ijlpr 2020; doi 10.22376/ijpbs/lpr.2021.11.1.L16-22

International Journal of Lifescience and Pharma Research

Research Article

Physiotherapy for better pain management

Effectiveness of Muscle Energy Technique and Proprioceptive Neuromuscular Facilitation in Knee Osteoarthritis

Minal Bharat Masekar[1], Dr. Amrutkuvar Rayjade[2]*, Dr.Trupti Yadav[2] and Dr.Khushboo Chotai[3]

[1] *Final Year Student , faculty of physiotherapy, Krishna institute of medical sciences deemed to be university, Karad, Maharashtra, India.*
[2]*Assistant professor, department of musculoskeletal sciences, faculty of physiotherapy, Krishna institute of medical sciences deemed to be university, Karad, Maharashtra, India*
[3]*Assistant professor, department of sports,, faculty of physiotherapy, Krishna institute of medical sciences deemed to be university, Karad, Maharashtra, India*

Abstract: This study was undertaken to determine the effectiveness of techniques such as muscle energy technique and proprioceptive neuromuscular facilitation in reduction of pain levels, improvement in flexibility of hamstring muscle and functional mobility, in patients with osteoarthritis of knee. An experimental study was carried out using a pre test and post test study design. The study was carried out in Krishna Hospital, Karad with a sample size of 36 individuals suffering from osteoarthritis of knee using a random sampling method. Individuals with Osteoarthritis of knee within the age group 40-60 years have been included. The collected data was analysed using paired and unpaired 't' tests. When the data was analysed, the results showed that the patients in Group A and B receiving PNF stretching and MET respectively, the pain levels measured using NPRS shows more improvement in group A(7.66 ±1.02) as compared to group B (3.44 ±0.92). Hamstring flexibility in group A (10.63 ±4.89) was also found to be higher than in group B (4.37±2.01) when Active knee extension test was performed as a measure for hamstring flexibility, when functional mobility was measured using Western Ontario and McMaster universities arthritis index, improvement seen in group A (27.21 ±12.31) was significantly higher than in group B (14.11±7.88). The primary finding was that the patients of group A receiving PNF stretching along with the baseline protocol showed better improvement in pain levels, hamstring flexibility and level of functional mobility as compared to the patients in group B receiving MET along. with baseline protocol

Keywords: Osteoarthritis, Proprioceptive neuromuscular facilitation, Muscle energy technique, Pain, Hamstring flexibility, Functional mobility.

***Corresponding Author**

Dr. Amrutkuvar Rayjade , Assistant professor, department of musculoskeletal sciences, faculty of physiotherapy, Krishna institute of medical sciences deemed to be university, Karad, Maharashtra, India

Recieved On 25 February 2020
Revised On 13 May 2020
Accepted On 01 June 2020
Published On 04 January 2021

Funding This research did not receive any specific grant from any funding agencies in the public, commercial or not for profit sectors.

Citation Minal Bharat Masekar, Dr. Amrutkuvar Rayjade, Dr.Trupti Yadav and Dr.Khushboo Chotai , Effectiveness of Muscle Energy Technique and Proprioceptive Neuromuscular Facilitation in Knee Osteoarthritis.(2021).Int. J. Life Sci. Pharma Res.11(1), L16-22 http://dx.doi.org/10.22376/ijpbs/lpr.2021.11.1.L16-22

This article is under the CC BY- NC-ND Licence (https://creativecommons.org/licenses/by-nc-nd/4.0)
Copyright @ International Journal of Life Science and Pharma Research, available at www.ijlpr.com

