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Original Article / Araştırma Makalesi

THE EFFECT OF NEUROMUSCULAR EXERCISES ON FUNCTIONALITY, PHYSICAL ACTIVITY AND BALANCE IN PATIENTS WITH OSTEOARTHRITIS: RANDOMIZED CONTROLLED STUDY

Osteoartritli Hastalarda Nöromusküler Egzersizlerin Fonksiyonellik, Fiziksel Aktivite ve Denge Üzerine Etkisi: Randomize Kontrollü Çalışma

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ABSTRACT

This study was planned as single- blinded randomized controlled trial to examine the effects of neuromuscular exercises on functionality, physical activity, and balance in patients with osteoarthritis. Sixty patients with osteoarthritis were included. Patients were selected using the random sampling method and allocated to two groups: The experimental group (n=30), and the control group (n=30). The exercises were administered to both groups 6 days a week for 6 weeks, with one set under the physiotherapist's control and two sets of home exercises repeated 10 times. Pain (VAS), physical activity level, functionality, and balance were evaluated before and after treatment. We found a significant difference in levels of functionality, pain (p <0.001), physical activity, and balance (p <0.05) in both groups at the end of our study. Although the above-mentioned parameters improved significantly in both the groups after treatment, the pre-and post-treatment evaluations in the experimental group were higher than those in the control group in a positive way (p <0.05). We postulate that in addition to classical physiotherapy, neuromuscular exercises are necessary for osteoarthritic patients and are more effective for pain and increased physical activity, function, and balance than conventional knee exercises.

Keywords: Arthritis, Exercise, Physical activity, Proprioception, Rehabilitation.

ÖZ

Bu çalışma osteoartritli hastalarda nöromusküler egzersizlerin fonksiyonellik, fiziksel aktivite ve denge üzerine etkisini incelemek amacıyla randomize kontrollü, tek kör olarak randamize kontrollü, tek kör olarak planlandı. Osteoartritli 60 hasta dahil edildi. Hastalar randomize örneklem yöntemi ile seçildi ve iki gruba bölündü Deney grubu (n=30), kontrol grubu (n=30). Egzersizler her iki gruba da 6 hafta boyunca haftada 6 gün, bir set fizyoterapist kontrolünde ve iki set ev egzersizi olarak 10 kez tekrarlanarak uygulandı. Ağrı (VAS), fiziksel aktivite düzeyi, fonksiyonellik ve denge tedavi öncesi ve sonrası değerlendirildi. Çalışmanın sonunda her iki grupta da fonksiyonellik, ağrı (p<0,001), fiziksel aktivite ve denge (p<0,05) düzeylerinde anlamlı farklılık bulduk. Yukarıda belirtilen parametrelerde tedavi sonrası her iki grupta da anlamlı düzelme olmasına rağmen deney grubunda tedavi öncesi ve sonrası değerlendirmeler kontrol grubuna göre olumlu yönde daha yüksekti (p<0,05). Osteoartrit hastaları için klasik fizyoterapiye ek olarak nöromüsküler egzersizlerin de gerekli olduğunu ve ağrı, artan fiziksel aktivite, fonksiyon ve denge açısından geleneksel diz egzersizlerine göre daha etkili olduğunu düşünüyoruz.

Anahtar kelimeler: Artrit, Egzersiz, Fiziksel Aktivite, Propriosepsiyon, Rehabilitasyon.

