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The effect of short-term neuromuscular electrical stimulation on pain, physical performance, kinesiophobia, and quality of life in patients with knee osteoarthritis

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Abstract

Introduction. To examine the effects of short-term neuromuscular electrical stimulation (NMES) on pain, physical performance, and kinesiophobia in individuals with knee osteoarthritis.
Methods. The study involved 38 individuals (21 in treatment group, 17 in control group) diagnosed with knee osteoarthritis. The participants were randomly assigned to the treatment and control groups. Physical performance tests, pain assessment, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Tampa Scale of Kinesiophobia, and Nottingham Health Profile were applied. Both groups received a combined physiotherapy program for 2 weeks, 5 sessions a week. NMES and combined physiotherapy were implemented in the treatment group.
Results. Statistically significant differences were detected between the pre- and post-treatment scores of the individuals with regard to the obtained parameter values (Visual Analogue Scale, physical performance tests, WOMAC, kinesiophobia, and health quality) in both groups ($p < 0.05$). However, no statistically significant differences were observed in the between-group pre- and post-treatment changes of the mentioned parameters ($p > 0.05$).
Conclusions. The study results show that 10-session NMES application in patients with knee osteoarthritis did not provide additional benefits on pain, physical performance, kinesiophobia, or quality of life. Therefore, the results should be considered when planning the treatment program. Also, we believe that clinical studies comparing long- and short-term NMES applications in addition to physiotherapy programs are needed to achieve accurate results as the present outcomes refer to short-term NMES application.
Key words: neuromuscular electrical stimulation, knee osteoarthritis, pain, physical performance, kinesiophobia

Introduction

Osteoarthritis is a chronic and degenerative musculoskeletal disease, seen frequently in the world, characterized by loss of joint cartilage and reshaping of bone structure around the joint; it is associated with various traumatic, biomechanical, inflammatory, and genetic factors [1]. Among the conditions that osteoarthritis might cause, there are fear of movement, increasing pain and involvement, longer disease duration, reduced muscle strength and joint range of motion. In patients with knee osteoarthritis, activities like walking and climbing stairs are complicated, and it affects daily life activities in time. The lack of strength in the muscles around the knee increases pain and negatively affects functionality. For this reason, strengthening the muscles that move the knee joint is one of the principles of treatment [2]. In the literature, the quadriceps muscle is reported as the most affected muscle in patients with knee osteoarthritis [3, 4]. Another important clinical finding in these patients is kinesiophobia, or fear of movement. Kinesiophobia is defined as a fear-avoidance condition caused by a feeling of sensitivity to painful and repetitive injuries, and fear of physical action [5, 6]. The definitions of osteoarthritis and kinesiophobia involve the concepts pain, avoidance, and physical activity. At the same time, kinesiophobia might be considered as a cause of physical insufficiency in patients with osteoarthritis [7].

Studies on the interventions to prevent the formation and progress of osteoarthritis are continuing at a fast pace. On the one hand, decreasing the pain, stiffness, and kinesiophobia in people who have developed the disease, and on the other hand, increasing their functionality are among the primary goals [2].

There are several rehabilitation methods for strengthening muscles in patients with knee osteoarthritis. Neuromuscular electrical stimulation (NMES) is considered in the literature to be an effective technique to strengthen quadriceps muscle [8, 9]. NMES means that muscle contraction is provided through the motor nerve. It was reported in previous studies that NMES improved muscle strength and functional performance, and prevented muscle atrophy caused by prolonged immobilization [10, 11]. Type I muscle fibres are first activated with a voluntary muscle contraction, and are followed by type II muscle fibres. In turn, type II fibres are more activated by NMES protocols than type I fibres. Since the maximal force in the muscle depends on the activation of type II fibres, it was reported that selective strengthening of type II muscle fibres with NMES might result in a bigger increase in the overall strength of the muscle in submaximal training [12].

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The purpose of the present study was to examine the effects of short-term NMES on pain, balance, physical performance, and kinesiophobia in individuals with knee osteoarthritis and to compare the results with the control group.

