern.	LBP educational booklet	CLBP	The study found that PNF has a good effect in the long-term on pain reduction and increases muscle activity in LBP condition
Kim & Lee, (2017) ^[27]	Quasi-experimental study	Rhythmical Initiation, Stabilization, Hold Relax, Contract Relax, RS and COI in seated and lying (supine, hook, side and prone)	Traditional Physical Therapy Intervention	CLBP	The PNF was showed effective improving pulmonary function and decrease pain and improve the functional ability of LBP condition
Malla et al. (2018) ^[28]	Quasi-experimental study	RS on Trunk Pattern	Motor Control Exercise on Ball	Chronic non-specific LBP	The PNF with RS trunk pattern and Motor control exercise showed the same beneficial result on reduce pain, and disability and improving the Lumbar ROM in LBP conditions.
Anggiat et al. (2018) ^[8]	Quasi-experimental study	RS and COI on Trunk pattern	McKenzie and Home Exercise	Chronic non-specific LBP	The PNF showed better results in reducing the pain compared to the McKenzie method in LBP condition.
Zaworski & Latosiewicz. (2018) ^[29]	Single-blinded RCT	PNF for Trunk	Manual Therapy, PNF with Manual Therapy and Traditional Kinesiotherapy	Non-specific LBP	The PNF combined with manual therapy showed more improvement in functional capability. But, all treatments gave the same result in reducing pain and disability.
Areeudomwong & Buttagat, (2019a) ^[7]	Randomised controlled trial	RS and COI on Trunk pattern	Core stabilisation exercise (CSE) and Control group (General Trunk Strengthening and Ultrasound Therapy)	CLBP	The PNF group and CSE group showed similar results in the short and long term in reducing pain, and functional disability and improving patient satisfaction in LBP conditions.
Areeudomwong & Buttagat, (2019b) ^[30]	Randomised controlled trial	Modified RS and COI on Trunk pattern and bilateral diagonal limb movements, with maximal resistance.	General trunk exercise programme	CLBP	The PNF training provides a greater result in the reduction of pain and improving the functional ability and static balance in LBP conditions.
Singh et al. (2019) ^[31]	Quasi-experimental study	Rhythmic Stabilization Exercise on trunk	Conventional back exercises	CLBP	The PNF approach using rhythmic stabilization showed more good in reducing pain and functional

					disability compared with conventional treatment.
Saxena & Thiyagarajan, (2020) ^[32]	Quasi-experimental study	Scapular and pelvic pattern of PNF (with Conventional strengthening exercises)	Conventional strengthening exercises alone	Non-specific LBP	The PNF approach showed more good in improving pain index and flexibility of the lumbar spine.
Anggiat et al., (2020a) ^[2]	Quasi-experimental study	RS and COI on Trunk pattern	Mc Kenzie and Home Exercise	Chronic non-specific LBP	The PNF with other compared treatments showed there was no difference in improving lumbar ROM in LBP conditions.
Anggiat et al., (2020b) ^[34]	Quasi-experimental study	RS and COI on Trunk pattern	Mc Kenzie and Home Exercise	Chronic nonspecific LBP	The PNF approach exercise has more effect in improving functional disability in LBP conditions.
Kim et al. (2021) ^[35]	single-blinded, Randomized clinical trial	General Physiotherapy and Trunk stabilization exercise combined with PNF stretching was performed using contract-relax techniques of agonists in supine, prone, side-lying, and half-kneeling positions	General Physiotherapy and Trunk stabilization exercise combined passive static stretching in the supine, prone, side-lying, and half-kneeling positions.	CLBP	The PNF approach with general physical therapy treatments and PNF stretching were effective in reducing pain, improving hip ROM, and decreasing dysfunction.
Sipko et al. (2021) ^[36]	Quasi-experimental study (Pilot Study)	Stabilizing reversal technique, COI, Rhythmic Initiation	Tilting the trunk forward. Transition from sitting to standing position with the assistance of a therapist.	CLBP	The PNF approach with a single session showed a better effect on pain and postural control in LBP conditions.
Nugraha et al. (2021) ^[37]	Randomized controlled trial	Various PNF approach combined with Kinesiotaping (KT) and Ultrasound Therapy (UST)	Sensory motor training (SMT) combined with KT and UST	Non-specific LBP	The PNF approach with other group comparisons showed similar results in reducing pain, increasing ROM of LBP condition.
Park, (2021) ^[38]	Experimental Study	Biofeedback PNF lower limb pattern.	-	CLBP	The PNF lower pattern with biofeedback was suggested to increasing abdominal muscle activity and decreasing unwanted lumbopelvic rotation in patients with LBP.