1. INTRODUCTION

Osteoarthritis (OA) is a chronic disorder which is degenerative in nature having a multifactorial etiology characterized by subchondral sclerosis, loss of the articular cartilage, hypertrophy of the marginal bone along with morphological and biochemical changes in the joint capsules and synovium[1] The prevalence of OA knee in India is 28.7%[2] . There are possibilities for a rise in the prevalence of Osteoarthritis due to an improvement in the expectancy of human life, it is a condition that causes severe pain and disability adversely affecting the quality of life of the individuals suffering[3]. Among the age group of 40 years and above, Osteoarthritis is considered as a major factor for impairment in mobility[4]. Studies and evaluation conducted worldwide indicates that 18% of women and 9.6% of men which are above the age of 60 years suffer from symptomatic OA. Knee Osteoarthritis has been commonly observed to be occurring after 40 years of age with a gradual development over a period of time[5]. There are several reasons for the high rates of prevalence of OA in India in which the genetic factor is one of the major causes, while the other factors involve sedentary lifestyle, squatting habits, and dietary conditions[6]. In OA knee, knee pain is the major symptom which increases with activity and seems to be reduced during rest periods[7]. Individuals suffering from knee OA have shown a reduction in functional capacity in their lower extremities caused by significant loss of muscle strength, joint pain and stiffness[8]. Diagnosis of OA knee is made by radiological investigations and clinical examinations which include findings of palpation, special function tests and joint range of motion[9]. The impairments in muscles associated with this condition may be the primary cause of the functional impairment[10]. Muscle dysfunction has been observed as an important factor preceding and accelerating the deterioration of the joint cartilage[11]. Studies show that muscle dysfunction is related to the pathogenesis of OA knee[12]. Individuals suffering from Osteoarthritis have heterogeneous manifestations, and it has variations in terms of appearance in different patients. Thus, it may appear differently in men and women[13,14], in obese patients, in athletes and in patients with or without trauma, this supports the fact that for patients with different profiles different treatments may be required[15]. There is a wide range of treatment methods available for OA knee but there remains still scope for interventions which help in improving the symptoms with very less side effects[3] The treatment for OA knee involves a variety of pharmacological and non pharmacological approaches. Currently not many disease modifying approaches are present, and the pharmacological interventions are directed towards alleviating symptoms to prevent loss of function and inactivity[16]. The pharmacological treatment options involve Non steroidal anti inflammatory drugs (NSAIDS), Acetaminophen, Opioids, Intra articular injections, Chondroitin sulfate, Glucosamine sulfate whereas the non pharmacological approach involves Massage therapy, Hydrotherapy, Thermotherapy, Manual therapy, Electrotherapy, other physiotherapeutic modalities and Surgery[17]. Pharmacological approaches have been majorly used for the management of Osteoarthritis knee. Pharmacological interventions have been observed to improve the condition but they have to be taken for a long period of time and also have significant side effects[3].Physiotherapeutic approaches have been found to have positive effects in reducing disability and pain in individuals with OA knee, apart from the above mentioned modalities, proper use of canes, taping of knee, orthotics, balance training and isometric exercises to prevent muscle atrophy are used[18]. Physiotherapeutic techniques such as Proprioceptive Neuromuscular Facilitation (PNF) and Muscle Energy Technique (MET) have also been used for the management of OA knee. Intervention like PNF stretching is proven to be safe and effective in improving the symptoms of OA knee with minimal side effects by the patients[3]. The term stretching is generally used to describe any therapeutic technique to elongate the structures which are shortened pathologically and thus effective in improving the range of motion[10]. PNF stretching (hold-relax) technique involves a short isometric contraction of the agonistic muscles which are targeted to be stretched[19] and is useful in improving the range of motion[20]. Intervention like MET is observed to lengthen the shortened muscles, for strengthening weakened muscles, for mobilization of restricted joint range of motion and to reduce localized edema[21]. It is an active technique in which the patient utilizes his muscles voluntarily from a specifically controlled position in a particular direction against a precisely executed counterforce. Post isometric relaxation and reciprocal inhibition are the principles used[22].Electrotherapeutic modality such as Interferential Therapy is used for the treatment of deeper tissues as the skin resistance is overcome by a lower pulse amplitude. It has physiological effects on the tissues such as relief of pain, absorption of exudates and motor stimulation [23-24] Since there is paucity in literature available which examines the effect of both the techniques over each, this study is being carried out to determine the effectiveness of PNF as compared to MET in management of pain, hamstring flexibility and functional mobility in OA knee.