Subjects and methods

Participants

The study involved 38 individuals who were admitted to the Faculty of Medicine at Kırıkkale University for knee pain and who had been diagnosed with stage 2 or stage 3 bilateral knee osteoarthritis at least 6 months earlier in accordance with the Kellgren-Lawrence radiological staging. After the individuals were randomly assigned to the treatment and control group with the closed envelope method, they were separated depending on the specified exclusion and inclusion criteria. Evaluations were made before and after the treatment.

Non-inclusion criteria involved a neurological disease, a cardiopulmonary or systemic disease that prevented receiving a physiotherapy program and exercise, inflammatory arthritis, not being independently mobilized, history of knee or hip replacement surgery, a pathology other than knee osteoarthritis that might cause knee pain, any pathology of the back and hip that might cause pain reflected in the knee, having received an intra-knee injection for any reason in the previous year, and cognitive problems.

As a result of power analysis and sample size analysis of the study, it was established that 17 patients (34 patients in total) should be included in each group for 80% power with 5% error. The study finally involved 38 individuals (21 in the treatment group, 17 in the control group).

Tests and data collection

The sociodemographic data (age, height, weight, body mass index, gender) and clinical data (dominant part, affected part, osteoarthritis duration) of individuals were recorded.

Physical performance tests specific to knee osteoarthritis, pain assessment, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Nottingham Health Profile (NHP), and Tampa Scale of Kinesiophobia (TSK) were applied. In the scope of physical performance tests, the stair climb test (SCT) and timed up and go (TUG) test were performed.

During SCT, the patient was asked to climb 9 steps up and down fast, and the time was recorded in seconds. The same steps were used in all participants [13].

TUG was applied to evaluate balance and risk of fall in individuals. A standard chair was used for the test. Firstly, the patient was asked to sit on the chair. Then, they were to stand up and walk with regular steps at a distance of 3 meters, turn around, walk back to the chair, and sit down on it. The walking duration of the patient during the test was measured in seconds with a stopwatch. The test was repeated 3 times and the average value was recorded [14].

Visual Analogue Scale (VAS) was used to assess pain intensity during activity. On a line of 10 cm (0–10), the patient was asked to mark the pain severity; 0 indicated no pain, and 10 indicated that the patient had unbearable pain. The distance marked was recorded in millimetres [15].

WOMAC is a health condition measurement specific to a disease, and is widely used in patients with knee and hip osteoarthritis. Its form consists of 3 sections (pain, stiffness, physical function) and 24 questions. The questions of each section are scored between 0 and 4. The total score for each section is recorded [16]. A validity and reliability study of the Turkish version of WOMAC had been conducted earlier [17].

The NHP questionnaire, which is used to measure the physical, social, and emotional effects of diseases on people, includes 38 questions. The questions refer to pain (8 questions), physical activity (8 questions), exhaustion (3 questions), social isolation (5 questions), emotional conditions (9 questions), and sleep (5 questions). The evaluation is made by taking the percentage of the ‘yes’ answers. The total score ranges between 0 and 100 [18].

TSK consists of 17 questions, scored with the Likert scale. It examines activity-related injury/re-injury and fear-avoidance parameters. The person receives scores between 17 and 68. A higher score implies higher fear of movement. Tunca Yilmaz et al. [19] had examined the validity of the Turkish version of the scale and provided its cultural adaptation.

Treatment program

Both groups received a combined physiotherapy program for 2 weeks, with 5 sessions a week. It included hot pack, therapeutic ultrasound, transcutaneous electrical nerve stimulation (TENS), and exercises program. NMES and combined physiotherapy were implemented in the treatment group. At the beginning of a treatment session, the hot pack (23.1–41 cm), which is a superficial heat agent, was applied on both knees for 20 minutes when the patient was in a sitting position. To provide deep heat, the Chattanooga Intelect device was used (full-contact technique with 1 MHz set). Conventional tests were performed for 20 minutes with the Intelect brand TENS device. The frequency was set at 100 Hz, and the pulse width at 60 ms. The intensity was raised until the patient felt. The NMES Chattanooga Intelect device was employed with the quadriceps muscle in a sitting-up position for 10 minutes at 10–40 Hz, 250 ms, with a 5-second warning, 15-second resting time with 3 beats a minute [20].

