Title: Effectiveness of Neuromuscular exercises (NEMEX) in knee osteoarthritis: A Systematic Review with meta-analysis

Authors: Jyoti Sabharwal, Shabnam Joshi, Rekha Chaturvedi, Meenakshi Bagri, Vandana Rani

Jyoti Sabharwal - 0000-0003-1808-0400
Shabnam Joshi - 0000-0003-1497-9734
Rekha Chaturvedi - 0000-0002-6491-0500
Meenakshi Bagri - 0000-0002-3222-3124
Vandana Rani - 0000-0003-0437-0706

DOI: https://doi.org/10.5114/areh.2021.111588

To appear in: Advances in Rehabilitation

Received date: 04 August 2021
Accepted date: 02 December 2021


This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting and typesetting. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.
Effectiveness of Neuromuscular exercises (NEMEX) in knee osteoarthritis: A Systematic Review with meta-analysis

Jyoti Sabharwal*1,A-E, Shabnam Joshi1,E-F, Rekha Chaturvedi1,B-C, Meenakshi Bagri1,B,E, Vandana Rani1,B,E

1Guru Jambheshwar University of Science & Technology, Hisar

Abstract
The main objective was to evaluate the effectiveness of Neuromuscular exercises (NEMEX) on pain and function in patients with knee osteoarthritis. Pubmed, Cochrane and Pedro and Google Scholar were accessed with eligibility criteria Randomized controlled trials, single blinded controlled trial and Controlled before and after study comparing and assessing the effectiveness of NEMEX in knee osteoarthritis, articles published in English language till 2020 with NEMEX either alone or in conjunction with other interventions (drugs, educational packages) in patients with Knee osteoarthritis. Outcome measures used for meta-analysis were visual analog scale (VAS) for pain and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for function and the other measures Knee injury osteoarthritis outcome score (KOOS), Knee Index and Knee Adduction Moment (KAM) and Hip Disability and osteoarthritis outcome score (HOOS). The result of the meta-analysis for the included two studies showed statistically significant reduction in pain (VAS) in the NEMEX group as compared to the other group Z = 0.64, p = 0.03, I² = 79% and no significant reduction in WOMAC scores Z = 0.70, P = 0.64. The study concludes that there was statistically significant improvement in pain (VAS) but no functional improvement (WOMAC) with the NEMEX whether used in isolation or in conjunction with other interventions was seen in the patients with knee OA. However, large numbers of studies are required to generalize the effectiveness of NEMEX in knee osteoarthritis. Implications of the study includes NEMEX can be used as a potential intervention in reducing pain, improving strength and function in knee osteoarthritis patients.

Keywords: Osteoarthritis, Visual Analog Scale, Range of Motion, Knee joint, Gonarthrosis

*Correspondence: Jyoti Sabharwal, Guru Jambheshwar University of Science & Technology, Hisar; email: jyotisabharwal35@gmail.com
Introduction

