Neuromuscular versus Strengthening Program on Pain, and Function in Knee Osteoarthritis

Abdelrahaman M. Hewidy[1*], Karim Ghuiba[2], Waleed M. Ewais[3], Mohammed S. Abdelsalam[2]

1- Physical Therapy Department, Almenshawy General Hospital, Tanta
2- Department of musculoskeletal disorders and its surgeries, Faculty of Physical Therapy, Cairo University
3- Department of orthopedic surgery, Faculty of Medicine, Tanta University

Corresponding Author: (Abdelrahaman M. Hewidy, master student)
dr.abdelrahman.hewidy.94@gmail.com

ABSTRACT

Background: Osteoarthritis is a major public health problem. Both neuromuscular training, and strengthening has been increasingly applied for patients with osteoarthritis. **Purpose of the study:** was to compare effects of neuromuscular training and strengthening exercises on pain, disability level, and physical activity in knee osteoarthritis. **Subjects and Methods:** Fifty one patients with knee osteoarthritis, aged 45–65 years, and BMI 18-30 kg/m^2, participated in this study. Patients were divided randomly into 3 equal groups of 17 patients each. Group [A] [Control group], received TENS and warm up exercises. Group [B] [Strengthening exercises group] received same as group [A] plus strengthening exercise program. Group [C] [Neuromuscular control group] received same as group [A] plus neuromuscular control training program. All participants were evaluated before and after 12 sessions (3 sessions a week for 4 weeks) through measuring visual analog scale, Western Ontario and McMaster Universities Arthritis Index, timed up and go test and 6-minutes walking test, to evaluate pain, disability level, and physical activity respectively. **Results:** The results revealed a significant effect of treatment in improving all parameters within all groups. Further, groups B and C were significantly better than group A in pain (VAS), and level of disability (WOMAC), but with non-significant differences in functional tests, post-treatment. Albeit, there was no significant difference between groups BandC. **Conclusion:** both neuromuscular and strengthening program showed significant improvement with no differences between both groups on decreasing pain, improving disability level, and improving physical activity in KOA patients.

Key words Knee Osteoarthritis; neuromuscular training; strengthening exercises.

INTRODUCTION

Osteoarthritis [OA] is a common, age related, heterogeneous group of disorders characterized by focal areas of loss of cartilage [1, **2**]. The entire joint, including cartilage, bone, ligament, and surrounding muscles, is affected by OA, with narrowing in joint space, bony osteophytes, and sclerosis visible on X-ray. It is the most frequent joint disorder among the elderly, and it is one of the leading causes of disability [**3**].

Patients with knee osteoarthritis (KOA) complain mostly of pain, and they are less physically active than the general public. Self-reported and objective measurements of physical function is now recommended to get a full picture of function in patients with OA [2].

According to literature review of OA non-pharmacological, pharmacological, or surgical treatments are available. Literature, generally, recommends non-pharmacological treatment, that include physical therapy modalities such as TENS, Laser, Ultrasound and orthotics [4]. Moreover, evidence-based recommendations support a combination of medical education, exercises, and weight loss as the first-line treatment for degenerative knee disease [5]. Exercises, have been reported to relieve pain and enhance muscle function [2].

The main goals of exercise in these patients are to reduce pain, improve physical function and optimize participation in social, domestic, occupational and recreational pursuits. It can improve impairments associated with OA such as muscle weakness, restrictions in joint range of motion, and proprioception and balance deficits. Both neuromuscular control training and muscle strengthening are considered as essential parts of most exercises programs for KOA [3].

Quadriceps muscle weakness is a common symptom in knee OA, so quadriceps strengthening exercises is an important component of the exercise program recommended as part of conservative management [6]. The quadriceps muscle's strength is related to the indications of severity of OA in the knee joint. Quadriceps weakness in knee OA leads to decreasing shock absorption capability and leads to joint instability, as well as changes in the joint's neuromuscular function [6]. Quadriceps strengthening exercises are highly effective for decreasing pain and improving physical functional ability in patients with KOA [3].

Furthermore, hip muscles play an important role in the normal function of the lower limb. Many researchers found that hip muscles dysfunction is associated with lower limb impairments or diseases [7]. Hip-abductors weakness may permit excessive femoral internal rotation and adduction and decrease control of dynamic knee valgus, which resulting in repetitive stress injuries such as patellofemoral and tibiofemoral OA [8]. Hip abductors strengthening improve function and reduce pain in patients with KOA [9].

