Medical Communication

Effectiveness of Hold Relax Proprioceptive Neuromuscular Facilitation Technique in Total Knee Arthroplasty

Mohammad Miraj,[1,2]* Msaad AlZhrani,[1] Ahmad Alanazi,[1] Fuzail Ahmad,[1] Faizan Kashoo,[1] Abdul Rahim Shaik,[1] Mohamed Seyam,[1] Deepak Kumar,[2,3] Achal Pathak,[3] Kamran Afzal,[4] Ahmad Abdullah A Alsaleh,[4] Mazen AlQahtani[5] and Mehrunnisha Ahmad[6]

[1]Department of Physical Therapy and Health Rehabilitation, College of Applied Medical Sciences, Majmaah University, AlMajmaah 11952, Saudi Arabia

[2]Department of Applied Health Sciences, AIHMS, New Delhi, India

[3]Department of Physiotherapy, Santosh University, Ghaziabad, India

[4]Department of Basic Sciences, College of Medicine, Majmaah University, AlMajmaah 11952, Saudi Arabia

[5]College of Applied Medical Sciences, Al Mareefa University, Riyadh 13713, Saudi Arabia

[6]Department of Nursing, College of Applied Medical Sciences, Majmaah University, AlMajmaah 11952, Saudi Arabia

ABSTRACT

Proprioceptive Neuromuscular Facilitation (PNF) is a popular flexibility training, which involves stretching and contraction of the target muscle group. PNF stretching is effective among athletes for improving passive range of motion, flexibility, and performance. Patients who undergo total knee replacement surgeries exhibit pain, swelling, decreased range of motion, muscle weakness, and stiffness. This study aimed to investigate the effect of the hold relax PNF technique to improve the balance and muscle strength in subjects with a bilateral knee replacement. Sixty four patients were selected based on inclusion/exclusion criteria. The patients were allocated into two groups by random allocation. The experimental group A (n=32) received the Hold Relax PNF technique with conventional treatment whereas, the control group B (n=32) received only conventional treatment as a part of the Home Exercise Program (HEP). Outcome measures used for evaluation included the Visual Analogue Scale (VAS), Manual Muscle Testing (MMT), and Berg Balance Scale (BBS) Score for measuring pain, muscle strength, and balance respectively. Students t-test showed significant differences between variables mean scores from two groups after three weeks of intervention. There was a statistical significant ($t(32) = 2.38$, $p = 0.02$) change in the mean scores of VAS in the experimental group (mean difference pre-post=3.19) as compared to control group (mean difference pre -post=3.19) with Cohen's $d = 2.744588$. Similarly for MMT($t(32) = 0.415$, $p = 0.005$) and BBS scores ($t(32) = 2.628$, $p = 0.035$). The result of the study suggests that the Hold Relax PNF technique is more effective than conventional treatment alone in decreasing pain as well as increasing balance and muscle strength in bilateral knee replacement patients.

KEY WORDS: PNF(HOLD RELAX), KNEE ARTHROPLASTY, HOME EXERCISE PROGRAM.

INTRODUCTION

Total knee arthroplasty (TKA) procedures have expanded dramatically in last one decade due to aging population with rising lifestyle diseases, resulting in increased prevalence of Osteoarthritis, especially in Knees. The exponentially growing health insurance linked with increasing penetration of private healthcare has led to changes in payment policies which has caused post-TKA rehabilitation primarily been transferred to home health and outpatient settings. Knee arthroplasty is a surgery that replaces the weight-bearing surfaces of the knee joint to relieve pain and impairment, most typically been used to treat osteoarthritis apart from other knee illnesses including RA and psoriatic arthritis. Knee replacement surgery can be conducted in two ways: partial or total. A knee replacement might be more accurately termed as knee resurfacing because only the surfaces of the bone are replaced (Lauermann et al., 2014, Varacallo, Luo, and Johanson, 2021).

Article Information:*Corresponding Author: m.molla@mu.edu.sa
Received 25/10/2021 Accepted after revision 30/12/2021
Published: 31st December 2021 Pp- 1919-1923
This is an open access article under Creative Commons License,
Published by Society for Science & Nature, Bhopal India.
Available at: https://bbrc.in/ DOI: http://dx.doi.org/10.21786/bbrc/14.4.80

Whether comparing rehabilitation received in different venues or analyzing different physical therapy (PT) procedures, numerous studies have indicated that rehabilitation is related with improved post-TKA results. Following total knee arthroplasty, the mainstay of rehabilitation is achieving maximal feasible knee range of motion (ROM) and achieving specified functional goals (TKA) (Koca et al.,2014; Yang et al.,2019; Han et al.,2021). ROM is one of the most important outcomes after TKA since patients with less than 105° of knee flexion have difficulty going up and down stairs or getting out of a low chair, and is a major sign of patient discontent (Han et al.,2021).