Osteoarthritis (OA) is the most common rheumatic disease that primarily affects the articular cartilage and the subchondral bone of a synovial joint that results in pain and increased difficulty with functional activities. There is a large contribution of Knee OA for walking disability, stair climbing and housekeeping than any other disease [1–3]. Osteoarthritis of the knee joint presents with the symptoms such as pain, swelling, instability and decreased range of motion (ROM). These symptoms lead to functional impairment, disability and difficulty in activities of daily living [4,5]. And these disease-related factors can potentially be improved by the exercises [6,7]. The quadriceps muscle act as a shock absorber for the knee joint and the weakness in the quadriceps and muscles of thigh alters the joint mechanics, resulting in overload at the knee joint [8]. Various studies have suggested that exercises are the cornerstone in the management of the osteoarthritis and should be given as 1st line of treatment to all the patients [9]. There is an analgesic effect of the exercises in osteoarthritic patients that helps in improving the physical function and quality of life [10]. Patients of OA have impaired sensorimotor function, altered muscle activation patterns and reduced functional performances [7,8,10,11]. From this point of view, it seems apparent that training programs addressing various aspects of sensorimotor function to improve function and alleviate symptoms can be beneficial in KOA patients. Another commonly encountered problem in OA patients is functional instability and defective neuromuscular function [12]. Therefore, the neuromuscular training must be incorporated in the management of patients with knee OA. Neuromuscular exercises are individualized and goal-based exercise program that address the functional instability and impaired muscle function for the lower extremities. Neuromuscular exercises typically involve multiple joints and muscle groups that perform in functional weight-bearing positions. Neuromuscular exercises specifically target neuromuscular impairments in patients with knee osteoarthritis. The major goal of the NEMEX is to improve the functional joint stabilization, neuromuscular control and strength. The neuromuscular training is based on biomechanical and neuromuscular principles [13]. The principles are based on active movements that are performed in synergy along with initiating the normal movement to achieve the bilateral motor learning effect. NEMEX consists of three phases: Warming up phase, NEMEX and cooling down phase. Warm up phase includes the general ergo meter cycle, treadmill walking for about 10 minutes [14]. Second phase consist of posture control, strength of lower extremity, balance, and functional stabilization of trunk and knee. And the cooling down phase includes gait retraining, backward walking (10 minutes) [15,16]. These exercises
will be performed in closed kinetic chain for even distribution of pressure on the articular surface. Muscular co-activation and quality of performance is also an important aspect to be followed in neuromuscular exercises. These exercises influence the knee joint loading and also may be beneficial in patients with varus thrust. There is direct relationship between pain and varus thrust and neuromuscular exercises alters that varus thrust and ultimately pain get reduced. The effect of neuromuscular exercises has been explored in knee injuries and other injuries of the lower extremities [17,18]. However, its use is not well explored in musculoskeletal conditions such as knee OA. Various studies have targeted the effectiveness of different muscle strengthening exercise programs in knee OA patients but, have produced conflicting results making it difficult to recommend specific exercise for the patients with knee OA. A very few studies have explored the effects of unique exercise such as neuromuscular exercises which specifically target functional joint stabilization and sensorimotor deficits in patients with knee osteoarthritis. Therefore, the present study intends to gather the relevant literature that explores the effect of neuromuscular exercises in knee OA patients.

Materials and methods

Eligibility criteria

Inclusion criteria

This systematic review was done according to PRISMA guidelines. This study was registered at the PROSPERO 2020 CRD42020173499. All English language, full text, randomized controlled trials, single blinded controlled trial and controlled before and after study from year 2010 to 2020 assessing the efficacy of neuromuscular exercises in knee osteoarthritis with outcome variables VAS, WOMAC, KOOS, KAM, HOOS and Knee Index (KI) were included for the systematic review and VAS WOMAC for meta-analysis.

Exclusion criteria

Articles in other language, full text unavailable, not randomized controlled trials were excluded for this review.

Information sources
Pubmed, Cochrane, PEDro databases and Google Scholar were used as the source for locating the literature. The search was done in last week of February 2020. A supplementary electronic search was done to update the original search in February 2021 that included all the above databases.

**Search strategy**

To search the literature in Pubmed, keywords in the advanced search option used were: "Neuromuscular exercises" OR "NEMEX" AND "Osteoarthritis" OR "OA" AND "knee" all in Title/Abstract. To scrutinize the articles, Filters used were: Randomized Controlled Trial and Humans. For searching the literature in Cochrane, keywords used were: (“Neuromuscular exercises”): ti, ab, kw OR (“NEMEX”): ti, ab, kw AND (“Osteoarthritis”): ti, ab, kw OR (“OA”). For searching in Pedro, keywords used were: (“Neuromuscular exercises”): ti, ab, kw AND (“knee Osteoarthritis”): ti, ab, kw.

**Study selection**

Eligible and relevant studies in which NEMEX was given in isolation or in combination with other interventions (drugs, educational packages) to the patients of knee osteoarthritis were scrutinized by title first and by title and abstract then and lastly by the availability of the full text by one reviewer (J) only were selected. Studies that included VAS for pain, WOMAC for function, Knee injury osteoarthritis outcome score (KOOS), Knee Index and Knee Adduction Moment (KAM) and Hip Disability and osteoarthritis outcome score (HOOS) was considered for this review. Those studies were excluded from this systematic review, in which data in terms of mean and standard deviation (SD) were unavailable.

**Data collection**

The search was done independently by two authors (J, RC) and data was drawn out according to the MeSH term and related keywords. Any conflict was fixed after conversation with SJ and the majority option was chosen.

**Data Extraction**

To determine the efficacy of the intervention, Mean and standard deviation (SD) of pain (VAS) and function (WOMAC) from both the experimental and control group were extracted.
Data for author/year, country/continent and total number of subjects for both the groups were also extracted and compared.

Risk Bias in Individual Studies

PEDro (The Physiotherapy Evidence Database) was used to assess the methodological study quality. The studies meeting the criteria for randomization and allocation concealment, assessor blinding and intention-to-treat analysis were scored with more than 7 scoring in PEDro (Tab. 2). Quality assessment was done by two investigators (J, SJ) independently.