2. MATERIALS AND METHODS

An experimental study was conducted in the department of physiotherapy Krishna institute of medical sciences, Karad. All procedures performed in this study involving human participants were in accordance with the ethical standards of the Institutional ethics committee of Krishna institute of medical sciences (Ethics committee Registration No. ECR/307/Inst/MH/2013/RR-16) on 4th October 2019. About 36 patients were selected based on the inclusion criteria (1) Radiologically and clinically diagnosed cases of Osteoarthritis knee by certified Orthopaedic surgeon or Physiotherapist. (2)Between the age group of 40-60 years including both men and women. (3) Patients with Grade 2 or 3. Osteoarthritis knee using Kellgren - lawrence classification, and exclusion criteria (1) Other knee joint pathologies eg. Chondromalacia patella, plica syndrome, (2) Neurological disorders,(3)Post traumatic knee patients,(4)Post surgical patients. A written informed consent has been taken from all the participants. The study has been approved by the Ethics committee of Krishna institute of medical sciences. The participants have been divided into 2 groups, Group A(18 participants) received PNF stretching and Group B(18 participants) received MET, baseline treatment given to both groups included HMP and IFT.

2.1 (a) Group A – Treatment protocol will consist of the following:

- Hot moist pack

The patient will be made to lay in a supine position with the affected knee in slight flexion A hot moist pack will be applied around the knee for 15 minutes.

Muscle energy technique: combination of Post- isometric relaxation (2 sets of 5 repetitions) and Reciprocal inhibition (2 sets of 5 repetitions)

- Post-isometric relaxation

The subject will be placed in a prone lying position while the hip is flexed to 90°. The subject will be asked to flex their knee further using 20% of their strength. The contraction will be maintained for 5 seconds while resistance being applied to the agonist muscle. 2 sets with 5 repetitions will be performed with a 5 seconds relaxation phase in between each repetition[21].

- Reciprocal Inhibition

The subject will be placed in a prone lying position while the hip being flexed to 90°. The subject will be asked to flex their knee further using 20% of their strength. The contraction will be maintained for 5 seconds while resistance is applied to the antagonist muscle. 2 sets with 5 repetitions will be performed with a 5 seconds relaxation phase in between each repetition[21].

- Interferential therapy

Interferential therapy will be applied using the four pole vector method for 20 minutes.

2.1 (b) Group B – Treatment protocol will consist of the following:

- Hot moist pack

The patient will be made to lay in a supine position with the affected knee slightly flexed. A hot moist pack will be applied around the knee for 15 minutes.

- Proprioceptive neuromuscular facilitation technique: PNF stretching Hold Relax (2 sets of 5 repetitions)

The subject will be positioned in supine lying with 90° hip flexion. Therapist extends the patient's knee until a mild stretch is felt in the hamstrings. An isometric contraction is achieved by asking the subject to flex his knee against resistance by the therapist. Contraction is held for 8 seconds after which the therapist commands to relax the hamstrings, immediately after which the muscle is extended until a mild to moderate painless stretch is felt which is held for 30 seconds. The procedure is performed in 2 sets with 5 repetitions and 10 seconds relaxation phase in between[27].

- Interferential therapy: Interferential therapy will be applied using the four pole vector method for 20 minutes.

2.2 ETHICAL CLEARANCE

Approval for the study was obtained from the protocol committee and institutional ethical committee of Krishna Institute of Medical Science 'Deemed to be University' (Ethics committee Registration No. ECR/307/Inst/MH/2013/RR-16)

2.3 OUTCOME MEASURES

2.3.1 Numerical Pain Rating Scale

This scale was found to be one of the most reliable outcome measurements for pain. A straight line indicating 0 at the start and 10 at the end of the line was drawn on the evaluation sheet, the patients were asked to mark on the line based on their perception of pain with '0' indicating no pain and '10' indicating severe pain[3]

2.3.2 Active Knee Extension Test

This test was used to determine the tightness of hamstring muscles. The patient was made to lie supine with hip and knee flexed to 90° and stabilizing the hip joint by grasping the thigh. With fulcrum of the goniometer placed on the lateral femoral condyle with proximal arm parallel to femur and distal arm parallel to the lower leg the patient is asked to extend his knee with hip held in 90°[25]

2.3.3 WOMAC

The Western Ontario and McMaster Universities Arthritis Index is used to assess patients with OA knee[26]. This scale includes the measurements of the levels of functional mobility and pain levels of the participants based on their subjective ratings out from 0-4.