Literature review suggests that different strategies and techniques are being used for improving range of motion in comparison to other strategies used primarily on healthy or elderly individuals (Oh 2013; Rhyu, Kim and Park, 2015; De Carvalho et al.,2017). The Proprioceptive Neuromuscular Facilitation technique(popularly called as PNF) is one such popular technique been used to increase ROM and flexibility (Hindle et al.,2012). Originally developed by Dr. Herman Kabat in year 1940, the technique mainly works on the principle of raising neuro-inhibition mechanism for releasing muscular spasm and elongating muscle length, or increasing neuro-excitation mechanism for boosting muscle strength. It comprises of 3 main techniques namely, Hold Relax (HR), Contract Relax (CR), and Contract Relax Agonist Contract (CRAC)(Gonzalez, Gomez and Garcia, 2012).

The effect of PNF stretching on both joint restriction improvements is less well understood. Likewise, balance impairment, which is again one of the major problems encountered by the patients after knee replacement is due to the weakness of quadriceps muscles, which is further a consequence of the direct trauma from the surgical incision. The hold relax PNF technique is one of the most popular techniques and helps to develop muscular strength and endurance joint stability, mobility, neuromuscular control, and coordination all of which are aimed at improving the overall functional ability of people (Hindle et al., 2012; Koca et al.,2014; De Carvalho et al.,2017). However, not many evidence-based researches are present, where the Hold Relax PNF technique has been used in patients with total knee arthroplasty(Kim Kang and Kim,2018; Han et al.,2021). Hence, the present research study aims to explore the application of PNF stretch for changes in pain, muscle strength, and balance and therefore on the overall functionality of the lower extremity following total knee arthroplasty.

MATERIAL AND METHODS

The study design was a randomized controlled trial (pretest-posttest experimental control group design), where the patients were recruited from Rehabilitation Center, College of Applied Medical Sciences, Majmaah University located at Al-Majmaah city. Necessary approval was taken from the Institutional review board, Majmaah University. The study was commenced in Sept 2020 and was completed in May 2021. A total of 64 subjects between the age of 42 to 73 years were included in the study who fulfilled the inclusion criteria of patients diagnosed with OA knee as well as undergoing bilateral TKR. The exclusion Criteria included knee flexion more than 110 degrees or thigh girth more than 55 cm, poor cognition, CNS or PNS neuromuscular disease, received operation in recent 3 months, joint infection and loosening, revision total knee arthroplasty, or complication during follow up. Those who met the study's eligibility requirements and gave their consent to participate were finally chosen to participate in the study.

Table 1. Showing treatment protocol for experimental and control group.

Week 1. •Active quad contraction •Safe independent ambulation with a walker •Passive knee extension to 0° •Knee flexion to 90° or greater •Control of swelling, inflammation, bleeding.	Week 2. Same as phase 1 • Straight leg raising test • Hip abduction and adduction
Week 3 • VMO recruitment during quad sets and SLR • Terminal knee extension 45 to 0° • Hamstring curls • Knee flexion to at least 115°	Hold Relax PNF Treatment(Group A) •Hold relax technique to start from Day 7 of TKR up to 3wks. •Muscle under Treatment (Quadriceps or hamstrings muscle) •Few seconds (6 - 10 second /10 repetitions) is given for quads muscle as well as 10 repetitions is given for hamstring muscle/day •Patient position: Patient is sitting on high bed knee at 90 flexion •Back should be in a straight position •Foot should not touch on the ground
Group A (Hold Relax PNF + Conventional Home Exercise Program)	Group B (Conventional Home Exercise Program)

The minimum sample size of 60 participants was required using statistical power of 80%, the effect size of 0.20, and a level of significance of 0.05 to measure the effectiveness of the technique used in the study. In the present study, 32 patients were recruited who fulfilled the inclusion criteria subjects were then randomly assigned into experimental (n=32) and control groups (n=32). While the Experimental group A(n=32) received PNF along with conventional treatment, the control group B, (n=32) received only conventional treatment. The outcome measures used for evaluation were Manual Muscle Testing (MMT) and Berg Balance Score (BBS) were used for measuring muscle strength and balance respectively.

