doi: ISSN 0103-5150
Fisioter. Mov., Curitiba, v. 26, n. 4, p. página 777-789, set./dez. 2013

Neuromuscular electrical stimulation, exercises against resistance, muscle strength, pain, and motor function in patients with primary osteoarthritis of the knee

Eletroestimulação neuromuscular, exercícios contra resistência, força muscular, dor e função motora em pacientes com osteoartrite primária de joelho

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Abstract

Introduction: Knee osteoarthritis is a degenerative process and its symptoms are mechanical pain and periods of inflammatory pain, joint stiffness, and muscle weakness. It has no cure and the treatment objective is relieving signs and symptoms and, whenever possible, slowing down its evolution. Muscle strengthening is indicated as treatment for osteoarthritis. **Objective**: Compare the effectiveness of neuromuscular electrical stimulation and resistance against exercise in the gain of knee extensor strength, in pain reduction, and in the recovery of motor function in patients with primary knee osteoarthritis. **Materials and methods**: The research had the participation of 23 patients diagnosed with primary knee osteoarthritis, according to the clinical and radiological criteria of the American College of Rheumatology. They were randomly allocated to a group of resistance against exercise (n = 9), a group of neuromuscular electrical stimulation (n = 8), and a control group (n = 6), and they underwent characteristic procedures of their group 3 times a week until completing 24 sessions. Knee extensor strength, pain, and motor function were evaluated in a blind way. We used the 3 x 2 MANOVA test with repeated measurements, for $p < 0.05$. **Results**: A significant difference ($p < 0.05$) was found just in intra-group comparisons for knee extensor strength only in the group neuromuscular electrical stimulation and for pain in the groups neuromuscular electrical stimulation and resistance against exercise. **Conclusion**: The strengthening of knee extensor muscles may help reducing pain in patients with osteoarthritis. Neuromuscular electrical stimulation, when applied according to the protocol used in this study, may be an interesting therapy for treating knee osteoarthritis.

Keywords: Arthrosis. Russian current. Quadriceps.

Resumo

Introdução*: A osteoartrite (OA) do joelho é um processo degenerativo e os sintomas são dor mecânica e períodos de dor inflamatória, rigidez articular e fraqueza muscular. Ela não tem cura. O objetivo do tratamento é aliviar os sinais e sintomas e, quando possível, retardar sua evolução. O fortalecimento muscular é indicado como tratamento da OA.* ***Objetivo****: Comparar a eficácia da eletroestimulação neuromuscular (EENM) e de exercícios contrarresistência (ECR) no ganho de força extensora de joelho, na diminuição da dor e na recuperação da função motora em pacientes com OA primária do joelho.* ***Materiais e métodos****: Participaram da pesquisa 23 pacientes com diagnóstico de OA primária do joelho, segundo os critérios clínicos e radiológicos do American College of Rheumatology. Eles foram alocados aleatoriamente para um grupo de ECR (n = 9), um grupo de EENM (n = 8) e um grupo controle (n = 6), e foram submetidos aos procedimentos característicos de seu grupo três vezes por semana até completar 24 sessões. Foram avaliadas de forma cega a força extensora de joelho, a dor e a função motora. Foi utilizado o teste MANOVA 3 x 2 com medidas repetidas para P < 0,05.* ***Resultados****: Foi encontrada diferença significativa (P < 0.05) somente nas comparações intragrupos para força extensora de joelho no grupo EENM e para dor nos grupos EENM e ECR.* ***Conclusão****: O fortalecimento da musculatura extensora de joelho pode auxiliar na diminuição da dor de pacientes com OA. A EENM, quando aplicada de acordo com o protocolo utilizado neste estudo, pode ser uma terapia interessante para o tratamento da OA do joelho.*

Palavras chave*: Artrose. Corrente russa. Quadríceps.*

Introduction

Gonarthrosis, osteoarthritis, osteoarthrosis, or simply knee arthrosis, is a degenerative process which may or may not be connected to inflammatory processes (1); it occurs due to loss of the homeostasis of the functional unit meniscus-cartilage-subchondral bone and has a progressive evolution with cartilage loss and, later, bone tissue loss. It is classified according to etiology as primary, when the causative factor is unknown, or secondary, when it derives from inflammatory conditions or sequelae of meniscal and ligamentous lesions, fracture or infection, for instance (2).

