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The effect of proprioceptive neuromuscular facilitation stretching exercises on pain and postural balance in patients with knee osteoarthritis

Dwi Rosella Komalasari[1*], Raden Andrea Zalfa Zaki Gazella[1]

ABSTRACT

Background: Osteoarthritis is a degenerative disease that can cause pain, stiffness, and reduce balance function, thus interfering with daily activities. Proprioceptive Neuromuscular Facilitation Stretching (PNFS) can increase proprioceptive stimulation and activate muscles, reducing pain and improving postural balance in the OA knee. This study aimed to determine the effect of PNFS on reducing pain and increasing postural balance in patients with knee OA.

Methods: This type of research was an experimental study with a quick experimental approach without a control group. Nineteen respondents with knee OA were taken by purposive sampling and met the inclusion and exclusion criteria. PNFS was done with the hamstring and quadriceps muscles twice a week for four weeks. The pain was evaluated using a numeric rating scale (NRS), while the dynamic balance was assessed by the timed up and go test (TUG), and static balance was examined by the one-leg stance (OLS) as well as Functional Reach Test (FRT).

Results: There was a significant positive effect of PNFS to reduce pain and improve TUG, OLS, and FRT with *p*-values <0,05, respectively.

Conclusion: Pain is the main problem in OA knee and reduced balance. However, PNFS exercises were recommended for rehabilitation management in patients with knee OA.

Keywords: knee osteoarthritis, pain, postural balance, proprioceptive neuromuscular facilitation.

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INTRODUCTION

Osteoarthritis (OA) is a degenerative joint disease in the elderly. It is characterized by increasing joint pain, stiffness, and limited range of motion (ROM).[1] OA knee happens in the knee joint frequently.[2] OA is considered a disease that is difficult to avoid with age that will damage joints and bone, followed by the formation of new bone or osteophytes on the joint surface.[3]

OA is characterized by pain, especially when moving to knee flexion, stiffness, articular deformation, decreased range of motion (ROM), and physical disability. This occurs due to postural instability, which can increase the internal pressure on the knee joint structures, especially on the subchondral bone, which causes activation of nociceptive fibers and increases pain.[4] Pain is a major problem in knee OA, and is the beginning of a progressive decline in quality of life resulting in decreased muscle strength and changes in gait, decreased walking speed, decreased body postural balance, and increased risk of falling.[2] Elderly who experience severe knee pain will complain of more difficulties in carrying out various activities compared to people with mild knee pain.[5]

Pain can impact activity limitations and cause physical function deficits, including a decrease in postural stability, so the risk of falling increases.[6] Pain, decreased muscle strength, limited knee joint range of motion, and decreased functional activity in knee OA are ongoing problems.[7] Decreased muscle strength, especially in the quadriceps femoris and hamstring muscles, is an important problem because these muscles play an important role in maintaining the body's postural balance.[8] The decrease in the quadriceps femoris muscle is progressive with increasing pain and continues with a decrease in hamstring muscle function that will increase the risk of falling.[9,10]

Many interventions have been applied to knee OA with various perspectives, including stretching techniques[11], including the Proprioceptive Neuromuscular Facilitation Stretching (PNFS) technique. Stretching is done continuously and regularly to increase muscle flexibility, activate extrafusal muscle fibers, and improve muscle connection. Previous studies suggested that prolonged stretching can significantly improve the range of motion and balance.[12] PNFS is a stretching technique that can combine with several designs, as well as contract-relax stretching (CR), hold

[1]Physiotherapy Department, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, Indonesia.

*Corresponding to:
Dwi Rosella Komalasari;
Physiotherapy Department, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, Indonesia;
drks133@ums.ac.id

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relax stretching (HR), and contract-relax agonist contraction (CRAC).[1,2,3]

Many PNFS techniques and static or dynamic stretching formulas are reported to increase muscle flexibility effectively. Unfortunately, combining these three techniques (CR, HARI, and CRAC) still needs to be improved in previous literature, especially for postural balance.[13] Therefore, this study aimed to observe the effect of a combination of PNFS (CR, HARI, and CRAC) techniques on pain and postural balance in knee OA patients.