The Hold relax PNF technique is one of the key PNF techniques. In this method, the muscle under treatment is lengthened to the point of limitation or to the extent that is comfortable for the subject. The subject then performs a pre-stretch, end range, an isometric contraction for 5 to 10 seconds followed by voluntary relaxation of the tight muscle(Oh 2013). The Conventional treatment protocol which was the Home exercise Program(HEP) was illustrated in Table 1(Minshull et al., 2014; Kim et al 2018). The protocol was same as described in an earlier published research, (Alaca et al 2015). The physiotherapist sat in front of the patient on a low-height stepper with one hand placed on the lower quadriceps muscle as well as another hand placed on the lower tibia anteriorly. Command was given to the subject to perform knee extension against resistance and was asked to hold for 6 to 10 seconds followed by relaxation as per detailed protocol given in Table1.

Statistical analysis: Using the Statistical Package of Social Science (SPSS) version 22.0, the data were checked for normality assumptions using the Kolmogorov–Smirnov test (Chicago, IL). The normally distributed data were then analyzed for mean, SDs, t-values, and p values to conclude group comparisons. The unpaired t-test score was used to compare participant characteristics and demographic data between groups.

Table 2. Showing baseline characteristics of the patients in both group A and B

Characteristics	Group A (n =32)	Group B (n =32)
Gender (M: F)	22: 10	18: 14
Mean Age	65.54(7.2)	65.06(6.87)
Mean BMI	29.54(4.53)	31.22(5.88)
Baseline Active Flexion	41(11.89)	48(12.44)
Baseline Passive flexion	48(14.53)	52(13.54)
Baseline Knee Circumference	41.56(3.31)	42.74(2.94)

RESULTS AND DISCUSSION

The baseline characteristics values for the demographic characteristics for all the participants are depicted in Table 2 with no significant differences observed between the two groups in terms of baseline demographic data and clinical findings (Table 1, $p \geq 0.05$). The treatment for both groups continued for 3 weeks with readings measured for all the outcome variables at 0 weeks (Baseline line) and 3rd week (Table3,4 and 5).

Table 3. Showing VAS Score between group A and group B

VAS Score	Group A	Group B	T score(p-value)
Week 1	6.68(0.54)	6.83(0.79)	NS
Week 3	2.77(0.75)	4.61(0.58)	2.38(0.02*)

Visual Analogue Scale (VAS) readings were measured for both the groups at Week 1 followed by 3 weeks of intervention in both groups. It was observed that while significant improvement was observed in both groups but on intergroup comparison Group A fared better than group B($p=0.02$*) (Table 3).The outcome measures of Manual Muscle Testing for both the legs for both the groups at week 1 and Week 3 are depicted in Table 4. Regarding the MMT measurement between the two groups A and B, about both the limbs (Right and Left leg) it was observed that over the 3 weeks both groups witnessed a significant change in the muscle strength, however, group A demonstrated a greater gain in strength in both rights (T score = 1.8 and 0.33, $p<0.05$**) and left leg (T-score =1.031 and 0.4, $p<0.05$**) respectively(Table 4).

In Table 5, within a group as well as an intergroup comparison for groups A and B were measured for the BBS scale. The table shows a statistically significant difference over the 3 weeks both within the groups (T value (Gp. A, t score = 24.04 and Gp. B=10.22, $p<0.05$**) as well as between the groups with Gp. A showing significant improvement in BBS as compared to Group B(t score = 2.628, $p<0.05$**) (Table 5).

The purpose of the present study was to investigate the effectiveness of the hold relax PNF technique to improve balance and muscle strength in subjects with a bilateral knee replacement. The result suggests that there was a significant improvement in PNF group A when compared with the conventional group B. Visual analog Scale (VAS), Manual muscle testing (MMT), and Berg Balance Score (BBS) were found to be statically significant in both the groups, however in the PNF group A, there was a significant decrease in pain along with a significant increase in MMT and BBS score than the conventional group as their mean and standard deviations suggested ($p<0.05$**, Table 3,4 and 5).

The results of the study draw an analogy from the study conducted by De Carvalho et al. (2017) where two exercise protocols were compared for postural balance among elderly women. They found the PNF group showed a significant reduction in most of the stabilometric parameters. Similarly, the BBS score in the experiment group was also found better than the control group thus concluding that women in the PNF group demonstrated better improvement in postural static stability using evaluation of various stabliometric parameters. Likewise, significant improvement was

also noticed for dynamic balance using functional test performance.