3. STATISTICAL ANALYSIS

A total of 36 subjects were selected on the basis of the inclusion and exclusion criteria and were randomly divided into two groups Group A (PNF) Group B (MET); the outcome measures used were the NPRS, AKET, WOMAC. PNF stretching was given to group and MET was applied to group B along with baseline protocol to both groups respectively. The data was analysed using parametric tests such as paired't' test(before and after treatment) and independent 't' test (comparisons between group) using theGraphPad instat version 3.1

4. RESULTS AND DISCUSSION

Table no.1 : The mean age and percentage of gender

Characteristic	Group A (PNF)		Group B (MET)	
Age	Mean	SD	Mean	SD
	54.05	3.63	57.72	3.34
Gender	Female	Male	Female	Male
	76.66%	23.33%	66.66%	33.33%

The mean age and percentage of gender of the participants has been described in the above table number 1.

Table no.2 : The mean pre and post treatment statistics

Statistical measures (NPRS)b	Group A (Pnf)		Group B (Met)		Pre Post Difference	
	Pre-Test	Post-Test	Pre-Test	Post-Test	PNF	MET
Mean	7.66	2.88	8.16	6.33	3.50	1.57
Standard deviation	1.02	0.32	1.64	0.48	1.97	1.05
Minimum	6.00	2.00	6.00	6.00	1.00	0.00

Maximum	9.00	3.00	9.00	7.00	6.00	3.00
Lower 95% CI	7.15	2.72	7.64	6.09	1.42	0.47
Upper 95% CI	8.17	3.05	8.68	6.57	5.57	2.68
't' value	21.500		7.895		2.100	
'p' value	<0.0001		<0.0001		0.0621	

The above table number 2 represents that in Group A the mean pre-treatment NPRS was 7.66 ±1.02 with a reduction in the post –treatment NPRS as 2.88 ±0.32 . The value was found to be <0.0001 by paired 't' test which is extremely significant.In Group B the mean pre-treatment NPRS was 8.16±1.64 with a reduction in the post –treatment NPRS as 6.33±0.48 . The value was found to be <0.0001 by paired 't' test which is extremely significant.

Table no. 3 : The mean pre and post treatment statistics

Statistical measures (AKET)	Group A (Pnf)		Group B (Met)		Pre Post Difference	
	Pre-Test	Post-Test	Pre-Test	Post-Test	PNF	MET
Mean	25.00	13.16	27.16	22.16	10.63	4.37
Standard deviation	2.22	1.54	0.92	1.61	4.89	2.01
Minimum	21.60	10.00	25.00	19.00	1.81	1.28
Maximum	29..00	16.00	28.00	25.00	16.00	7.00
Lower 95% CI	24.39	12.39	26.70	21.36	5.50	2.26
Upper 95% CI	26.60	13.93	27.62	22.97	15.76	6.49
't' value	28.830		16.529		2.897	
'p' value	<0.0001		<0.0001		0.0159	

The above table number 3 represents that in Group A the mean pre-treatment AKET was 25.00 ±2.22 with a reduction in the post –treatment AKET as 13.16 ±1.54 . The value was found to be <0.0001 by paired 't' test which is extremely significant. In Group B the mean pre-treatment AKET was 27.16 ±0.92 with a reduction in the post –treatment NPRS as 22.16±1.61 . The value was found to be <0.0001 by paired 't' test which is extremely significant.

Table no.4 : The mean pre and post treatment statistics

Statistical Measures (Womac)	Group A (Pnf)		Group B (Met)		Pre Post Difference	
	Pre-test	Post-test	Pre-test	Post-test	PNF	MET
Mean	82.50	51.61	85.55	70.44	27.21	14.11
Standard deviation	5.33	5.48	3.41	4.51	12.31	7.88
Minimum	74.00	40.00	80.00	61.00	5.63	4.36
Maximum	91.00	61.00	91.00	81.00	42.00	27.00
Lower 95% CI	79.84	48.88	83.85	68.19	14.28	5.83
Upper 95% CI	85.15	54.34	87.25	7.69	40.14	22.39
't' value	23.257		14.690		2.194	
'p' value	<0.0001		<0.0001		<0.0001	

The above table number 4 represents that in Group A the mean pre-treatment WOMAC score was 82.50 ±5.33 with a reduction in the post –treatment WOMAC score as 51.61 ±5.48 . The value was found to be <0.0001 by paired 't' test which is extremely significant. In Group B the mean pre-treatment WOMAC score was 85.55 ±3.41 with a reduction in the post –treatment WOMAC score as 70.44± 4.51. The value was found to be <0.0001 by paired 't' test which is extremely significant.