Wear of the joint cartilage is initially asymptomatic, progressing with the installation of bone lesions and inflammatory processes of the joint structures, when there is an acute worsening of symptoms, however, even in the asymptomatic phase changes in motor behavior may be observed (3).

Knee osteoarthritis (KO) is the leading cause of pain and functional disability in middle-aged women, this is the most affected population (4); in the United States, KO is the second leading cause of absenteeism, second only to ischemic heart diseases (5) and its incidence is higher with increasing age (6).

Symptoms are mechanical pain, which is directly related to joint movement, and periods with inflammatory pain that correspond to inflammatory outbreaks secondary to mechanical changes, a symptom influencing the fulfillment of functional activities (7); joint stiffness, which progresses in proportion to cartilage loss (8) and muscle weakness (3). The most common clinical signs are: crepitus, swelling of the joint, joint effusion (1), disuse muscle atrophy, and deformities in varus, valgus, or flexion (8). Osteoarthritis has no cure and treatment serves to relieve the signs and symptoms and, whenever possible, slow down the progression (9) and muscle strengthening is indicated as a treatment for KO in the Brazilian Consensus for the Treatment of Osteoarthritis and the Osteoathritis Research Society International (OARSI) (10, 11).

Neuromuscular electrostimulation (NMES) is known by the name of Russian current and it consists of an alternating current with a medium frequency of 2,500 Hz, able to cause muscle contraction, being widely used for therapeutic purposes according to various indications (12). Studies have shown NMES as part of: the treatment for bladder dysfunctions in patients with multiple sclerosis (13), the rehabilitation of dysphagia (14), the treatment for chronic shoulder pain in hemiplegic patients (15), the treatment for chronic low back pain (16), and the postoperative rehabilitation of anterior cruciate ligament reconstruction (17). Its muscular responses have a central and peripheral origin, and its results with regard to muscle strengthening are maintained even after the suspension of applications (18-20).

Several studies have already tested the effectiveness of muscle strengthening in the treatment of the KO signs and symptoms using various protocols, among them NMES and resistance against exercise (RAE) (21-24). In a study carried out in 2006, the researchers followed a group treated with RAE and another group treated with flexibility exercises for 30 months; the group treated with RAE showed greater strength in the end of treatment and a slower progression of disease (25).

However, the response of KO signs and symptoms to muscle strengthening is not clear, yet, since most studies have used muscle strengthening associated to other therapeutic ways.

This study aimed to compare the effectiveness of NMES and RAE with regard to knee extensor strength gain, decreased pain, and recovery of motor function in patients diagnosed with primary KO.

Materials and methods

Design

The study was a controlled experiment, randomized and blind. Patients were randomly allocated to 1 out of 3 groups: NMES, undergoing neuromuscular electrical stimulation; RAE, performing exercise against resistance; and control, which did not undergo any intervention. The female physiotherapist who applied the interventions did not evaluate knee extensor strength, pain, and motor function. Data evaluation and analysis were blind.

Sample

The study participants were patients with a diagnosed primary KO, according to the clinical and radiological criteria of the American College of Rheumatology (ACR), who sought the services of the Clinical Research Group FIT School, from Universidade Gama Filho (UGF), between January 20 and August 30, 2010.

The clinical and radiological criteria of ACR for diagnosing KO are joint pain on most days in the last month, radiological evidence of marginal osteophytes, and at least one of the following criteria: crepitus during active movement, joint stiffness in the morning for less than 30 minutes, and age over 38 years (26).

The plan for recruiting patients for this research was put into action by means of posters distributed throughout the facilities of UGF, previously authorized by the campus city hall.

The patients were informed about the study and they signed a free and informed consent term, thus agreeing to participate in the research, according to the Resolution 196/96, from the Brazilian National Health Council. The experimental protocol of this study was approved by the Research Ethics Committee of UGF, under the Protocol 119/2010.

The flow of subjects in this study is shown in Figure 1.

We excluded from the study patients who were waiting for arthroplasty surgery, patients with secondary arthrosis, patients without functional movement range, patients undergoing recent infiltration, patients with a history of recent trauma, and patients with a health status incompatible with the execution of RAE and NMES.

The patients were randomly allocated to 3 groups: a RAE group, a NMES group, and a control group. For random allocation, we used the function Fx = If (RANDOM()<0.333334;1;If (RANDOM() < 0.666667;2;If (RANDOM() < 1.000001;3))) of the software *Microsoft Excel*. The numbers were attributed to the patients according to their arrival. If "1", the patient was allocated to the NMES group, if "2", the patient was allocated to the RAE group, and if "3", the patient was allocated to the control group.