It is suggested that the hold relax PNF technique more effectively increases muscle activity with decreased muscle fatigue. This could be because during hold relax PNF, isometric contraction of the muscle causes autogenic inhibition, which inhibits - motor neurons of contracted muscle and synergist in interneuron and activates antagonist by transmitting tendon tension to the anterior horn of the spinal cord via 1 b afferent nerve fiber (Minshull et al.,2014). Concentric contraction generates reciprocal inhibition, which activates -motor neurons of contracted muscles and synergists while inhibiting antagonists during agonist contraction (Cha, Cho and Choi, 2014).

Table 4. Showing the manual muscle testing (MMT) score for both groups A and B

MMT			Group A (n=32)		Group B (n=32)		T score (p-value)
			Mean	SD	Mean	SD	
WEEK 1	Right Leg	F	3	0.365	2.8*8	0.342	NS
		E	2.31	0.479	2.63	0.5	NS
WEEK 3	Right Leg	F	3.94	0.443	3.75	0.447	1.192(p=0.008**)
		E	3.75	0.447	3.69	0.602	.333(p=0.062**)
MMT			**Group A n=32**		**Group B n=32**		**T score**
			Mean	**SD**	**Mean**	**SD**	**(p-value)**
WEEK 1	Left Leg	F	3.06	0.443	3.06	0.25	NS
		E	2.44	0.629	2.69	0.479	NS
WEEK 3	Left Leg	F	3.94	0.443	3.75	0.577	1.031(p=0.043*)
		E	3.81	0.403	3.75	0.447	.415*(p=0.005**)

**significant at 0.05 level

Table 5. Showing Berg balance scale (BBS) score for both groups A and B

BBS (Within Group Comparison)	Group A (n=32)		T-Value	Group B (n=32)		T score (p-Value)
	Mean	SD		Mean	SD	
WEEK 1	16.88	4.787	NS	16.83	4.745	NS
WEEK 3	39.06	4.739	24.04**	33.19	7.583	10.220** (p=0.006**)
Between Group Comparison						
At Week 3	**Group A(n=16)**			**Group B (n=16)**		**T score (p-value)**
	39.06	4.739		33.19	7.583	2.628** (p=0.035**)

** significant at 0.05 level, mean and SD of BBS (week 1 and week 3) for both groups A and B

The findings gain credibility by yet another study conducted by Kim, Kang, and Kim(2018) in Korea where PNF exercises were found to improve range of motion, pain, and functional activity among TKR patients. However, the present study differs from the Korean study using the outcome measures since the authors measured the improvement by objective indices including the MMT and BBS scores. In yet another study by Rhyu, Kim, and Park (2015), a six-week elastic band exercise program using proprioceptive neuromuscular facilitation (PNF) was evaluated to measure isotonic strength of abductor's muscles in the lower extremity. It was found that PNF-based band exercises significantly improved the peak explosive muscular power in the isotonic contraction of the lower limb abductors. It was hypothesized that the PNF facilitates certain physiological changes which potentiate the functioning of both the central and

peripheral vestibular system and thereby are responsible for the therapeutic results.

The perception of articular position and mobility is critical for maintaining strength and balance as reduced articular sensitivity contributes to balance impairments in both the aged and osteoarthritic individuals (Jette et al. 2020). These imbalances are caused by decreased articular mobility. Both pain and decreased proprioception have an adverse effect on the joint increasing the risk of falling. In the present study, using hold relax PNF Technique in the experimental group, had brought out significant change(p=0.035*) in Berg Balance Score(BBS) thereby proving its efficacy post arthroplasty (Table 5). This suggests that PNF might improve both neuromuscular control as well as joint stability bring better control in both static and dynamic balance (Gong 2020). There are some limitations to this study. The trial was limited to the Rehabilitation Department of Majmaah University and generalizability of the study cannot be justified. The study used only bilateral TKR patients and therefore evaluating the effects of the PNF techniques in unilateral cases arthroplasty especially in terms of strength, balance and proprioception cannot be emphasized clearly.

CONCLUSION

The data of the study conclude that the addition of the hold relax technique of PNF to the consercation exercise program decreases pain, improves range of motion and balance in patients with bilateral TKR as compared to conservative exercise progam alone.