Synthesis of Results

Results were synthesized using Review Manager 5 (RevMan 5.3), a Cochrane Collaboration's software for systemic reviews and meta-analysis. The data was entered for mean, SD and total number of the subjects for both NEMEX group and the other group and mean difference and 95% CI were calculated. Forest plots were generated for Pain (Fig. 2), WOMAC (Fig. 3). The level of Significance was 0.05 and the analysis was done by two independent investigators (J, SJ).

Result

Study Characteristics

All the studies included in this review were randomized controlled trials having 765 patients in total. Three studies are from Victoria Australia, Melbourne, Australia [19,20,21] three from Odense and Middelfart, Denmark and Svendborg Hospital, Odense University Hospital, Denmark, Aalborg, Denmark [22,23,24] and in the other study participants were recruited from Skane University Hospital, Lund, Sweden [25]. All the studies used NEMEX either alone or in combination with other intervention and were compared to the other group. Two study compare the neuromuscular exercises (NEXA) with quadriceps strengthening (QS) twice weekly for 12 weeks [19,20]. The third study used 3-month treatment program with MEDIC group compared to usual care in patients with knee osteoarthritis [21]. The fourth study assessed the patients with medial knee OA enrolled in a 12-week treatment program, comparing neuromuscular exercise to quadriceps strengthening exercises [22]. The Fifth study includes 100 patients aged between 40 years to 70 years and divided into two groups (NEMEX group and Pharma group) and found that there can be an alteration in dynamic knee joint loading in patients with knee
osteoarthritis and found that neuromuscular exercises can decrease that knee joint loading that is the main reason for the development of pain in degenerative disorders [23]. The sixth study includes 165 patients with an average age of 65 years and found that ADL and functional performance both were improved and pain was reduced after the successful completion of 8 week of neuromuscular exercises programme [24]. The seventh study includes 100 patients of both hip and knee osteoarthritis with outcome measures Hip Disability and osteoarthritis outcome score (HOOS) and physical function at the baseline and at the follow-up before the joint replacement and found neuromuscular training showed significant improvement in patient reported outcome (HOOS, KOOS) and physical function in patients with knee and hip osteoarthritis [25]. All the studies had measured changes in pain (VAS) and functional assessment (WOMAC), Knee injury osteoarthritis outcome score(KOOS), Knee Index and Knee Adduction Moment (KAM) and Hip Disability and osteoarthritis outcome score (HOOS). Table 1 summarizes the findings of the included studies. The initial yield was 85 papers from the primary search. From these, 24 duplicates were discarded and on the basis of the title and abstract, 22 references were excluded. There were 3 study protocols, 9 registered clinical trials and 15 others were also excluded. And out of the 85 papers 15 full text articles (RCTs) were assessed for the eligibility. 8 articles out of the 15 articles were excluded which don’t comply the selection criteria. All seven studies which met the inclusion criteria were randomized clinical trials [19-24,25] that were included for the systematic review and out of 7 studies 5 were excluded because the desired outcome was not reported. And the remaining 2 studies [19,20] were used for meta-analysis. In the supplementary search, no paper fulfill the inclusion criteria and subsequently no further studies were incorporated in the review. Figure 1 depicts the PRISMA flow diagram. The result of this meta-analysis suggests that there is a significant reduction in pain (VAS) with $\text{df} = 1, P = 0.03, Z = 0.64 (0.52)$ and $\Gamma^2 = 79\%$. But there is no significant functional improvement with $\text{df} = 1, P = 0.64, Z = 0.70$ and $\Gamma^2 = 0\%$. Figure 2 Forest plot for pain (VAS) in patients with knee Osteoarthritis, Figure 3 Funnel plot for pain (VAS) in patients with knee Osteoarthritis.
Tab. 1 Findings of included studies