As the exercise program, the quadriceps muscle isometric strengthening exercises, terminal knee extension, straight leg lifting exercises, and adductor muscle isometric strengthening exercises were given under the supervision of a physiotherapist at the end of each session. All exercises were performed in 3 sets of 10 repetitions.

Statistical analysis

The normal distribution of the variables was tested with the Kolmogorov-Smirnov test. The Wilcoxon rank test was used in the intragroup evaluations. The Mann-Whitney U test was applied in intergroup evaluations. Categorical data analysis was made with the chi-squared test. All numerical variables were expressed as arithmetic means ± standard deviations. The data were analysed with the SPSS 21.0 software (SPSS Inc., Chicago, USA). The error level was set as < 0.05 [21].

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Kırıkkale University Ethical Committee (decision No. 06/08, dated on 20.03.2018).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

A total of 38 individuals (21 in the treatment group, 17 in the control group) aged 50–78 years were included in the study (Figure 1).

The sociodemographic and clinical data of the patients are shown in Table 1. No differences were detected when the pre-treatment clinical data of individuals were compared ($p > 0.05$). Statistically significant differences were observed between the pre- and post-treatment scores of the participants with regard to the obtained parameter values in both groups (VAS, physical performance tests, WOMAC, kinesiophobia, and health quality) ($p < 0.05$) (Tables 2 and 3). However, no statistically significant differences were found in the post-treatment change levels of VAS, physical performance tests, WOMAC, kinesiophobia, or health quality values compared with the pre-treatment values ($p > 0.05$) (Table 4).

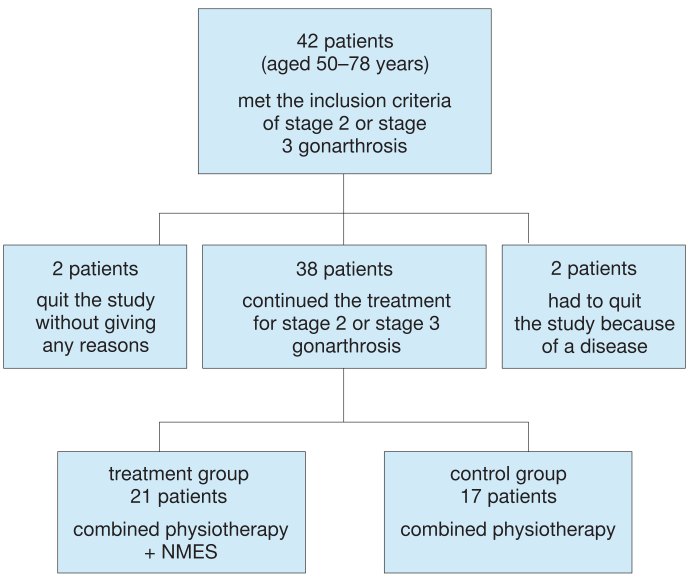

Figure 1. Study flow chart

Discussion

The purpose of the present study was to examine the effects of NMES on pain, physical performance, kinesiophobia, and quality of life in patients with knee osteoarthritis. When the pre- and post-treatment results were examined in groups, statistically significant differences were detected both in the treatment group and in the control group with regard to pain in activity, physical performance tests, WOMAC total score, and NHP scale. When intergroup examinations were performed, it was observed that short-term NMES application resulted in no statistically significant improvements in pain, balance, physical performance, and kinesiophobia evaluation results. Although there are studies in the literature reporting benefits of NMES in patients with knee osteoarthritis in terms of pain, performance-based physical functions, and quality of life, we believe that NMES does not provide additional short-term effects, as there were no significant differences between the treatment and control group after a total of 10 sessions of NMES, including 5 days a week for 2 weeks. Longer term NMES has been applied in several studies, indicating that the method is effective on physical performance and pain. This may have affected our result.