Neuromuscular training (NMT) relieves pain, enhances physical activity performance, improves the muscle-activation patterns of the surrounding knee musculature, achieve sensorimotor control, and improve daily functions in KOA patients. [10].

Whether an exercise program that includes either strengthening exercises or neuromuscular control training would achieve significantly better pain control, and function enhancement in KOA compared to the other, is still to be ascertained. Therefore, this study aimed to explore whether one form of exercises; strengthening and neuromuscular control, would show significant results in pain, and function in KOA.

Materials and methods:

This study was conducted to compare the effects of neuromuscular training program (NMT) and strengthening exercises program (SEP) in patients with KOA. It was conducted at Physical therapy department at Almenshawy general hospital in Tanta, Egypt. It took a period of 6 months from November 2021, till April 2022.

Study Design: A single blinded randomized controlled trial.

Participants: Fifty one patients of both genders with mild to moderate knee osteoarthritis ≤ 3 on the Kellgren and Lawrence scoring system, their age range from 45-65 years old. The sample size was estimated using the G*power 3.0.10 software. Calculation of the numbers of patients in this trial depending on a pilot study from 6 patients. The estimated total sample size was 51 subjects; with 17 patients within each group.

Inclusion criteria:

Both genders with age ranges between 45-65years old; ; BMI ranges between 18-30 kg/m2; Patient with mild to moderate OA ≤ 3 on the Kellgren and Lawrence scoring system and Patients who can walk with painful knee OA without assistive devices. [5, 10].

Exclusion criteria:

Post knee surgery or intraarticular corticosteroid injection within 6 months. Other arthritis diseases. Current or past within, 4 weeks, oral corticosteroid treatment or corticosteroid injections, uncontrolled hypertension, history of cardiovascular disease, pregnancy, or cognitive impairments [6, 10].

All participants were referred by orthopedic surgeons according to their clinical features and radiological investigations.

- **Group A (Control group):** 17 patient received TENS and warm up exercises.
- **Group B (Strengthening exercises group):** 17 patient received same as group one plus strengthening exercise program.
- **Group C (Neuromuscular group):** 17 patients received same as group one plus neuromuscular training program.

Randomization:

Each participant included in the study signed an informed consent, and then randomly assigned to one of the three groups using random number generator, which generated 3 sets of numbers from 1-51 without repetition (www. randomization. com).

Allocation to one of the three groups was revealed to the patients at the time of confirmation of enrolment.

Measurement procedures

All Patients were evaluated by same examiner. Measurements were taken before and after 12 physical therapy sessions. Visual analogue scale [VAS] was used to evaluate the pain intensity. Participants were asked to mark on the 10-cm line the point that he/she felt to represent perception pain intensity at time of evaluation [11]. WOMAC questionnaire Arabic version to evaluate of three domains; pain, stiffness and functional ability, was self- filled by the patients [11].

Timed up and go (TUG) test to evaluate functional performance: patients were asked to stand up, walk to a mark 3m away, turn around and return to sit back in the chair at their regular pace. Same chair used for re-testing [11]. Six -minutes' walk test [6MWT] to assess the patient's walking ability. Participants were instructed to walk at their own pace in a well-ventilated, and flat surface hallway with two cones were placed 20 meters apart to cover maximum distance in 6 min [12, 13].

Treatment procedures:

All groups received

1. TENS was applied using two electrodes which were placed on the medial and lateral parts of the knee joint line. TENS was applied to the patients using a frequency of 100 Hz, pulse width of 50–100 μs, and quadratic biphasic symmetrical pulse shape for 20 min. The intensity [mA] was set at the individual threshold of a tingling sensation [4]. Device used was EME Therapic 9200, (EME Physio, Via degli Abeti 88/161122 Pesaro (PU), Italy).
2. Warm up exercises:

Walking at self-pace on a flat surface for 10 min. In addition to hamstring and calf gentle stretching exercises [4]. Stretching was carried out for 5 repetitions of 30 seconds each.

Group (B)

In addition to warm up and TENS application, group B received strengthening exercises program that was adapted and modified from **Dhanakotti et al., 2016** [1]. Exercises were performed in 2 levels; level 1 during the first two weeks of experiment. [6 sessions], and progressed to level 2 during the last 2 weeks of experiments. It consisted of isometric Exercises for quadriceps applied for 3 sets, each set of exercises consist of 10 repetitions of 5 seconds hold for each repetition. Level 1 was applied from supine, then level 2 from long sitting. Straight leg raises (SLR), the last degrees of knee extension, and hip abductors strength exercises were applied (10 rep X 3sets). For these 3 exercises level one was applied without resistance, then in level 2 resistance weights were used for progression.