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INTRODUCTION

Osteoarthritis (OA) is one of the most common diseases worldwide, accompanied by decreased physical activity and increased weight gain. The prevalence of knee OA in the aging population has been reported to be 19.2-45.6% (Wanaratna, Muangpaisan, Kuptniratsaikul, Chalermsri, & Nuttamonwarakul, 2019). The disease is accompanied by subchondral bone sclerosis, loss of joint proprioception, decreased muscle strength, disturbed joint stabilization, muscle imbalances, and decreased neuromuscular control (Dong et al., 2018). Impaired neuromuscular control of the muscles, in turn, affects weight transfer, walking, and balance, resulting in associated pain, loss of daily activities, and functional activities, and lock-up of the knee joint (stiffness) (Roos, Herzog, Block, & Bennell, 2011). Thus, as expected, the demand for surgical or conservative interventions is increasing to circumvent this problem. Apart from surgical interventions, there are no radical pharmacological methods that can change the course of the disease and treat the disrupted joint structure (Recondo et al., 2000; Uysal FG, 2009) This increases the importance of rehabilitation for the treatment of OA. Several meta-analysis studies have reported the usefulness of exercise training for OA treatment (Brosseau et al., 2004; Goh et al., 2019). Studies performed so far have reported the use of isometric, isotonic, and isokinetic exercises with different electrotherapy applications to increase muscle strength in knee OA (Huang, Lin, Yang, & Lee, 2003; Peter, Nelissen, & Vlieland, 2014). Since the mechanisms of pain reduction by such exercises are not fully understood, various exercise interventions are performed from aerobic exercise to isolated resistance training (Juhl, Christensen, Roos, Zhang, & Lund, 2014). Recent studies have shown that the neuromuscular exercise (NME) program includes seven parameters; functional mobility (dynamic warming, and flexibility), functional stability (postural control, general and local joint stabilization, body stabilization training, and balance training), sensorimotor system education (proprioception, kinesthetic, oscillation, and perturbation training), proprioceptive neuromuscular training techniques, plyometrics exercises, reactive neuromuscular training, and technical training (Holm et al., 2004; M. A. Risberg, Mørk, Jenssen, & Holm, 2001). Neuromuscular control exercises including balance, strengthening, functional exercises, flexibility, agility, postural control, postural orientation, plyometric exercises, and sports-specific exercises rebuild and rearrange features such as static joint stability, dynamic joint stability, and reactive neuromuscular control (Zech et al., 2009). This allows patients to actively improve their functional capacity. It is known that neuromuscular exercise program has been used in patients with anterior cruciate ligament injury, patients who have undergone arthroscopic knee surgery, or who have undergone knee replacement. In patients with knee osteoarthritis who have not undergone surgery, the effect of the neuromuscular exercise program on functionality and pain has been examined, and no study has been found examining the effect on physical activity. In our study, we planned to examine the effects of a neuromuscular exercise program as a preventive treatment option in patients with knee osteoarthritis (Bennell et al., 2014; May Arna Risberg, Mørk, Jenssen, Holm, & Therapy, 2001; Villadsen, Overgaard, Holsgaard-Larsen, Christensen, & Roos, 2014).

In this context, our study aimed to evaluate the effect of an NME program on functionality, physical activity, and balance in patients with knee OA and to compare it with a standard exercise program. The hypotheses of the study are as follows: 1) Neuromuscular exercises increase physical activity in patients with knee osteoarthritis. 2) Neuromuscular exercises increase functionality in patients with knee osteoarthritis. 3) Neuromuscular exercises increase balance in patients with knee osteoarthritis.

MATERIAL AND METHOD

A prospective, single-blind, randomized controlled study was designed involving patients with knee OA who had visited the Physiotherapy Rehabilitation department between June 2017 and December 2017. To conduct this study, approval was received from the Malatya Clinical Research Ethics Committee dated 14.06.2017 and numbered 2017/72. This study was also recorded in the Clinical Trials Registry (NCT Number: NCT03470090, March 21, 2018). The study was performed by the CONSORT guidelines. Prior to enrollment in the study, all individuals provided informed consent. The experimental protocol was approved according to the ethical standards of the Declaration of Helsinki.

The universe of the study consists of patients with knee osteoarthritis. Patients who were diagnosed with osteoarthritis by an orthopedic specialist and were referred to a physical therapy and rehabilitation specialist, who had not had any previous knee surgery, had no neurological disease, and agreed to participate in the study were included in the study with random sampling. Patients who had a previous knee injection, had previously received exercise therapy, refused to participate in the study, and could not adapt to the study were excluded from the study. Patients over 65 years of age were excluded from the study to eliminate age-related consequences of balance parameters. Patients were randomly divided into two groups: the experimental group subjected to classical physiotherapy and NME program, and the control group, where classical physiotherapy with conventional knee exercise program was applied.

Eighty-one patients between the ages of 35 and 65 years met the inclusion criteria and were selected for the study. In the experimental group, five patients who did not perform home exercise regularly during the 6-week treatment period and 10 patients who underwent intra-articular injection were excluded from the study. In the control group, six patients were excluded from the study because they did not exercise regularly. When any patient was leaving the group, the next patient was taken into that group. Sixty patients were finally evaluated in this study (Figure 1).