It is considered that pain in patients with osteoarthritis causes functional losses through reflex mechanisms [21]. The results of studies that examined the efficacy of NMES on pain in knee osteoarthritis are contradictory. In the literature, although there are studies reporting a significant reduction in pain severity with NMES application [1, 22, 23], there are also several studies showing that NMES had no effect on pain [24–26]. In a systematic review conducted by Zeng et al. [27] on the effects of electrical stimulation on pain in patients with knee osteoarthritis, it was concluded that NMES did not reduce the pain of the participants. However, in the literature, it was also stated that there was a sudden decrease in pain 15 minutes after NMES application. It was reported that the reason of this sudden decrease in pain was the transcutaneous conduction of electrical current and the stimulation of large-diameter nerve fibres in the posterior horn, which inhibited second-degree neurons and then the nociceptive stimuli and the thalamus were prevented from reaching the periaqueductal grey matter [28]. When the results of our study

Table 1. Sociodemographic and clinical characteristics of participants

Characteristics	Treatment group (*n* = 21)	Control group (*n* = 17)	*p*
Age, mean ± *SD*, years	64.85 ± 8.90	60.58 ± 7.92	0.132†
BMI, mean ± *SD*, kg/m^2	31.33 ± 4.65	30.13 ± 4.88	0.447†
Gender, *n* (%)			
Female	10 (47.6)	11 (64.7)	0.342††
Male	11 (52.4)	6 (35.3)	
Hand dominance, *n* (%)			
Right	21 (100)	16 (94.1)	0.447††
Left	0	1 (5.9)	
Affected part, *n* (%)			
Bilateral	21 (100)	17 (100)	0.561†
OA duration, years	26.43 ± 18.70	32.00 ± 25.53	

SD – standard deviation, BMI – body mass index, OA – osteoarthritis
† Mann-Whitney U test, †† chi-squared test

Table 2. Comparison of pre- and post-treatment variables in the treatment group

Characteristics	Treatment group (*n* = 21)		
	pre-treatment mean ± *SD*	post-treatment mean ± SD	*p*
VAS (activity pain severity), 0–100 mm	48.43 ± 28.85	35.59 ± 27.61	0.001*†
SCT, s	23.82 ± 12.54	22.11 ± 11.89	0.040*†
TUG, s	13.78 ± 4.43	12.37 ± 4.01	0.001*†
WOMAC pain score	8.53 ± 3.96	6.23 ± 3.30	0.011*†
WOMAC stiffness score	2.89 ± 2.01	2.34 ± 1.74	0.130†
WOMAC physical function score	28.64 ± 13.86	22.18 ± 12.50	0.026*†
WOMAC total score	40.97 ± 18.92	32.41 ± 16.23	0.027*†
TSK	39.76 ± 6.70	38.85 ± 5.29	0.274†
NHP – pain	60.58 ± 31.20	37.76 ± 24.47	0.001*†
NHP – physical mobility	45.85 ± 17.31	38.20 ± 17.83	0.007*†
NHP – energy level	46.18 ± 44.22	36.61 ± 43.25	0.080††
NHP – sleep	42.23 ± 30.28	32.06 ± 29.39	0.173††
NHP – social isolation	11.10 ± 21.04	9.09 ± 19.64	0.750††
NHP – emotional reaction	23.61 ± 28.06	14.49 ± 19.77	0.059††
NHP – total score	227.00 ± 127.64	167.58 ± 105.33	0.006*††

SD – standard deviation, VAS – Visual Analogue Scale, SCT – stair climb test, TUG – timed up and go test, WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index, TSK – Tampa Scale of Kinesiophobia, NHP – Nottingham Health Profile
* $p < 0.05$, † paired samples test, †† Wilcoxon signed-rank test