METHODS

All participants signed informed consent before the interview and testing. The study protocol was approved by The Medical Research Ethics, Medical Faculty, Universitas Muhammadiyah Surakarta, protocol number 4538/B.1/KEPK-FKUMS/X/2022. This study was conducted at Physiotherapy Department, Pandan Arang Hospital, Boyolali, Central Java, Indonesia, from October 2022 to January 2023. This study was a quasi-experimental study without a control group design. There were 19 respondents involved in this study taken by purposive sampling and who met the inclusion criteria, such as (1) had a medical diagnosis of unilateral knee OA, (2) having patient aged 45-75 years, (3) having OA with at least grade 2 based on the *Kellgern-Lawrance* classification, (4) knee pain of at least three as measured by NRS, (5) the patient was able to walk without the assistive devices and able to communicate well. As for the exclusion criteria; (1) had complaints of low back pain related to knee OA, (2) had a history of surgery on the lower extremities, and (3) had neurological diseases such as stroke, Parkinson's, and cerebral palsy.

In this study, respondents were given treatment using the PNFS technique two times a week for four weeks with a dose of each method of 3-4 x repetitions and 1-2 sets. PNF stretching techniques used in this study include hold relax (HR), contract-relax (CR), and contract-relax agonist contract (CRAC). Pain and postural balance were evaluated before and after treatment. The pain was assessed with the NRS, where the scale was 0 (no pain at all and 10 (unbearable pain).[14] Postural balance was measured as dynamic balance and static balance. Emotional balance was measured by the timed up and go test (TUG), while two tests examined static balance. There were the one-leg stance test and the functional reach test. The TUG test measures balance during mobility in clinical or community settings. The patients perform walking for 3 meters and back to sit again. They used their regular footwear.[15] The participants tried once to become familiar with the test. The faster time indicated a better performance than recorded seconds.[16] The time was ≥ 13,5 seconds, indicating a high risk of falling.[17] TUG could also predict a fall with 80% and 56% sensitivity and specificity, respectively.[18] The OLS reported they had good reliability for some populations. It had excellent internal consistency in patients with hip OA (ICC=0,91).[19] Four positions do it for the right and left sides of the leg in the open and eyes closed.[20]

The FRT was used to measure static balance, whereas the participants stood beside the wall with feet apart at shoulder width and barefooted. The shoulder flexed 90 degrees with the elbow extended, and held the hand, then recorded the starting point in the third metacarpal bone. I asked the participants to reach forward as far as without taking a step, then measured the ending point. Distance called was the difference between the starting and ending points. The participants were allowed to try once before being tested. The score was the average between twice performances in centimeters.[21]

The statistical analysis used the statistical software package SPSS for Windows version 18 (SPSS Inc., Chicago, IL, USA). The univariate analysis presented respondents' characteristics, including frequency (n), minimum value, maximum value, mean and standard deviation. While to determine the effect of PNF stretching on pain and postural balance used, the *wilcoxon* analysis by.

Hold relax for the Hamstring muscle was done in the supine position. The therapist held the knee and ankle, then moved to the hip and flexed passively until the range of the patient's tolerance. This movement was born for 5 seconds, then instructed the patient to inhale, therapist gave resistance, and the patient tried to load for 10 seconds, then relaxed. Repeated this movement and increased the degree of hip flexed by the therapist. Did this section 3-4 times. At the same time, the quadriceps muscle was applied in a prone position. The therapist moved the knee patient to flexion up to the patient's pain threshold. Then, the therapist slightly lifts the patient's hip/hip extension until you feel stretched, then hold for 5 seconds, then the patient is instructed to inhale and hold for 10 seconds, then exhale after the patient exhales, the patient is asked to have hip extension performed by the therapist for 10 seconds, after the therapist moves the hip extension ask the patient to relax repeat the above procedure 3-4x by increasing the degree of patient's hip extension movement.[22]

Whereas the Contract Relax (CR) technique is performed on the hamstring muscles in a supine position, the therapist moves hip flexion passively