From the results obtained, PNF is considered to have a good effect on the condition of LBP. Most of the LBP conditions used in this study were Chronic Nonspecific LBP conditions. Although, in some of the article titles obtained it is not said to be nonspecific. However, the inclusion criteria of existing studies indirectly state the nonspecific condition of LBP.

Starting in 2015, there were 4 studies which suggested that PNF was dominant over other exercise therapies. The first is a research in 2015 by Jadeja, with the Randomized Controlled Trial method with a PNF approach that refers to previous research by Kofotolis & Kellis [22]. However, this study compared PNF with conventional back exercise which consisted of several standardized circuit exercises with several components of body weight training. PNF doses with comparison exercises were made equivalent by the researcher and supervised by a physiotherapist. In addition, both groups were given the same intervention by a physiotherapist in the form of inferential therapy (IFT). The results also state that PNF is better than conventional back exercise in terms of reducing pain and increasing core muscle strength. Then, a research by Young et al., stated almost the same thing. However, differences occur in the PNF method approach [23]. In their research, the PNF approach used is the PNF Integrated Pattern (PIP) which is combined in a cross-training program. Furthermore, the parameters used are not only pain, but also balance, with the research subjects being elderly patients with chronic LBP. However, PNF remained dominant in reducing pain and improving balance compared to Swiss ball exercises.

PNF research with other approaches was also carried out by Kumar & Moitra [24]. They took the PNF approach with the Contract Relax technique on the hamstring muscles which were considered to have reduced flexibility due to LBP. In their study, they also compared it with Muscle Energy Techniques and Static Stretching, but the results of these three interventions were equally good in increasing the flexibility of the hamstring muscles in LBP patients.

Furthermore, a fairly comprehensive study using the randomized control trial method was carried out by Mavromoustakos et al., where they carried out an intensive PNF approach to their research subjects without following or modifying the PNF approach by Kofotolis & Kellis [25]. The PNF approach consisted of 11 exercises in a sitting to standing position. The exercises are also carried out progressively with several criteria. Likewise, in the comparison group, the exercises used also included standardized exercises from previous studies with progressive stages. The results of their study also showed that PNF was quite impressive in reducing pain and increasing functional ability, even improving trunk stability and mobility compared to the general exercise group in chronic LBP patients.

In 2017, there were not many published studies related to PNF in Chronic LBP conditions compared to 2018. However, there were 4 studies that were quite similar in between 2017-2018. Started in 2017, there is a research by Areeudomwong et al., who modified the PNF approach by Kofotolis & Kellis, which is divided into phases 1 and 2 in the first and second weeks by focusing on the patient's understanding of the exercise pattern given by the physiotherapist [26]. Then at the end of the phase, maximal resistance is given to trunk movements both in rotation and diagonal directions using bilateral diagonal limb movements. The research method used was a randomized control trial with a comparison of the control group given the LBP educational booklet. In the end, there were good results from the PNF group in terms of reducing pain and increasing back muscle activity in LBP patients.

With modifications and variations in both sitting and lying positions, Kim & Lee also used PNF for the condition of subjects with CLBP [27]. However, in their research, PNF was compared with Traditional Physical Therapy (TPT) Intervention, namely hot packs, Interferential

Therapy (IFT) and ultrasound. In this study, additional parameters besides pain and functional disability were used, namely Forced Expiratory Volume at 1 second (FEV1). The results show that the PNF approach is better than the TPT intervention in terms of reducing pain and disability and increasing FEV1. This result becomes a new addition because it measures respiratory capacity with the use of PNF in CLBP patients.

Then, there are two further studies that use and follows the PNF approach in LBP conditions by Kofotolis & Kellis. The first research was conducted by Malla et al., which only uses RS on the Trunk pattern and compares it with the Motor Control Exercise method [28]. The result obtained is that the PNF approach with the RS technique is better than Motor Control Exercise in LBP patients in terms of pain, disability and Lumbar ROM. Then, there is a research by Anggiat et al., which specifically uses the PNF approach with the RS and COI techniques and then compares the two groups, namely the McKenzie Method and LBP Exercises at home [8]. However, the only parameter that was examined was the change in pain of the LBP patients who were their study subjects. The results obtained also show that PNF has a more significant effect in reducing pain than McKenzie and Home Exercise. Both studies used the same quasi-experimental method while still randomizing the subject. One slightly different study was conducted by Zaworski & Latosiewicz [29]. Their study used a single-blinded RCT, then they compared 4 intervention groups. The four intervention groups are Manual Therapy, PNF for Trunk, PNF with Manual Therapy and traditional kinesiotherapy. All treatments were performed on patients with nonspecific LBP and resulted in the same reduction in pain. However, subjects in the PNF group with a combination of manual therapy had a better effect on reducing disability. However, this research cannot be accessed in full because what can be accessed is only the abstract of the article. The use of techniques and procedures is not explained so that it cannot be studied further by the researcher.