Table 3. Comparison of pre- and post-treatment variables in the control group

Characteristics	Control group (*n* = 17)		
	pre-treatment mean ± *SD*	post-treatment mean ± *SD*	*p*
VAS (activity pain severity), 0–100 mm	52.29 ± 30.20	34.37 ± 29.71	0.019*†
SCT, s	19.51 ± 10.13	17.95 ± 8.81	0.045*†
TUG, s	14.79 ± 4.10	13.03 ± 3.78	0.001*†
WOMAC pain score	9.67 ± 3.59	7.78 ± 9.65	0.043*††
WOMAC stiffness score	2.80 ± 1.65	1.98 ± 1.40	0.034*†
WOMAC physical function score	29.10 ± 14.83	19.24 ± 12.91	0.014*†
WOMAC total score	42.28 ± 19.64	28.80 ± 16.29	0.015*†
TSK	43.00 ± 7.59	40.18 ± 7.83	0.143†
NHP – pain	72.48 ± 27.16	51.11 ± 30.95	0.005*††
NHP – physical mobility	34.80 ± 21.42	33.53 ± 26.43	0.824††
NHP – energy level	67.34 ± 32.33	56.84 ± 36.26	0.039*††
NHP – sleep	44.92 ± 31.83	34.23 ± 32.21	0.096††
NHP – social isolation	16.81 ± 24.07	10.38 ± 23.25	0.045*††
NHP – emotional reaction	32.08 ± 31.20	21.01 ± 28.65	0.001*††
NHP – total score	267.27 ± 125.72	213.07 ± 139.18	0.004*††

SD – standard deviation, VAS – Visual Analogue Scale, SCT – stair climb test, TUG – timed up and go test, WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index, TSK – Tampa Scale of Kinesiophobia, NHP – Nottingham Health Profile
* $p < 0.05$, † paired samples test, †† Wilcoxon signed-rank test

Table 4. Comparison of the changes in VAS, physical performance tests, WOMAC, kinesiophobia, and health quality between the treatment and control groups

Characteristics	Treatment group (*n* = 21) mean ± *SD*	Control group (*n* = 17) mean ± *SD*	*p*
VAS (activity pain severity), 0–100 mm	12.83 ± 15.24	18.21 ± 27.79	0.457††
SCT, s	1.70 ± 3.45	1.56 ± 2.95	0.454†
TUG, s	1.40 ± 1.39	1.75 ± 1.40	0.893†
WOMAC pain score	–2.30 ± 3.75	1.89 ± 8.57	0.296††
WOMAC stiffness score	–0.55 ± 1.59	0.81 ± 1.34	0.629††
WOMAC physical function score	–6.46 ± 12.31	9.85 ± 13.55	0.439††
WOMAC total score	–8.56 ± 15.97	13.47 ± 18.76	0.409††
TSK	0.90 ± 3.68	2.81 ± 7.26	0.304††
NHP – pain	–22.81 ± 23.38	21.36 ± 25.29	0.702†
NHP – physical mobility	–7.65 ± 11.73	1.26 ± 20.30	0.110††
NHP – energy level	–9.56 ± 28.36	10.49 ± 17.08	0.507††
NHP – sleep	–10.16 ± 32.99	10.69 ± 4.96	0.957††
NHP – social isolation	–2.00 ± 17.01	6.43 ± 12.22	0.304††
NHP – emotional reaction	–9.12 ± 20.55	11.07 ± 11.77	0.231††
NHP – total score	–59.42 ± 83.94	54.70 ± 67.06	0.872††

SD – standard deviation, VAS – Visual Analogue Scale, SCT – stair climb test, TUG – timed up and go test, WOMAC – Western Ontario and McMaster Universities Osteoarthritis Index, TSK – Tampa Scale of Kinesiophobia, NHP – Nottingham Health Profile
† independent sample *t*-test, †† Mann-Whitney U test