The statistical analysis of the data collected during the pre and post treatment sessions determines that the results obtained were significant. When NPRS was taken as an outcome measure for indicating the levels of pain in the subjects of both the groups A and B receiving PNF stretching and MET respectively, the mean difference improvement seen in group A(7.66 ±1.02) was higher than in group B (3.44 ±0.92) and proven significant. The mean difference improvement seen in group A (10.63 ±4.89) was significantly higher than in group B (4.37±2.01) when Active knee extension test was taken as a measure for hamstring flexibility and the mean difference improvement seen in group A (27.21 ±12.31) was significantly higher than in group B (14.11±7.88) when Western Ontario and McMaster universities arthritis index was used to evaluate the subjects. Osteoarthritis is a degenerative disorder which is chronic in nature and in the older age groups knee is the most common joint affected by osteoarthritis[28]. Knee osteoarthritis has been identified as one of the leading causes of functional limitation and disability in the elderly [29]. The muscles play a significant role in joint structure and functioning. In OA knee, impairment of the muscles lead to loss of knee joint stability causing a decline in the performance and independence in daily activities and also reduction in the confidence levels ultimately leading to disability and dysfunction[30]. The main features of OA knee include joint pain and stiffness along with a marked reduction in the joint range of motion[31]. Out of the 291 disorders identified as the highest cause of disability OA knee ranked 11th [32]. OA knee affects an individual's quality of life, social participation and body fitness[33]. The primary aim of conducting this study was to determine the effectiveness of PNF and MET in patients with OA knee on the symptoms such as pain, hamstring flexibility and functional mobility. This study determines that, the patients who received PNF stretching along with the baseline protocol including IFT and HMP resulted in having better improvement in pain, hamstring flexibility and functional mobility as compared to the patients who received MET along with the baseline protocol. MET seemed to have effects on reducing pain, improving range of motion and functional mobility but less significant as compared to PNF. The mean age of the participants in this study was found to be 54.05 in Group A and 57.72 in Group B. This determines the fact that the grade 2 and grade 3 OA knee affects individuals above the age of 50 years as this age group are subjected to joint degeneration due to the wear and tear in the earlier years,

and early as the literature suggests affects individuals in their 40's. The percentage of female participants in group A is 76.66% whereas 23.33% of males and in group B IS 66.66% for females and 33.33% for males which shows that females are seen in majority as compared to males suffering from this degenerative joint disease. In this study, the rationale for an increase in the hamstring muscle flexibility by applying PNF (Hold-relax) stretching could be due to neural inhibition that is caused by PNF, which causes a reduction in the reflex activity[10] which is supported by a similar study conducted. MET seemed to have effects on reducing pain, improving range of motion and functional mobility but less significant as compared to PNF. According to a study, PNF stretching causes relief of pain via the pain gate control, stimulates the proprioceptive muscle fibres by isometric contraction of muscles[34]. Passive extension of a hypertonic muscle to a new resting length can be done after an isometric contraction immediately. According to a study, the inhibition of the golgi tendon organ and muscle spindle occurs by PNF stretching[35]. During the hold and relax technique involving an isometric contraction of the hamstrings, autogenic inhibition of the hamstring muscles occurs causing muscle relaxation and reduction in stretch resistance, thus improving ROM. On the other hand, the viscoelastic properties of muscle tendon junctions determine the flexibility of hamstrings[36] Due to the viscoelastic properties of the muscles, the musculotendinous junction can increase in length in response to the amount of load applied and its duration. Thus, if a muscle is repeatedly exposed to specific loads for specific durations can cause a change in the muscle length, this reduction in resistance is termed as stress relaxation. Since there is a paucity of literature determining the effectiveness of PNF over MET in management of symptoms in OA knee, this study was carried out which resulted in improved status of the patients in terms of pain, flexibility of hamstrings and functional mobility in the patients who received PNF stretching as compared to MET.