In the span of 2019, there were two studies by Areeudomwong and Butttagat. First, they used the same PNF approach as the previous study and compared them with two groups, namely core stabilization exercise and control group (general strengthening exercise and ultrasound). From this study, the three groups produced the same good results [7]. Then, the second study modified the PNF approach and compared it with general trunk exercise alone. The results of their second study showed that the PNF approach was better at reducing pain, reducing disability and static balance [30]. Both studies were conducted using a Randomized Control Trial.

Then, there is a research from Singh et al., which used only one technique, namely RS on the trunk and compared it with conventional back exercise [31]. Their research resulted in RS on the trunk providing pain relief and increased functional ability. It is almost the same as other research by Saxena & Thiyagarajan, which added conventional strengthening exercises to the PNF approach with the scapular and pelvic pattern [32]. Thus, their study stated that PNF was better than conventional strengthening alone in reducing pain, disability and lumbar flexibility in CLBP patients.

Anggiat et al., published two of their same study in 2018. However, the difference is in the results, which is in the evaluation of lumbar ROM which states that PNF is as good as McKenzie and the control group [33]. On the other hand, the PNF approach gave better results in reducing disability compared to McKenzie and the Control group [34].

Finally, in 2021, there were three published studies of PNF in CLBP patients. First, there is a study by Kim et al., which provides a PNF contract relax approach to the iliopsoas muscle combined with trunk stabilization exercise and general physiotherapy treatment and compared with passive static stretching combined with the same basic intervention [35]. The result is that PNF with combination intervention is better in reducing pain, increasing hip ROM and reducing dysfunction

of CLBP patients. Furthermore, there is also a research by Sipko et al., where their study only looked at the effect on acute conditions after one PNF session compared to general exercise [36]. They found that PNF resulted in reduced pain and improved postural control in CLBP. Their research model is a form of pilot study as the beginning of their main research.

Other research by Nugraha et al., used the PNF approach and combined it with kinesiotaping and ultrasound therapy and then compared with sensory motor training combined with the same intervention in the PNF group [37]. The results of this study showed that both groups gave the same effect in reducing pain, increasing ROM and reducing pain in nonspecific LBP patients. However, the PNF approach in this study is not detailed, because it only shows the pattern used in the scapula and pelvis but does not provide what technique is used.

Subsequent research was carried out by Park, which did not compare the PNF approach to other exercises [38]. The researchers only conducted experiments on the use of biofeedback combined with the PNF approach. The results of this study showed that PNF in combination with biofeedback provided an increase in abdominal muscle activity and control of trunk stability in CLBP patients.

This study is a simple literature review study, but includes almost all research on PNF in LBP conditions from the 2015-2021. However, some studies may not be included in this study due to the limitation of researchers in searching the literature, research results in journals that have not been indexed in the database, and research results that are not in English. Although there are two studies in the form of systematic review and meta-analysis, research with the same method is very much needed by taking into account the limitations in this study and including more complete publication data [39,40]. Two of those studies were published before this research was published. Research using the PNF approach from all articles presented are with quite diverse patients, but still almost the same in the condition, namely Chronic NSLBP. Therefore, it can be said that the PNF approach can be given to all patients with NSLBP.

CONCLUSION

All studies have shown that the PNF approach in patients with LBP, whether chronic or not, is sufficient to provide beneficial effects in reducing pain, increasing functional ability, postural control, trunk stability, flexibility of the lumbar and hip, increasing FEV1 and increasing trunk muscle activity. In addition, there are many variations of the PNF approach in LBP patients by investigators. Although not uniform, the most frequently used approach techniques are RS and COI. This needs to be a concern and it is very reasonable because physiotherapists have different ideas when applying the PNF approach to patients. Furthermore, in general, PNF also appears to be more dominant than other exercises for the management of LBP conditions. But still, exercise or other interventions can also be combined to provide optimal results in patients with LBP.

Recommendation

Physiotherapists can use the PNF exercise approach in LBP conditions in a wider practice, not limited to procedures and techniques, but rather leading to the patient's functional movements. Physiotherapists are also expected to start using PNF more in research in order to contribute to the development of interventions for LBP conditions in particular and musculoskeletal conditions.

Conflicts of interest

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Authors Contribution

Conceptualization- Lucky Anggiat, Novlinda Susy Arianawati Manurung, James Wilson Hasoloan Manik.

Methodology- Lucky Anggiat, Novlinda Susy Arianawati Manurung

Formal Analysis- Novlinda Susy Arianawati Manurung, James Wilson Hasoloan Manik

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