<table>
<thead>
<tr>
<th>S.No</th>
<th>Reference article</th>
<th>Participants characteristic</th>
<th>Origin of Study</th>
<th>Study design</th>
<th>Treatment group</th>
<th>Control group</th>
<th>Outcome measures</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kim L. Bennell et al. 2015 [19]</td>
<td>100 patients with Knee OA</td>
<td>Victoria australia</td>
<td>Randomized controlled trial</td>
<td>12 weeks NEXA</td>
<td>12 weeks QS</td>
<td>VAS, WOMAC</td>
<td>For people with an observable varus thrust, NEXA was significantly more effective than QS for pain relief.</td>
</tr>
<tr>
<td>2</td>
<td>Kim L. Bennell et al. 2014 [20]</td>
<td>100 patients with Knee OA</td>
<td>Victoria australia</td>
<td>Randomized controlled trial</td>
<td>12 weeks NEXA</td>
<td>12 weeks QS</td>
<td>KAM, VAS</td>
<td>Neither group showed a change in knee moments following exercise, whereas both groups showed similar significant reductions in pain and improvement in physical function.</td>
</tr>
<tr>
<td>3</td>
<td>Hall et al. 2017 [21]</td>
<td>100 patients with Knee OA</td>
<td>Melbourne, Australia</td>
<td>Randomized controlled trial</td>
<td>12 weeks NEXA</td>
<td>12 weeks QS</td>
<td>VAS, WOMAC</td>
<td>statistically significant association between increased knee extensor</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>No.</th>
<th>Authors et al.</th>
<th>Study details</th>
<th>Methodology</th>
<th>Intervention duration</th>
<th>Comparator</th>
<th>Outcome measure</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>S.T. Skou et al. 2015 [22]</td>
<td>100 patients with Knee OA Aalborg, Denmark</td>
<td>Randomized controlled trial</td>
<td>12 weeks MEDIC</td>
<td>12 weeks Usual care</td>
<td>VAS</td>
<td>The MEDIC group had larger improvements from baseline to 3 months in peak pain intensity.</td>
</tr>
<tr>
<td>5</td>
<td>Clausen B, Holsgaard-Larsen A, Søndergaard J, Christensen R, Andriacchi TP, Roos EM 2014 [23]</td>
<td>100 patients with Knee OA Odense and Middelfart, Denmark</td>
<td>Single blinded controlled trial</td>
<td>8 weeks NEXA</td>
<td>Pharma group</td>
<td>Knee Index, KAM, KOOS</td>
<td>Neuromuscular exercises are more beneficial in comparison to pharma group in terms of knee joint loading, pain and physical function.</td>
</tr>
<tr>
<td>6</td>
<td>Villadsen A, Overgaard S, Holsgaard-Larsen A, Christensen R, Roos EM 2014 [24]</td>
<td>165 patients with Knee OA Svendborg Hospital, Odense University Hospital, Denmark</td>
<td>Randomized controlled trial</td>
<td>8 weeks EX+EP</td>
<td>Control group</td>
<td>HOOS, KOOS</td>
<td>Self reported outcome were improved and pain was reduced after 8 weeks of neuromuscular exercise in patients with knee and hip osteoarthritis.</td>
</tr>
<tr>
<td>7</td>
<td>Ageberg E, Nilssdotter A, Kosek E,</td>
<td>100 patients with Hip &amp; Knee OA Lund, Sweden</td>
<td>Controlled before and after study</td>
<td>NEMEX-TJR (Total joint replaceme)</td>
<td>Reference Group</td>
<td>HOOS, KOOS</td>
<td>Neuromuscular training is superior to reference group in</td>
</tr>
</tbody>
</table>
Fig. 1. PRISMA Flow Diagram
**Fig. 2.** Forest plot for pain (VAS) in patients with knee Osteoarthritis

**Fig. 3.** Forest plot for function (WOMAC) in patients with knee Osteoarthritis

**Quality assessment**

Table 2 summarizes the quality of studies included in this review. All the included studies have PEDRO score of above 7 out of 11 that shows high quality of the studies. Table 3 summarizes risk of bias by Cochrane collaboration modified tool.

**Tab. 2.** Quality assessment of selected Randomized Controlled Trials using Physiotherapy Evidence Database (PEDro scoring). Higher score implies higher quality

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Specified eligibility criteria</th>
<th>Random allocation</th>
<th>Concealed allocation</th>
<th>Similar baseline</th>
<th>Subjects blinding</th>
<th>Therapists blinding</th>
<th>Assessors blinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No.</td>
<td>Measure/Analysis</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Yes/No</td>
<td>Total</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>8</td>
<td>Measures of key outcomes from more than 85% of subjects</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Intention to treat analysis of one key outcome</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Statistical comparisons between group of at least one key outcome</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Variability for at least one key outcome</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7/11</td>
<td>8/11</td>
<td>9/11</td>
<td>8/11</td>
<td>7/11</td>
<td>9/11</td>
</tr>
</tbody>
</table>
### Tab. 3. Risk of Bias by Cochrane collaboration modified tool