Patients from the groups NMES and RAE underwent characteristic procedures of their respective group 3 times a week until completing 24 sessions. In case of missing a session, patients attended another session. All patients underwent 24 sessions. The patients who were allocated to the control group did not undergo any form of treatment for 8 weeks and, after the 2nd evaluation, they participated in a group undergoing treatment with RAE.

Exercises against resistance

The subjects in this group performed RAE for quadriceps in an open kinetic chain, observing the individualities and the clinical conditions of each individual.

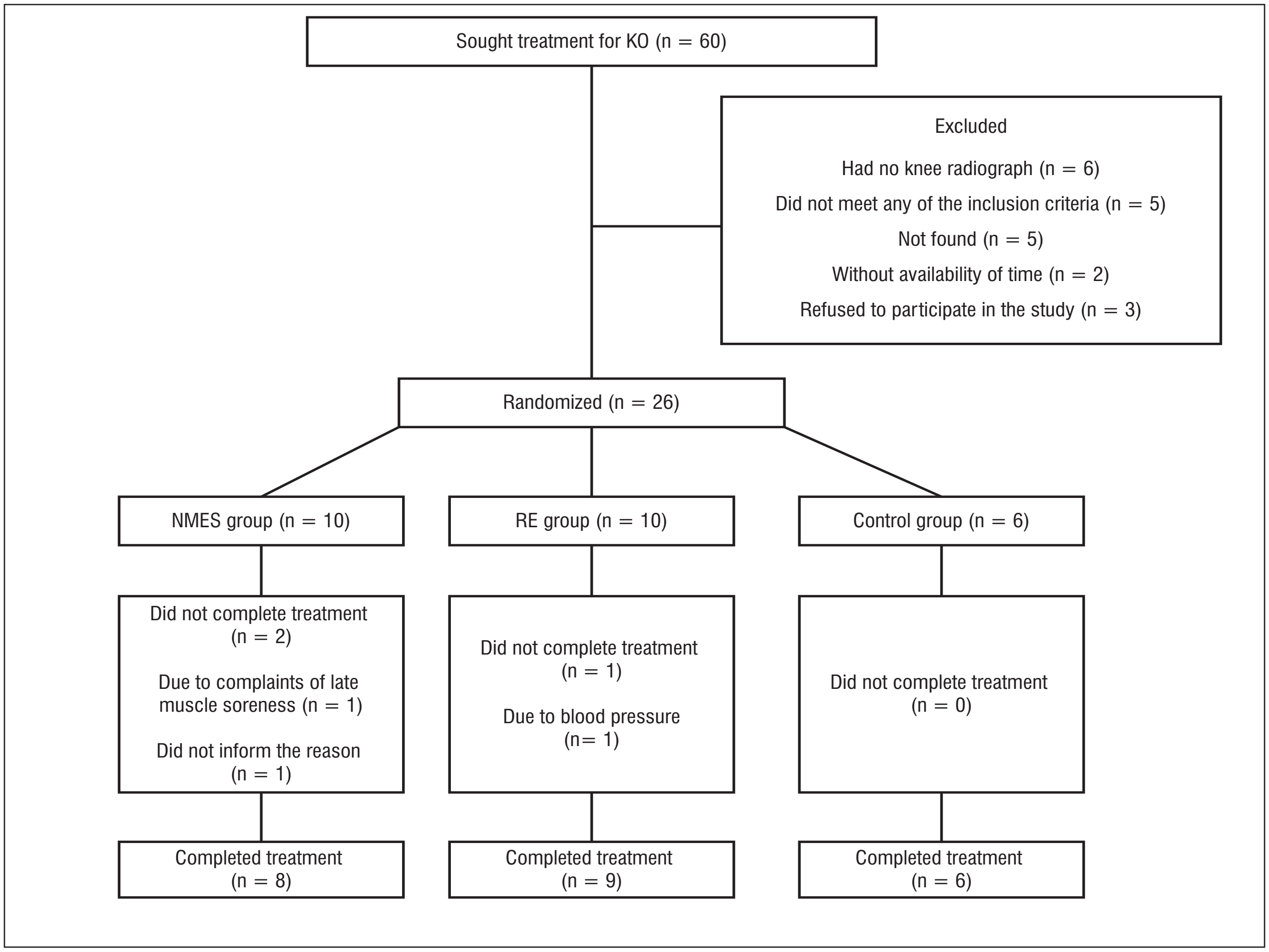


Figure 1 - Flowchart of patients' inclusion in the study
Source: Research data.