5. CONCLUSION

This study resulted in conclusion that PNF stretching and MET both are effective in decreasing pain levels, enhancing hamstring flexibility and improving functional mobility in patients with OA knee. However, the patients who received PNF stretching along with the baseline protocol involving Interferential therapy and Hot moist pack showed significantly better improvement in their pain levels, the flexibility of the hamstring muscles was seen to be increased and the functional mobility status as compared to patients who received MET. Thus concluding, the application of PNF stretching in protocol for OA knee patients yielded better results on pain reduction, increased flexibility of hamstrings and an independency in functional mobility.

6. ACKNOWLEDGEMENT

We acknowledge and thank the authors and coauthors of this manuscript.

7. AUTHORS CONTRIBUTION STATEMENT

Ms.Minal Masekar devised the project, designed the model and the computational framework and analysed the data as well as the main conceptual ideas and proof outline. Dr.Amrutkar Rayjade and Dr.Khushboo Chotai performed the numerical calculations for the suggested experiment. All authors discussed the results and commented on the manuscript. Ms.Minal Masekar and Dr.Trupti Yadav drafted the manuscript.

8. CONFLICT OF INTEREST

Conflict of interest declared none

9. REFERENCES

1. Hinton R, Moody RL, Davis AW, Thomas SF. Osteoarthritis: diagnosis and therapeutic considerations. Am Fam Physician. 2002 Mar 1;65(5). Availablefrom: https://pubmed.ncbi.nlm.nih.gov/11898956
2. Pal CP, Singh P, Chaturvedi S, Pruthi KK, Vij A. Epidemiology of knee osteoarthritis in India and related factors. Indian j orthop. 2016 Sep;50(5):518. doi: 10.4103/0019-5413.189608
3. Kumar KN, Gupta UK, Singh VK. Proprioceptive neuromuscular facilitation an innovative approach to treat osteoarthritis knee patients. International journal of scientific research. 2018; 7(1). https://www.doi.org/10.36106/ijsr
4. Lützner J, Kasten P, Günther KP, Kirschner S. Surgical options for patients with osteoarthritis of the knee. Nature Reviews Rheumatology. 2009 Jun;5(6):309. doi: 10.1038/nrrheum.2009.88
5. Heidari B. Knee osteoarthritis prevalence, risk factors, pathogenesis and features: Part I. Caspian journal of internal medicine. 2011;2(2):205. PMCID: PMC3766936 PMID: 24024017 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3766936/
6. Srinivas P, Swamy RK, DEVI KP, Sailaja B, LAKSHMIPATHI A. Assessment of dietary practice among Osteoarthritis Patients. International Journal of Pharmacy and Pharmaceutical Sciences. 2014. ISSN-0975-1491 https://www.researchgate.net/publication/279895622_Assessment_of_dietary_practice_among_osteoarthritis_patients
7. Goldring SR, Goldring MB. Clinical aspects, pathology and pathophysiology of osteoarthritis. Journal of Musculoskeletal and Neuronal Interactions. 2006 Oct;6(4):376. Avilable from: https://pubmed.ncbi.nlm.nih.gov/17185832/
8. Liikavainio T, Lyytinen T, Tyrväinen E, Sipilä S, Arokoski JP. Physical function and properties of quadriceps femoris muscle in men with knee osteoarthritis. Archives of physical medicine and rehabilitation. 2008 Nov 1;89(11):2185-9 doi: 10.1016/j.apmr.2008.04.012
9. Michael JW, Schlüter-Brust KU, Eysel P. The epidemiology, etiology, diagnosis, and treatment of osteoarthritis of the knee. DeutschesÄrzteblatt International. 2010 Mar; 107(9):152. doi: 10.3238/arztebl.2010.0152
10. Soundarya N. A comparative study on the effectiveness of PNF stretching versus static stretching on Pain and Hamstring flexibility in osteoarthritis knee patients. International Journal of Research in