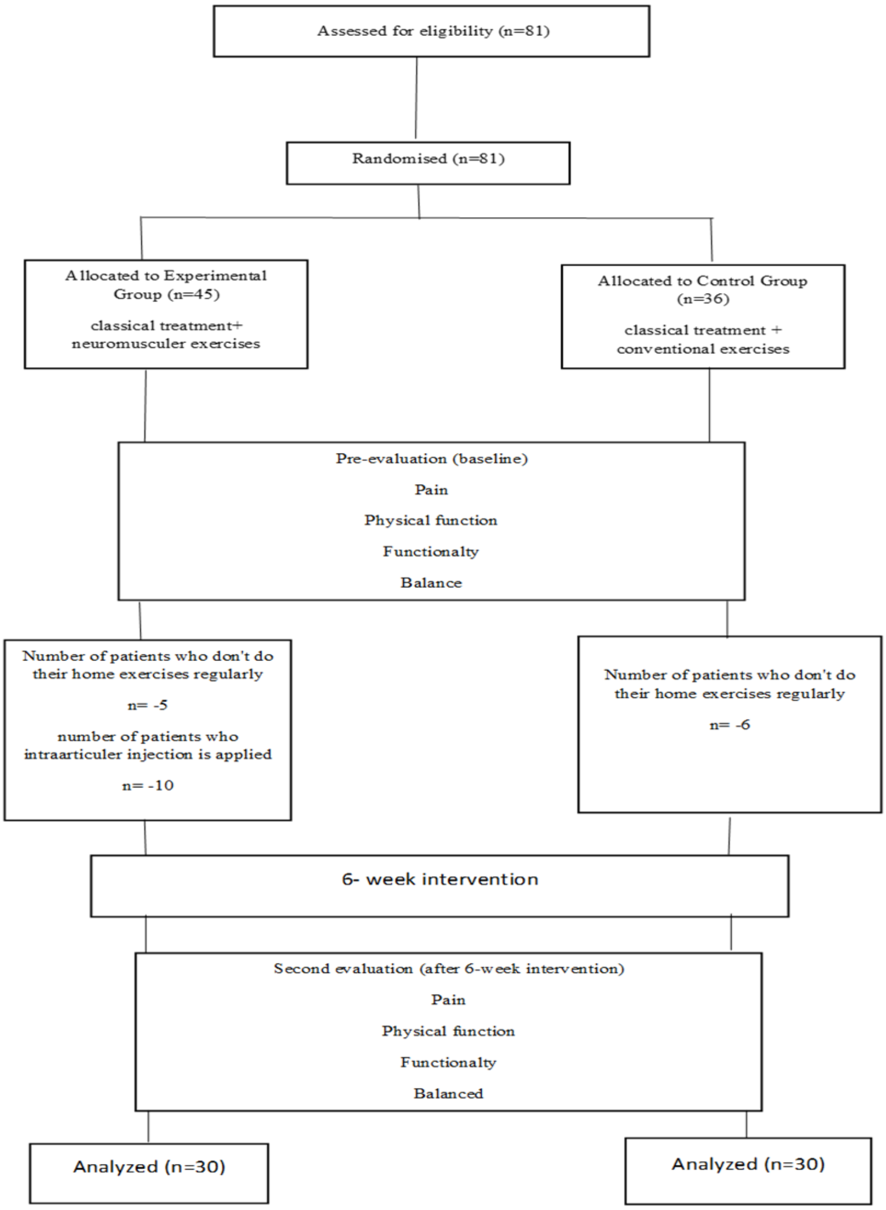

Figure 1. Study Flow Chart

Outcome Measures

Patient's demographic information including name, surname, age, weight, height, BMI, occupational dominant side, injured side, and previous surgical history related to the knee was recorded for evaluation.

A visual analog scale (VAS) was used to determine the severity of pain in the knee joint of patients with OA.

To assess the physical activity of the patients, a short form of the International Physical Activity Questionnaire (IPAQ short form) was used. The IPAQ short form consists of seven questions that provide information about the time spent in different activities including walking, moderate and intense work, as well as sitting. The Turkish validity and reliability study of the questionnaire was conducted by Saglam et al. (Saglam et al., 2010).

Functionality; knee pain, hardness, and physical functional measurements were performed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The Turkish validity and reliability study of the questionnaire was conducted by Tüzün et al. (Tüzün, Eker, Aytar, Daşkapan, & Bayramoğlu, 2005). The International Knee Documentation Committee (IKDC) subjective knee evaluation form was used to assess physical functioning. The WOMAC is the most commonly used disease-specific quality of life measure in OA. The scale contains 24 questions under three subgroups pain, stiffness, and physical function.