Table 1. Characteristics of respondents

Variable	Frequency (%)	Mean ± SD	Minimal	Maximal
Age		60 ± 7,2	47	73
Gender				
Male	4 (21,1%)			
Female	15 (78,9%)			
OA affected				
Right side	12 (63,2%)			
Left side	7 (36,8%)			
Duration of OA (months)		19,2 ± 8.2	7	38
Pain (NRS)		6 ± 1,6		
Grade				
Grade 2	12 (63,2%)			
Grade 3	7 (36,8%)			
Scale, OLS (seconds)				
Right side, open eyes		2,9 ± 1,7	0,3	5,7
Right side, eyes closed		1,2 ± 0,8	0,2	3,6
Left side, open eyes		2,9 ± 1,3	1,1	5,1
Left side, eyes closed		1,4 ± 0,7	0,0	2,9
FRT (centimeter)		9,2 ± 4,2	3	16
TUG (seconds)		14,2 ± 3,7	10,8	26
Low-risk to fall	11 (57,9%)			
High-risk to fall	8 (42,1%)			

Abbreviations: OA=Osteoarthritis, NRS=Numeric Rating, OLS=One Leg Stance, FRT=Functional Reach Test, TUG=Timed Up and Go test

Table 2. Effect of proprioceptive neuromuscular facilitation stretching (PNFS) for pain and postural balance

Variable	Negative ranks	Positive ranks	p-value
Pain	19	0	< 0,001
OLS for the right side, eyes open	0	19	< 0,001
OLS for the right side, eyes closed	1	18	0,001
OLS for the left side, eyes open	0	19	< 0,001
OLS for the left side, eyes closed	1	18	< 0,001
FRT	0	19	< 0,001
TUG	16	3	0,003

Abbreviations: OLS = one leg stance, FRT=functional reach test, TUG=timed up and go test

withheld onto the patient's knee, hip flexion is adjusted to the patient's ability and held for 5 seconds, then instructs the patient to inspiration and expiration, after the patient exhales, the patient was asked to do an isometric contraction at 75% -95% of the patient's strength and do it for 10 seconds, repeat the procedure 3-4x by increasing the degree of hip flexed. Whereas the quadriceps was done in the prone position, the therapist lifted or moved to the extension of the patient's hip slightly until the patient felt stretched on quadriceps muscles, then held this position for 5 seconds. The patient was instructed to inhale and exhale. After exhaling, the patient was asked to do isometric contraction at 75% -95% of the patient's strength and held for 10 seconds. This section was repeated 3-4x by increasing the degree of the patient's hip extension motion.[22]

Contract-Relax Agonist Contraction (CRAC) is a combination of CR techniques. The hamstring muscles were done in a supine position. The therapist moved the hip flexion passively by the fixation on the patient's knee, adjusted the hip flexion according to the patient's ability, and held this position for 5 seconds. The patient was asked to inhale and exhale, and at the end of the exhalation, asked the patient to do isometric quadriceps contractions for 10 seconds. Repeated this procedure 3-4 times by increasing the degree of the patient's hip flexion.

Whereas the CRAC for the quadriceps muscle was done in a prone. The therapist lifted the hip and extended it until it was stretched and held for 5 seconds. The patient was instructed to inhale and exhale, then asked the patient to do isometric contraction for the hamstring muscle. It was performed for 10 seconds. Repeated the procedure 3-4 times and increased the patient's degree of hip extension.[22]

RESULTS

Table 1. The average age of the respondents was above 60 years, with a minimum age of 47 years and a maximum of 73 years, with mostly females (78.9%). The minimum score of pain was three, and the maximum was nine. The respondents with the right side of OA were higher than the left side, and the duration of OA was about 19 months. More than 50% of respondents had grade 2 of OA.

The ability to maintain balance with the OLS test detected that the eyes closed were lower for the right and left sides than the open eyes test. The average ability to maintain static balance with OLS under closed-eye conditions shows that the power is far below the 10-second value.[15]

FRT test noticed an average value of 9,2 centimeters, while the normal value is 25-38 cm.[23] The average TUG test for respondents in this study showed 14,2 seconds, included in the low-risk category. The TUG test showed that almost 50% of respondents were categorized as having a high risk of falling. Furthermore, Table 2. Shows there was a positive effect of PNFS in reducing pain and increasing postural balance (static and dynamic) in patients with OA knee ($p<0,05$).