ACKNOWLEDGEMENTS

The authors are grateful to the Deanship of Scientific Research, AlMajmaah University via group No. RGP-2019- 35 for funding through Vice Deanship of Scientific Research Chair.

Declaration of Interest Statement: The authors report no conflicts of interest.

REFERENCES

Alaca N, Atalay A, Güven Z(2015) Comparison of the long-term effectiveness of progressive neuromuscular facilitation and continuous passive motion therapies after total knee arthroplasty. J Phys Ther Sci. 27(11):3377-3380. doi:10.1589/jpts.27.3377

De Carvalho FT, De Andrade Mesquita LS, Pereira R, Neto OP, Amaro Zangaro R(2017) Pilates and Proprioceptive Neuromuscular Facilitation Methods Induce Similar Strength Gains but Different Neuromuscular Adaptations in Elderly Women. Exp Aging Res. 43(5):440-452. doi: 10.1080/0361073X.2017.1369624. Epub 2017 Sep 26. PMID: 28949820.

González-Ravé JM, Sánchez-Gómez A, Santos-García DJ (2012) Efficacy of two different stretch training programs (passive vs. proprioceptive neuromuscular facilitation) on shoulder and hip range of motion in older people. J Strength Cond Res. 26: 1045–1051.

Han HS, Kim JS, Lee B. et al.(2021) A high degree of knee flexion after TKA promotes the ability to perform high-flexion activities and patient satisfaction in Asian population. BMC Musculoskelet Disord 22, 565 (2021). https://doi.org/10.1186/s12891-021-04369-4

Hindle KB, Whitcomb TJ, Briggs WO, Hong J(2012) Proprioceptive Neuromuscular Facilitation (PNF): Its Mechanisms and Effects on Range of Motion and Muscular Function. J Hum Kinet. 31:105-113. doi:10.2478/v10078-012-0011-y

Kim CH, Kang TW, Kim BR(2018) Effects of proprioceptive neuromuscular facilitation exercise on the range of motion, pain and functional activity of total knee arthroplasty patients. PNF and Movement.16(1):75–83. doi.org/10.21598/JKPNFA.2018.16.1.75

Koca I, Boyaci A, Tutoglu A, Boyaci N, Ozkur A (2014) The Relationship between Quadriceps Thickness, Radiological Staging, and Clinical Parameters in Knee Osteoarthritis. J Phys Ther Sci. 26(6):931-936. doi:10.1589/jpts.26.931

Lauermann SP, Lienhard K, Item-Glatthorn JF, Casartelli NC, Maffiuletti NA (2014) Assessment of quadriceps muscle weakness in patients after total knee arthroplasty and total hip arthroplasty: methodological issues. J Electromyogr Kinesiol. 24(2):285-91. doi: 10.1016/j.jelekin.2013.10.018. Epub 2013 Nov 13. PMID: 24290027.

Minshull C, Eston R, Bailey A, Rees D, Gleeson N (2014) The differential effects of PNF versus passive stretch conditioning on neuromuscular performance. Eur J Sport Sci. 14(3):233-41. doi: 10.1080/17461391.2013.799716. Epub 2013 May 20. PMID: 23688197.

Oh YT(2013) Effect of Hold Relax technique for college students with hamstring shortening. Journal of Korean Society of Physical Medicine. *(3) : 433-441 https://doi.org/10.13066/kspm.2013.8.3.433

Rhyu HS, Kim SH, Park HS(2015) The effects of band exercise using proprioceptive neuromuscular facilitation on muscular strength in lower extremity. Jour Exer Rehab;11(1) :36 -40.

Varacallo M, Luo TD, Johanson NA(2021) Total Knee Arthroplasty Techniques. In: StatPearls [Internet]. Treasure Island (FL): Stat Pearls Publishing; 2021 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK499896/

Yang X, Li GH, Wang HJ, Wang CY (2019) Continuous Passive Motion After Total Knee Arthroplasty: A Systematic Review and Meta-analysis of Associated Effects on Clinical Outcomes. Arch Phys Med Rehabil. 100(9):1763-1778. doi: 10.1016/j.apmr.2019.02.001. Epub 2019 Mar 2. PMID: 30831093.

Jette A, Haley SM, Coster W, Ni PS.(2020) Boston University Activity Measure for Post Acute Care (AM-PAC). http://am-pac.com/category/home/

Gong W. (2020). Effects of dynamic exercise utilizing PNF patterns on the balance of healthy adults. Journal of physical therapy science, 32(4), 260–264. https://doi.org/10.1589/jpts.32.260