IKDC is used to determine the maximum physical activity that can be performed without the restriction of movement for reasons such as swelling, crepitation, and pain in the knee, and to evaluate the physical function in daily life activities. The Turkısh validity and reliability study of the questionnaire was conducted by Celik et al. (Çelik, Coşkunsu, Kılıçoğlu, Ergönül, & Irrgang, 2014).

The Y-balance test was used to evaluate the dynamic balance of the OA patients. Individuals were evaluated pre- and post-treatment (at the end of week 6). The Y-balance test is a modified version of the Star Excursion Balance Test to evaluate dynamic balance. In this study, posteromedial (PM), posterolateral (PL), and anterior (A) measurements were performed at 120° angles. Three measuring tapes were placed on the floor at a 120-degree angle. The patient was asked to advance one foot in all three directions without touching the ground and return to the starting position.

Interventions

Experimental Group

The participants of this group were enrolled in the NME program after the pre-treatment evaluations. They were given classical physiotherapy and NMEs. In classical physiotherapy applications, individuals were given 20 min hot pack (HP), ultrasound (US), and transcutaneous electrical stimulation (TENS). NME for the knee was performed 6 days a week, with one set repeated 10 times under the physiotherapist’s control. Patients had to perform six such sets per week and two sets per day repeated 10 times as home exercise for 6 weeks. Subsequently, they were evaluated at the end of the 6th week.

The NME program included warming, NME, and cooling periods. The individuals in this group, with maximum pain limit, had to undergo walking on the treadmill for 10 min to complete the warm-up period, followed by NME. In the scope of NME, 4-way knee movements with theraband (terminal knee extension, abductıon, adductıon, flexion with theraband) were performed. During the exercise, an active movement was performed in four directions by holding the pelvis in a neutral position for 5 s in each position before returning to the starting position from the last point of the movement. Active movements were combined with respiration.

Dynamic knee stabilization was performed against stimuli given in different directions in the knee flexion position in such a way that the affected lower extremity was on the exercise ball to increase the proprioceptive entry and to provide quadriceps hamstring co-contraction. To provide stabilization of the core, transversus abdominus, and multifidus muscles, patients were given a bridge-building exercise that increased muscle contraction to ensure stabilization. During this exercise, an exercise ball was used to increase the proprioceptive input during weight transfer to the ankle and knee joints. At the beginning of the movement, the pelvis, shoulders, head, and neck were placed in a neutral position. The patient's hip, waist, and back were removed from the floor one by one, like a chain, by waiting for 5 s. The patient was asked to return to the initial position by placing the back, waist, and hip on one side in the opposite order. The floor of the balance board was changed to increase proprioceptive input. The patient moved the weight by holding the pelvis in a neutral position on the balance board without shoes. Then, the balance board was stopped for 10 s on one foot (knee extension and knee 0°-30° flexion). After NME, the cooling period was completed by walking on the treadmill for a maximum of 10 min.

Control Group

Pre-treatment evaluations of the subjects were followed by classical physiotherapy: HP, US, and TENS. This was followed by conventional knee exercises including isometric knee exercises and isotonic quadriceps strengthening exercises at the bedside. All performances were fixed six times a week, with one set repeated 10 times per day under physiotherapist control. Six such sets per week had to be repeated, with two sets per day 10 times as home exercise for 6 weeks. Home exercises were monitored by questioning the patients. The individuals were re-evaluated after 6 weeks.

Statistical analysis

Statistical Package for Social Sciences [SPSS] for Windows 22.0 [SPSS Inc., Chicago, IL] was downloaded and evaluated into the computer environment. In the power analysis performed before the study, a minimum of 30 subjects from each group was required to have 1.9 units (8.1 ± 2.2/6.2 ± 3.1) of the mean WOMAC pain score after the NME training in patients with knee OA with an $\alpha = 0.05$ and $1^{-\beta} = 0.80$. Thus, 30 patients were admitted to both groups. Descriptive statistics are presented as the mean ± standard deviation (SD) and percentages. The Pearson chi-square test and Fisher's exact test were used to evaluate categorical variables, and the McNemar test and McNemar-Bowker test were used to evaluate categorical variables. The suitability of the normal distribution of variables visually (histogram and probability graphs) and using analytical methods (Shapiro-Wilk Test) were performed. Statistical analysis was performed using Fisher's exact test (t-test). A paired t-test was used to compare the values before and after treatment in the two dependent groups. The relationship between pre- and post-treatment categorical variables and numeric variables was evaluated using Spearman’s correlation analysis. The relationship between the two groups was categorized as low-level relationship, 0.25-0.34, moderate relationship,0.35-0.59, strong relationship between 0.60-0.74, and very strong relationship between 0.75-1.00. Statistical significance was set at $p < 0.05$.