DISCUSSION

The average age of the respondents in this study was 60 years. This result was the same statement from WHO in 2015 that the prevalence of knee OA sufferers worldwide reaches 9.6% in men and 18% in women aged over 60 years.[16] Obesity is one of the risk factors for worse OA conditions.[24] Obesity is often associated as a factor that can exacerbate knee OA in patients and can impact 4 to 5 times more on accelerating damage to the joint cartilage structure because obesity can increase the biomechanical load on the knee joint during activity.[25,26] The results of previous studies stated that the prevalence of obese patients who can cause OA is 71.4%.[27]

In OA, women have a greater risk than men. This can be caused by several factors, one of which is hormonal changes in old age or what is known as menopause. The occurrence of menopause causes a reduction in the hormone estrogen, which can increase the risk of OA because several previous studies have shown that estrogen is involved in regulating cartilage metabolism and affecting the activity of joint tissue.[28] The anatomical structure of the knee between women and men also differs. Women have larger hip bones, narrower femurs, thinner patellas, larger angles in the quadriceps, and differences in the size of the condyle in the tibia, thus affecting the possibility of knee injuries. Women are also more prone to developing knee OA than men.[29] Based on the results of the effect test, the results were that there had a positive effect of PNFS administration for four weeks on reducing pain and static and dynamic balance in patients with knee osteoarthritis. This study's results are similar to previous studies, showing that PNFS can positively influence symptoms, relieve pain, and improve body balance.[30,31] Pain is the main symptom of many medical conditions, and the severity of pain has become an important component in formulating an appropriate and effective treatment.[32]

PNFS is an option to reduce pain in OA. PNFS is performed by stretching the muscles and doing the isometric resistance to the same powers, thereby causing nerve inhibition and reducing reflex activity. Inhibiting neurons can reduce motor neuron activity which results in muscle relaxation. Decreased resistance causes changes in blood flow and increased motor activity that affects vascular function. Muscle activation releases vasoactive substances that result in blood vessel dilation. The resulting blood vessel dilation removes pain-producing substances, which can then reduce pain.[33] according to the classic pain gate theory, peripheral pain and pressure receptors are connected to the same interneurons at the lower end of the spinal cord. Pain receptors are connected to small myelinated or unmyelinated afferent fibers, whereas pressure receptors are connected to larger ones. Pressure signals are transmitted down the spine before pain signals when both receptors are stimulated simultaneously.[34]

This study showed that PNFS positively affected static balance in patients with knee OA. Based on previous research stated that PNFS is useful for static balance in patients with knee OA.[34] PNFS is a technique to improve movement function by stimulating muscles, tendons, and joints and increasing muscle strength, flexibility, and balance. PNFS is used as an intervention in musculoskeletal disorders of muscles, bones, and joints.[31] The principle of PNFS is to provide contractions and produce more muscle power which will be maximized when implementing various patterns simultaneously. Combination patterns are better at increasing proprioception, strength, and movement coordination, thus increasing torso stability.[35] PNFS can also stimulate muscle and joint proprioceptors in the knee and improve sensorimotor regulation and balance performance.[36]

PNFS had a positive effect on dynamic balance in patients with knee OA as well in this study. A previous study reported PNFS as a stabilization exercise that can improve balance and gait.[37] The neuromuscular mechanism system preparing a movement in responding to activity needs to be easier. Thus, PNFS can stimulate the proprioceptors to increase neuromuscular demands and mechanisms, making the response easier. This stimulation aims to improve the ability of dynamic balance. In addition, PNFS can increase stability to reduce abnormal movements, and impulses received through mirror neurons or proprioception can increase impulses to perform a movement that increases dynamic balance.[38]

Limitations This study used a 1-group design without a control group. Therefore, it is hoped that future studies can look at the effect size of PNFS compared to other interventions in their research.

CONCLUSION

PNFS has a significant positive effect in reducing pain and improving postural balance in patients with knee OA. PNFS is a recommended technique that can be applied as a rehabilitation program for patients with knee OA.

CONFLICT INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICAL CONSIDERATION

This study has obtained research permission from the institutional review board of Medical Faculty, Universitas Muhammadiyah Surakarta Indonesia, with number 4538/B.1/KEPK-FKUMS/X/2022. We considered that all the participants had signed the informed consent and understood all the procedures of this study.

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AUTHORS CONTRIBUTIONS

DRK contributed to writing ideas, analyzing problems, collecting and analyzing data, and writing manuscripts. At the same time, RAZZG contributed to collecting the data, reporting the data, and writing the manuscript.

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