were considered, it was seen that there was a significant decrease in the pain severity during activity in both groups; however, there were no differences in the decrease in pain severity between the groups. It therefore seems that NMES does not have any advantage in reducing pain. We believe that the decrease in pain that occurred in the groups was because of the effectiveness of TENS application. The possible reason of the lack of decrease in pain after NMES application might be considered as the inadequacy of 10-session NMES usage for 2 weeks in sensory stimulation, causing insufficient endogenous analgesics release and, as a result, lack of decrease in adequate peripheral and central sensitization and lack of restoration of pain mechanisms. Knee osteoarthritis chronic joint pain causes losses in joint range of motion and decreases muscle strength, limiting the daily life activities of individuals [29]. Although the use of NMES is recommended in the literature to increase functionality in patients with knee osteoarthritis, the results of studies that examined the efficacy of NMES on physical functions are contradictory. White and Master [30] reported that WOMAC was a well-validated and reliable patient-reported measure and it was usually employed in the assessment of physical functions in studies on knee osteoarthritis. In our study, in line with the literature, WOMAC was used to evaluate the physical functions. When NMES activity was examined, no statistically significant intragroup differences were detected. A significant difference was observed in both the treatment group and the control group. We believe that this difference recorded in the groups might be a result of the exercise program applied in each group.

In most patients with osteoarthritis, one of the treatment objectives is to obtain independence in daily life activities by recovering locomotor abilities like climbing stairs and walking. Although there are studies in the literature reporting that NMES application provides a significant reduction in walking and climbing and descending stairs times [11], another study, conducted by Laufer et al. [24], argued that NMES added to the exercise program did not provide any additional improvements in climbing-descending steps and in walking times. In our study, when the results of intragroup evaluations were examined, although significant differences were detected in TUG and SCT in the control and treatment group, no significant intergroup difference was found after NMES application. Climbing and descending steps is a function that is most commonly impaired in individuals with knee osteoarthritis, and such individuals continue to have difficulty in this activity even after total knee arthroplasty. When we evaluate TUG, a normal joint operation and adequate muscle strength of the knee muscles are required to perform the test. The reason for not detecting a significant difference in TUG and SCT might be that a total of 10-session NMES application could be reflected in the functional test results.

Individuals with knee osteoarthritis, because of widespread musculoskeletal system pain, may present restricted movement and fear of movement. Prolonged high-level chronic pain may result in fear, pain, activity avoidance, and depression. As a consequence, the patient's functional and social status and quality of life may be negatively affected. The fear that is related to pain can cause a gradual decrease in physical and professional activities [31]. Scopaz et al. [32] reported relations between anxiety/fear and avoidance and physical function in patients with knee osteoarthritis. They indicated that high anxiety was related with low WOMAC physical function; moreover, fear-avoidance beliefs and high anxiety are bound with low function of lower extremity and low scores in the Activities of Daily Living scale. In the literature, there are no studies examining the effects of NMES on kinesiophobia in knee osteoarthritis patients. In our study, no significant intergroup differences were detected in kinesiophobia results after NMES administration. This may be due to the short treatment period.

The quality of life is defined as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. The health-related quality of life, on the other hand, is defined as the patient's evaluation of the effects of the disease and its treatment on the patient [33]. Bruce-Brand et al. [11] examined the effect of NMES on health-related quality of life in the treatment of patients with knee osteoarthritis and reported a statistically significant increase in quality of life as a result of 30-session NMES application. In our study, we did not detect a significant intergroup difference in quality of life assessment as a result of NMES application. In turn, we observed significant intragroup differences in quality of life when pre- and post-treatment evaluations were compared both in the control group and in the treatment group. It may be considered that decreased pain and increased physical performance positively affect the quality of life.

Limitations

Lack of objective muscle strength measurements may be considered as a limitation of the present study. If visual or audio biofeedback were used when NMES was applied, the effectiveness could have been higher.

Conclusions

NMES is a physiotherapy modality frequently applied in patients with osteoarthritis. However, the results of our study show that 10 sessions of NMES did not provide additional benefit on pain, physical performance, kinesiophobia, or quality of life in individuals with knee osteoarthritis. Therefore, these results should be considered when planning the treatment program. Also, we believe that clinical studies comparing long- and short-term NMES application in addition to physiotherapy programs are needed to achieve accurate results.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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