Song et al. (Song, Lee, Lam, & Bae, 2003) determined the appropriate number of samples. In the power analysis performed before the study, a minimum of 30 subjects from each group was required to have 1.9 units (8.1 ± 2.2/6.2 ± 3.1) of the mean WOMAC pain score after the neuromuscular exercise training in patients with knee osteoarthritis with an $\alpha = 0.05$ and $1^{\beta} = 0.80$.

RESULTS

The demographic characteristics of the 60 participants who completed the trial are presented in Table 1.

Table 1. Comparison Of Demographic Characteristics of The Groups

N:60		Experiment (n=30)	Control (n=30)	Total	p
Age (year)		49.60±8.45	50.66±7.85	50.13±8.10	0.614[a]
Gender	Man	10 (%33.3)	10 (%33.3)	20 (%33.3)	1.000[b]
	Woman	20 (%66.7)	20 (%66.7)	40 (%66.7)	
	Total	30 (%100)	30 (%100)		
BMI (kg/m^2)		29,13±4,02	30.95±5.72	29.83±5.29	0.160[a]
Dominant side	Right	29 (%96,7)	28 (%93.3)	57 (%95.0)	1.000[c]
	Left	1 (%3,3)	2 (%6.7)	3 (%5)	
The affected side	Right	17 (%56,7)	17 (%56.7)	34 (%56.7)	1.000[b]
	Left	13 (%43,3)	13 (%43.3)	26 (%43.4)	

a: independent groups t test
b: Pearson Chi-square test
c: Fisher's exact test

There was no statistically significant difference between the groups in terms of VAS, WOMAC, and İKDC scores before treatment ($p>.05$); however, a statistically significant difference was observed between the two groups in terms of VAS, WOMAC, and IKDC in favor of the experimental group after treatment ($p <.05$). Each of the groups showed marked improvement (statistically significant) in its pre-treatment and corresponding post-treatment parameters. In the experimental group pain level was evaluated by VAS, physical function score evaluated by WOMAC, and IKDC improved from 6.70 ± 1.68, 47.64 ± 18.74, and 33.65 ± 14.66 to 1.23 ± 0.97, 15.19 ± 8.33, and 66.98 ± 11.42, respectively ($p <.001$) (Table 2).

Table 2. Comparison Of VAS, WOMAC, And IKCD Scores Between the Study Groups and Within Each Study Group

N:60		Experiment (n=30)	Control (n=30)	P[a]
VAS	Pre-treatment	6.70±1.68	6.37±2.10	0.514
	After treatment	1.23±0.97	2.56±1.48	**0.000**
	P[b]	**0.000**	**0.000**	
WOMAC	Pre-treatment	47.64±18.74	50.47±17.32	0.547
	After treatment	15.19±8.33	27.43±14.10	**0.000**
	P[b]	**0.000**	**0.000**	
IKDC	Pre-treatment	33.65±14.66	30.93±12.75	0.446
	After treatment	66.98±11.42	56.32±12.90	**0.001**
	P[b]	**0.000**	**0.000**	

a: Independent groups t test
b: Paired t test

There were no differences between the groups in terms of the physical activity level before treatment ($p=.748$); however, the physical activity levels of the patients after the treatment were higher than the control group. (p <.05). When the physical activity levels were evaluated within the groups, there was a statistically significant increase in the activity levels after treatment in each of the groups (p=.004) (Figure 2).