Pharmaceutical Sciences. 2019 Jul 12;10(3):1789-94. doi:10.26452/ijrps.v10i3.1312
11. O'Reilly SC, Jones A, Muir KR, Doherty M. Quadriceps weakness in knee osteoarthritis: the effect on pain and disability. Annals of rheumatic diseases. 1998 Oct 1;57(10):588-94. doi: 10.1136/ard.57.10.588
12. Slemenda C, Brandt KD, Heilman DK, Mazzuca S, Braunstein EM, Katz BP, Wolinsky FD. Quadriceps weakness and osteoarthritis of the knee. Annals of internal medicine. 1997 Jul 15;127:97-104. doi: 10.7326/0003-4819-127-2-199707150-00001
13. Roman-Blas JA, Castañeda S, Largo R, Herrero-Beaumont G. Osteoarthritis associated with estrogen deficiency. Arthritis research & therapy. 2009 Oct;11(5):241. doi: 10.1186/ar2791
14. Herrero-Beaumont G, Roman-Blas JA, Castañeda S, Jimenez SA. Primary osteoarthritis no longer primary: three subsets with distinct etiological, clinical, and therapeutic characteristics. InSeminars in arthritis and rheumatism 2009 Oct 1 (Vol. 39, No. 2, pp. 71-80). doi: 10.1016/j.semarthrit.2009.03.006 WB Saunders.
15. Bruyere O, Cooper C, Arden N, Branco J, Brandi ML, Herrero-Beaumont G, Berenbaum F, Dennison E, Devogelaer JP, Hochberg M, Kanis J. Can we identify patients with high risk of osteoarthritis progression who will respond to treatment? A focus on epidemiology and phenotype of osteoarthritis. Drugs & aging. 2015 Mar 1;32(3):179-87. doi: 10.1007/s40266-015-0243-3
16. sterås N, Garratt A, Grotle M, Natvig B, Kjeken I, Kvien TK, Hagen KB. Patient-reported quality of care for osteoarthritis: development and testing of the osteoarthritis quality indicator questionnaire. Arthritis care & research. 2013 Jul;65(7):1043-51. doi: 10.1002/acr.21976.
17. Shehata AE, Fareed ME. Effect of cold, warm or contrast therapy on controlling knee osteoarthritis associated problems. Int J Med Health Pharm Biomed Eng. 2013 Sep 21;7:259-65. https://www.semanticscholar.org/paper/Effect-of-Cold%2C-Warm-or-Contrast-Therapy-on-Knee-Shehata-Fareed/e4d74071053915c47e94c164cdfb01a0f85ef351
18. Fitzgerald GK, Oatis C. Role of physical therapy in management of knee osteoarthritis. Current opinion in rheumatology. 2004 Mar 1;16(2):143-7. doi: 10.1097/00002281-200403000-00013.
19. Shanthi et al. A Study to compare the effectiveness of static stretching and hold-relax stretching technique over hamstring flexibility. Int J Physiotherapy. 2014; 1 (4): 205-208. doi: 10.15621/ijphy/2014/v1i4/54559
20. Bernhardt CM. A review of stretching techniques and their effects on exercise.Corpus ID: 1474755 https://www.semanticscholar.org/paper/A-Review-of-Stretching-Techniques-and-Their-Effects-Bernhart/e0cf81d9d805701a836bf50209e5b444d5f74407#paper-header
21. Chaitow L, Crenshaw K. Muscle energy techniques. Elsevier Health Sciences; 2006. https://scholar.google.co.in/scholar?q=Chaitow+L,+Crenshaw+K.+Muscle+energy+techniques.+Elsevier+Health+Sciences%3B+2006.&hl=en&as_sdt=0&as_vis=1&oi=scholart
22. Singh S, Jagtap V, PoovishnudeviT. Effect of Post isometric relaxation and reciprocal inhibition in osteoarthritis knee. Doi: http://dx.doi.org/10.22159/ajpcr.2017.v10i6.17720
23. Noble GJ, Lowe AS, Walsh DM. Interferential therapy review. Part 1. Mechanism of analgesic action and clinical usage. Physical therapy reviews. 2000 Dec 1;5(4):239-45. doi: 10.2522/ptj.20090335