RAEs for strengthening the quadriceps were performed on a leg extension device with seated patient. Knee extensions were made complying with the following protocol: a heating phase with a series of 15 repetitions without load and a phase of muscular strength training consisting of 2 series from 10 to 12 maximum repetitions, adding 1 kg whenever the patient reached 12 replicates, with a 2-minute interval between series.

Neuromuscular electrical stimulation

This group underwent NMES in quadriceps. We used self-adhesive electrodes (ValuTrode 5 x 5 cm) placed in pairs in the bellies of the rectus anterior muscle of the thigh, vastus lateralis, and vastus medialis, an electrostimulator (Neurodyn, IBRAMED) with a medium frequency of 2,500 Hz and a treatment frequency of 100 Hz, modulated at 50%, 1s/10s/1s/10s in the time *rise/on/decay/off*, respectively, and the stimulus is used in the synchronized mode with maximum intensity supported by the patient for 20 minutes. The patients underwent isometric contraction of the quadriceps associated to stimulation of NMES.

Knee extensor strength, pain, and motor function

All patients had their knee extensor strength, pain, and motor function measured before and after treatments by another researcher (blind evaluation).

Knee extensor strength was measured by means of an isokinetic dynamometer (Cybex Norm) used to measure the torque peak of the quadriceps. Patients were tested in an open kinetic chain in the sitting position with seat in the "up" position and 5 replicates were asked at a speed of 90º degrees per second. This protocol was applied twice with an interval of

20 minutes between tests. The result of the first test was used only to calculate the typical measurement error and the second as a result of the study.

For measuring pain and motor function, we used 2 dimensions of the questionnaire Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), before and after the treatment applied by another person instead of the one who performed the treatment (blind evaluation). This questionnaire has 3 dimensions: pain, joint stiffness, and motor function, and it shows a good reliability when undergoing test/retest (27). For this study, we used the dimensions pain, with 5 questions, and muscle function, with 17 questions; each question is scored on a scale from 0 to 4, according to the severity of symptoms.

Measurement error of knee extensor strength

We calculated the measurement error for the same day and with the same evaluator using the typical measurement error (TME) (28). For this, patients' muscle strength was measured twice consecutively in the same day, with a 20-minute interval.

The measurement error was equal to the second minus the first measurement. Over the measurement errors we applied the confidence limits proposed by Bland & Altman, in order to eliminate the outlier errors (29). Then, TME was calculated through standard deviation of the measurement errors divided by the square root of 2. The relative TME (%) was calculated by means of the ratio between absolute TME and the average muscle strength scores in the first and second measurements (28).

Data analysis

The same way as in the evaluations, data analysis was performed by another researcher (blind analysis), instead of those who measured responses and applied treatments.

The assumption of a difference between the groups, with regard to knee extensor strength, pain, and motor function, was tested by means of a 3 x 2 MANOVA with repeated measures, the first factor consisted of the groups NMES, RAE, control and the second factor consisted of the pre- and post-treatment muscle strength, pain, and motor function.

The assumptions that homogeneity and sphericity (Levene's ANOVA test) and the amount of subjects per group are over 3 times greater than the amount of variables in the response were not confirmed so that a 3 x 2 MANOVA was adopted, with repeated measurements. The Greenhouse-Geisser adjustment cannot be applied, because the amount of repeated measurements was lesser than 3. Then, we opted for a 3 x 2 ANOVA, with repeated measurements for each response.

The assumption of variance homogeneity required for using a 3 x 2 ANOVA with repeated measurements was confirmed only with regard to the variable knee extensor strength. Therefore, we opted for a 3 x 2 ANOVA, with repeated measurements followed by the Bonferroni adjustment to avoid inflation in the error type I (family-wise error rate), due to the multiple t-tests and simple ANOVA for the variables pain and motor function.

The error α was 0.05 and error β was 0.20, with the statistical power of 0.80. Data were analyzed with the Statistic 6.0 package.

The size of the intra-group effect was calculated through post-treatment average minus pre-treatment average divided by pre-treatment standard deviation (30).