Group (C)

1. Group C received warm up and TENS in addition to neuromuscular training sessions that extended for 30 to 40 minutes each session. The neuromuscular training exercises in this study was derived and modified from previous studies [2, 6]. Neuromuscular training program was also subdivided into 2 levels; level 1 over the first 2 weeks, then level 2 over the last 2 weeks of exercises. Exercises included 1) side stepping where patients walked sideway with the leading foot stepping sideways and trailing [affected] foot following to leading foot, then repeat the same in opposite direction [6]. 2) High knees march where patients marched forward while bending hip around 90° in high step pattern [6]. 3) Step up that involved standing in front of step board then step up and down [2]. 4) chair sit to stand where patients stood up and sat down putting equal loads on both legs [2]. 5) Pelvic lift patients lying supine with legs on Swiss ball and hand supported on the floor then left lower pelvis from the floor and hold as patient's ability [2]. 6) Tandem walk where patients heel of one foot landed just in front of opposite foot and walk in straight line [6]. For all 6 exercises, level 1 was applied with hand assistance while eyes were closed. This was followed by level 2 without hand assistance and eyes were open. Only one exception was pelvic tilt exercise which was applied only in level 2.

Data Analysis

ANOVA test were conducted for comparison of subject characteristics between groups. Chi- squared test was used for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test for all variables. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Mixed MANOVA was performed to

compare within and between groups effects on VAS, WOMAC, TUG and 6MWD. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparison. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies [SPSS] version 25 for windows [IBM SPSS, Chicago, IL, USA].

Results

- Subject characteristics:

There was no significant difference between all groups in age and BMI [$p > 0.05$]. Also, there was no significant difference in sex distribution between all groups [$p > 0.05$]. [Table 1]

Table 1. Basic characteristics of participants.

	Group A	Group B	Group C	p-value
Age, mean ± [SD], years	50.29 ± 5.42	53.35 ± 6.9	51.25 ± 4.78	0.29
BMI, mean ± [SD], kg/m²	28 ± 1.73	27.52 ± 2.62	27.17 ± 2.01	0.53
Sex, n [%]				
Females	11 [64.7%]	10 [58.8%]	8 [47.1%]	0.57
Males	6 [35.3%]	7 [41.2%]	9 [52.9%]	

SD, standard deviation; p-value, level of significance

Effect of treatment on VAS, WOMAC, TUG and 6MWD

Mixed MANOVA revealed that there was a significant interaction of treatment and time [$F = 14.62$, $p = 0.001$]. There was a significant main effect of time [$F = 289.42$, $p = 0.001$]. There was a significant main effect of treatment [$F = 6.05$, $p = 0.001$]. Table 2 showed descriptive statistics of VAS, WOMAC, TUG and 6MWD and the significant level of comparison between groups as well as significant level of comparison between pre and post treatment in each group.

Within groups comparison

There was a significant decrease in VAS, WOMAC and TUG in the three groups post treatment compared with that pretreatment [$p < 0.001$]. The percent of change of VAS, WOMAC and TUG in group A was 20.89, 9.55 and 8.95% respectively, and that in group B was 58.72, 24.95 and 20.44% respectively while that in group C was 58.12, 23.71 and 20.29% respectively.

There was a significant increase in 6MWD in the three groups post treatment compared with that pretreatment [$p < 0.001$]. The percent of change of 6MWD in groups A, B, and C were 1.5, 2.94 and 3.95% respectively.

Between groups comparison

Between groups comparisons pretreatment revealed a no significant difference in all parameters [$p > 0.05$]. Comparison between groups post treatment revealed a significant decrease in VAS and WOMAC of group B and group C compared with that of group A [$p < 0.01$] while there was no significant difference between group B and C [$p > 0.05$]. There was no significant difference in TUG and 6MWD between the three groups post treatment [$p > 0.05$].