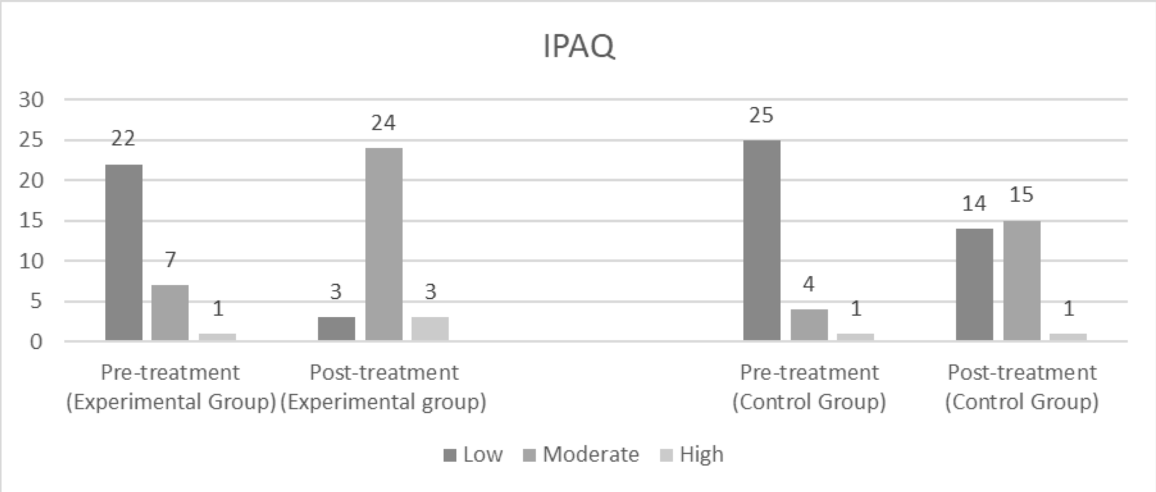

Figure 2. Comparison Of IPAQ Short Form Scale Results Between the Study Groups and Within Each Study Group

In all aspects, the pretreatment Y-balance test showed no statistically significant difference between the two groups (p>.05). After treatment, the experimental group results were statistically higher than those of the control group in whole directions in a positive way (p <.05). When the pre-treatment and post-treatment Y-balance test results within the groups were examined, a statistically significant improvement was observed in both groups after treatment in all directions (p <.05) (Table 3).

Table 3. Comparison Of Balance Scores Between the Study Groups and Within Each Study Group

		Experiment (n=30)	**Control (n=30)**	**P[a]**
Right Anterior	Pre-treatment	59.66±11.06	57.81±11.17	0.522
	Post-treatment	69.16±10.06	59.56±10.65	**0.001**
	P[b]	**0.000**	**0.000**	
Left Anterior	Pre-treatment	59.16±9.84	58.20±10.48	0.714
	Post-treatment	68.23±8.72	59.80±10.09	**0.001**
	P[b]	**0.000**	**0.002**	
Right Posteromedial	Pre-treatment	62.20±13.41	63.60±17.46	0.729
	Post-treatment	74.30±13.03	65.93±16.51	**0.033**
	P[b]	**0.000**	**0.001**	
Left Posteromedial	Pre-treatment	63.03±15.59	62.23±16.73	0.849
	Post-treatment	74.33±13.45	63.90±16.26	**0.009**
	P[b]	**0.000**	**0.000**	
Right Posterolateral	Pre-treatment	73.90±15.61	72.58±13.66	0.729
	Post-treatment	85.43±15.37	73.91±13.95	**0.004**
	P[b]	**0.000**	**0.000**	
Left Posterolateral	Pre-treatment	74.30±13.55	72.36±12.99	0.575
	Post-treatment	85.73±13.53	73.66±13.26	**0.001**
	P[b]	**0.000**	**0.000**	

a: independent groups t test
b:paired t test

DISCUSSION

In the present study, classical physiotherapy was found to be an effective method, but in addition to classical physiotherapy, NME was more effective for the management of pain, increased physical activity, function, and balance for the treatment of patients with OA.