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Random sequence generation (Selection bias)</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>2. Allocation concealment (Selection bias)</td>
<td>High Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>3. Blinding of participants and personnel (Performance bias)</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
</tr>
<tr>
<td>4. Blinding of outcome assessment (Detection bias)</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>5. Incomplete outcome data (Attrition bias)</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>6. Selective reporting (Reporting bias)</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>7. Other bias</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
</tr>
</tbody>
</table>
Discussion

The aim of the study was to assess the effectiveness of NEMEX in patients with knee OA. The neuromuscular exercises are based on biomechanical and neuromuscular principles and aims to improve sensorimotor control and achieve functional stability. Strengthening exercises are used for people with OA but the neuromuscular exercises were developed to target the sensorimotor deficiencies and functional instability associated with knee injuries as well as knee osteoarthritis. By addressing the quality of movement in all 3 movement planes (coronal, sagittal, and transverse) neuromuscular exercises improve the sensorimotor control and also assist in attaining functional joint stabilization. Various Studies have found that NEMEX effective in relieving pain alters knee biomechanics, improves the function and muscle-activation patterns of the knee in patients with knee OA and also in sports injuries like ligament and meniscal tears. Neuromuscular training also plays an important role in preventing the ligament injuries in male soccer players. Furthermore, NEMEX has been shown to improve articular cartilage quality in middle-aged patients who have had menisectomies and are at high risk of development of Knee OA. Therefore the NEMEX play an important role in the management of Knee OA. Neuromuscular exercises also helpful in improving the muscular strength and performance of the patients. In comparison with other exercise protocols neuromuscular exercises mainly improves the balance, coordination as well as quality of movement which are the key factors in maintaining the joint stability. The studies included in this review that varied widely in terms of population, group’s comparison, types and durations of the intervention. Overall, the included studies had high methodological qualities with an average score of 7 on the PEDro scale. One study found significant improvements in pain and physical function in both groups (NEXA group and Quadriceps group) and neuromuscular exercises was more effective in patients of knee OA with varus thrust as the varus thrust is directly related with pain and neuromuscular exercises alter that thrust which decreases the pain but no significant improvement in knee adduction moment (KAM) which is the main factor in genesis of knee osteoarthritis[19,20]. Previous study in 2015 compared themedic group which included 3 months protocol of exercises, education, diet, insoles and medications with usual care group and in that, MEDIC group showed larger improvements in peak pain intensity (P= 0.02) from baseline to 3 months and function on long term basis [21]. Various research evidences have suggested that NEMEX is effective in other injuries and disorders other than knee osteoarthritis like ligament injuries, childhood obesity, balance and functional improvement [13, 17]. It is also found that 8
weeks of neuromuscular exercises is more beneficial than use of medications (analgesic, anti-inflammatory drugs) in terms of knee joint loading, knee pain and physical function[23]. Neuromuscular exercises are feasible in patients with knee osteoarthritis and pain was relieved and performance of patients was improved in patients with knee and hip osteoarthritis[24]. Neuromuscular exercises are also beneficial for patients with hip and knee osteoarthritis [25]. This systematic review included only two studies for the meta-analysis and the included studies had high heterogeneity, making it difficult to conclude the effectiveness of NEMEX in knee osteoarthritis. The result of meta-analysis suggested that statistically significant improvement was there in the pain (VAS) with df=1, \( P=0.03 \), \( Z=0.64 \) and \( I^2=79\% \) but no functional improvement (WOMAC) was there with the use of NEMEX in patients with knee OA. It can be concluded from the result of the meta-analysis that NEMEX is an effective intervention in the management of knee osteoarthritis. Soin order to generalize the efficacy of NEMEX, more studies with large sample size are required to determine the role of NEMEX in treatment of knee osteoarthritis. Taking in account of the promising results shown by the NEMEX in various conditions and to some extent in knee OA, its efficacy can be further explored and may prove to be a potential intervention in management of knee osteoarthritis.

**Limitations**

There were variations in combination of NEMEX with quadriceps strengthening, usual care and medic care for treatment of osteoarthritis that might have caused bias in the analysis. Large sample size is required to generalize the effectiveness of NEMEX.

**Conclusion**

The result of the meta analysis suggests that there is a statistically significant reduction in pain with \( P=0.03 \). By focusing the finding of the study the neuromuscular exercises can be the choice of intervention for reducing pain in patients with knee osteoarthritis however no statistically significant functional improvement with \( P=0.64 \). However the effectiveness of NEMEX must be explored further for better management of pain can be recommended in patients with knee osteoarthritis.

**Conflict of Interest:** None
Source of Funding: None

References