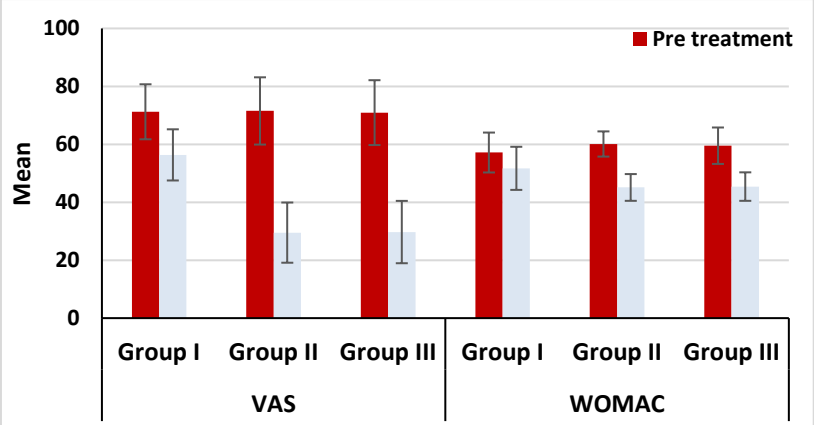

Figure 1. ***Mean VAS and WOMAC pre and post treatment of group I, II and III***

Table 2. ***Mean VAS, WOMAC, TUG and 6MWD pre and post treatment of groups A, B, and C:***

	Group A	Group B	Group C	p-value		
	mean ± SD	mean ± SD	mean ± SD	A vs. B	A vs. C	B vs. C
VAS						
Pre treatment	71.23 ± 9.49	71.52±11.61	70.94±11.19	0.99	0.99	0.98
Post treatment	56.35 ± 8.83	29.52±10.39	29.71±10.76	0.001*	0.001*	0.99
	*p = 0.001**	*p = 0.001**	*p = 0.001**			
WOMAC						
Pre treatment	57.17 ± 6.89	60.11 ± 4.35	59.52 ± 6.29	0.32	0.48	0.95
Post treatment	51.71 ± 7.44	45.11 ± 4.62	45.41 ± 4.92	0.005*	0.008*	0.98
	*p = 0.001**	*p = 0.001**	*p = 0.001**			
TUG [sec]						
Pre treatment	11.85 ± 1.28	12.62 ± 1.11	12.42 ± 1.29	0.16	0.36	0.88
Post treatment	10.79 ± 1.34	10.04 ± 1.09	9.9 ± 1.17	0.17	0.09	0.94
	*p = 0.001**	*p = 0.001**	*p = 0.001**			
6MWD [meter]						
Pre treatment	288.61 ± 11.25	284 ± 12.56	281.73 ± 12.13	0.51	0.22	0.84
Post treatment	292.94 ± 13.77	292.35±11.11	292.85 ± 14.56	0.99	1	0.99
	*p = 0.001**	*p = 0.001**	*p = 0.001**			

***P< 0.05; SD, Standard deviation; p-value, Level of significance**

Discussion

This study was designed to evaluate and compare the effects of neuromuscular training [NMT] and strengthening exercises on decreasing pain, reducing level of disability, and improving physical activity in patients with KOA

Results of current study showed that both strengthening exercises program and neuromuscular training program were equally effective in controlling pain, recovering functional disability, and enhancing functional performance in KOA.

The results of the current study were in agreement with that of **Ageberg et al. [2]** which state that exercise intervention for knee osteoarthritis patients be in form of General aerobic training, and local stretching and strengthening training, which show positive effects in reducing pain and improving physical functional ability. Further, they reported that neuromuscular training is effective in pain reduction and improvement of movement quality, and functional ability which supports results of current study.

Bennell et al.[3] concluded that strengthening exercises for lower limb is a key component of most exercise regimes for knee OA because it improves strength, decrease pain, improve balance, and enhance physical functional ability and quality of life which in agreement with results of current study. Moreover, the results of **Bennell et al.[3]** was consistent with the results of current study as they stated that Both exercise programs; neuromuscular or strengthening exercise, provided similar improvement in clinical outcomes, including pain, function, and physical activity.

Holm et al. [15] and **Balba et al. [16]** proved that there is no additional benefits on self-reported physical function when comparing lower-limb strength training to neuromuscular exercise training.

On the other hand, the results of current study aren't supported by the result of **Ganjave et al. [17]** as they stated that adding exercise program including neuromuscular training [NMT] in cases with knee osteoarthritis leads to higher improvement on pain, balance, and function than conventional strengthening exercises program. Also the results of **Teja et al. [18]** was not in agreement with the results of the current study as they reported that neuromuscular training is more effective in improving strength and function when compared with strengthening training. So neuromuscular Training is best for those patients with knee Osteoarthritis. Likewise, both **Rashid et al. [6]** and **Risberg et al. [14]** confirmed that The NMT group showed improvement in some of the gait, pain, stiffness, and functional limitation compared with strengthening program. No additional improvement was found between groups.

Conclusion

According to the results of the current study we concluded that applying a physical therapy program including either strengthening exercise training or neuromuscular training would has a great benefit on decreasing pain, reducing level of disability, improving physical functional activity in patient with KOA with no significant difference between both programs.

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