Previous studies have described the challenges faced by patients with knee OA including, joint structure deterioration, improper weight transfer, and a significant decrease in normal joint motion. In addition, signals from mechanoreceptors that turn both motion and position into electrophysiological events are also distorted, and afferent signals from the periphery are misinformed. These events result in incoordination and loss of strength in muscle activities, especially in the quadriceps femoris (Koralewicz & Engh, 2000). Reports from previous studies have explained the role of isometric, isokinetic, and isotonic exercises in increasing muscle strength significantly. However, there was no definite conclusion about the superiority of strengthening exercises to each other and given exercise program given to the muscle of the quadriceps femoris (Huang et al., 2003; Parr, Yarrow, Garbo, & Borsa, 2009). Eyigor et al. have evaluated the VAS and WOMAC scores for patients with knee OA before and after their 6-week exercise program involving isokinetic and progressive resistive exercises and stated that there was a significant improvement in those scores at the end of the treatment (Eyigor, Hepguler, & Capaci, 2004). Rogers et al. compared the effects of NME and strengthening exercises on physical function in patients with knee OA. They saw improvement in both groups after treatment, but more improvement was observed in the experimental group (Rogers, Tamulevicius, Coetsee, Curry, & Semple, 2011). Bennel et al. compared the effect of NME with quadriceps strengthening exercises in patients with knee OA. They did not find any difference in knee adduction momentum between the two groups; however, there were significant improvements in pain and physical function in the NME group compared to the other group (Bennell et al., 2014). In our study, we found similar improvements in pain and functional improvement in daily life activities in the group that underwent conventional exercise along with NME.

Regular physical activity has been reported to reduce the risk of knee OA (Hootman, Macera, Helmick, & Blair, 2003; Manninen, Riihimaki, Heliovaara, & Suomalainen, 2001; Sandmark, Hogstedt, & Vingård, 2000). Kovar et al. (Kovar et al., 1992) examined the effectiveness of walking, exercise, and training in patients with knee OA at the end of the 8-

week study and found significant improvements in physical activity and joint pain due to walking. However, most studies have been carried out on levels of function rather than physical activity levels in patients with OA (Fransen et al., 2015). As far as we have reviewed the studies done so far, no study investigating the effect of neuromuscular exercise on physical activity in patients with knee osteoarthritis has been found. Our study is the first study on this subject. This study disclosed that physical activity levels increased in patients who exercised regularly and who underwent NME training programs. This increase in physical activity level might be due to decreased pain and increased functionality.

Proprioception plays an important role in ensuring and maintaining joint stability. But it is not only to sense the position and motion of limbs, but also provides the sensation of force generation (Lin, Lin, Chai, Han, & Jan, 2007). Therefore, the perception of proprioception also changes due to the decreased force and deteriorated joint structure. With this changing perception of proprioception, the biomechanics of the knee also change. This causes functional impairments in walking and balance. To maintain balance and functional activity, it is important to coordinate afferent and efferent mechanisms with each other (Myer, Ford, Palumbo, & Hewett, 2005).

Diracoglu et al. (2005) studied the effects of balance and kinesthetic training on knee OA in 66 women with knee OA for 8 weeks. Patients who received kinesthesia, balance exercises, and strengthening exercises showed significant increases in isokinetic muscle strength, kinesthesia, and balance compared to the other group who performed only strengthening exercises (Diracoglu, Aydin, Baskent, & Celik, 2005).

Previous studies have concentrated mainly on isometric and isotonic exercises, focusing on static balance. We speculated that dynamic balance would be more affected in OA patients due to increased pain during activity, difficulty in climbing stairs, walking disorder, etc. Hence, we evaluated dynamic balance using the Y-balance test. The NME training in rehabilitation aims to provide a coordinated operation of afferent and efferent structures that improve dynamic stability. The NME program discussed in this study included muscle strengthening, proprioceptive exercises, balance exercises, sensorimotor system training, and stabilization exercises. Our evaluations indicate that the groups before treatment were homogeneous. Post-treatment, there was an increase in the balance scores in all directions, which was statistically significant in both groups. The increase in the control group was similar to that reported in the literature but the increase in the experimental group was higher than that in the control group.

The increase in the experimental group showed that the NME program was more effective in the development of balance. In this respect, this study contributes to the literature.

Our study has some limitations. It would have taken a long time to reach the number of individuals calculated using power analysis because 21 patients were excluded from the study for various reasons. Moreover, the long-term effects of the treatment were not examined. Further studies on the long-term effects of NME training may contribute to the literature. Based on the results of our study, we can say that neuromuscular exercises can be used as a preventive approach to the prevention of injuries in relieving the symptoms of patients with knee osteoarthritis.

CONCLUSIONS

In conclusion among non-surgical options, various exercise treatments have been used in patients with knee OA. This study showed that NME education with classical physiotherapy in patients with knee OA was more effective in improving physical activity, function, and balance. Our study also indicated that the physical activity level of individuals increased in patients with OA after treatment due to decreased pain and increased physical function. Thus, we conclude that NME is an effective, safe, and easy treatment option for OA patients.

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