24. Sluka K, Walsh D. Transcutaneous electrical nerve stimulation and IFT. In: Sluka K, editor. Mechanisms and Management of Pain for the Physical Therapist. Seattle, WA: International Association for Study of Pain Press; 2009. p. 167-86. doi: 10.1054/jpai.2003.434.
25. Odunaiya NA, Hamzat TK, Ajayi OF. The effects of static stretch duration on the flexibility of hamstring muscles. African journal of biomedical research. 2005;8(2):79-82. doi: 10.4314/ajbr.v8i2.35765
26. Jagtap V, Shanmugam S. Effect of Mechanical Traction in Osteoarthritis Knee. Age (years). 2014;57(2.98):57-84. Corpus ID:40514229. https://www.semanticscholar.org/paper/Effect-of-Mechanical-Traction-in-Osteoarthritis-Jagtap-Shanmugam/5e2295e722485ade231872155a70c7171ab9c224
27. Meena V, Shanthi C, Madhavi K. Effectiveness of PNF stretching versus static stretching on pain and hamstring flexibility following moist heat in individuals with knee osteoarthritis. International Journal of Physiotherapy. 2016 Oct 1;3(5):479-84. doi: 10.15621/ijphy/2016/v3i5/117434
28. Guccione AA, Felson DT, Anderson JJ, Anthony JM, Zhang Y, Wilson PW, Kelly-Hayes M, Wolf PA, Kreger BE, Kannel WB. The effects of specific medical conditions on the functional limitations of elders in the Framingham Study. American journal of public health. 1994 Mar;84(3):351-8. doi: 10.2105/ajph.84.3.351
29. Sharma L, Pai YC, Holtkamp K, Rymer WZ. Is knee joint proprioception worse in the arthritic knee versus the unaffected knee in unilateral knee osteoarthritis?. Arthritis & Rheumatism: Official Journal of the American College of Rheumatology. 1997 Aug;40(8):1518-25. doi: 10.1002/art.1780400821.
30. Emrani A, Bagheri H, Hadian MR, Jabal-Ameli M, Olyaei GR, Talebian S. Isokinetic strength and functional status in knee osteoarthritis. Journal of Physical Therapy Science. 2006;18(2):107-14. doi: 10.1589/jpts.18.107
31. Brotzman.S.B, Wilk.K.E. Clinical Orthopaedic Rehabilitation, 2nd edition. Copyright 2003, 1996 Mosby,Inc. https://scholar.google.co.in/scholar?q=Brotzman.S.B,+Wilk.K.E.+Clinical+Orthopaedic+Rehabilitation,+2nd+edition.+Copyright+2003,+1996+Mosby,Inc.&hl=en&as_sdt=0&as_vis=1&oi=scholart
32. Cross M, Smith E, Hoy D, Nolte S, Ackerman I, Fransen M, Bridgett L, Williams S, Guillemin F, Hill CL, Laslett LL. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. Annals of rheumatic diseases. 2014 Jul 1;73(7):1323-30. doi: 10.1136/annrheumdis-2013-204763
33. Rabenda V, Manette C, Lemmens R, Mariani AM, Struvay N, Reginster JY. Prevalence and impact of osteoarthritis and osteoporosis on health-related quality of life among active subjects. Aging clinical and experimental research. 2007 Feb 1;19(1):55-60. doi: 10.1007/BF03325211.

34. Addala.D, Kumar K.S, Effectiveness of PNF stretching on pain and ROM in OA knee. International journal. 2013; 7 (4): 29-33. http://www.i-scholar.in/index.php/ijpot/search/search
35. Gribble PA, Gustkiewicz KM, Prentice WE, Shields EW. Effects of static and hold-relax stretching on hamstring range of motion using the FlexAbility LE1000. Journal of Sport Rehabilitation. 1999 Aug 1;8(3):195-208. doi: 10.1123/jsr.8.3.195
36. Taylor DC, Dalton JR JD, Seaber AV, Garrett JR WE. Viscoelastic properties of muscle-tendon units: the biomechanical effects of stretching. The American journal of sports medicine. 1990 May;18(3):300-9. doi: 10.1177/036354659001800314.