The size of the inter-group effect was calculated through post-treatment average of the experimental group minus post-treatment average of the control group divided by pre-treatment standard deviation (30).

Results

The descriptive results (average ± standard deviation) of knee extensor strength, pain, and motor function before and after the 24-session program for NMES, RAE, and control are shown in Table 1.

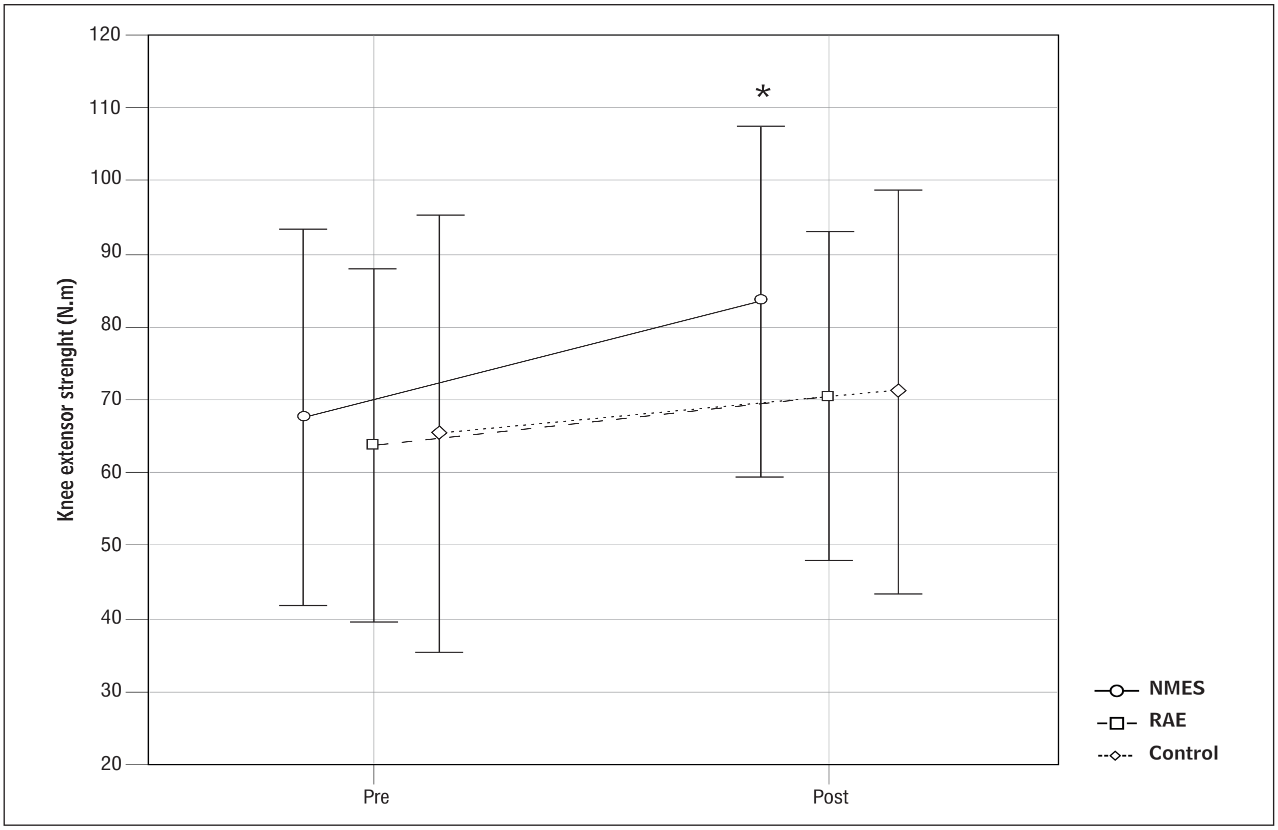
The 3 x 2 ANOVA with repeated measurements showed $F(2,20) = 1.69$; $P = 0.21$ for the interaction between knee extensor strength and the groups and $P = 0.001$ intra-groups. The Tukey test post hoc for unequal samples detected a $P = 0.01$ within the NMES group, $P = 0.53$ within the RAE group, and $P = 0.85$ within the control group (Graph 1).

The size of the knee extensor strength effect within the NMES group was 0.44; within the RAE group it was 0.23; and within the control group it was 0.13. The size

Tabela 1 – Knee extensor strength pain, and motor function before and after the 24-session program for neuromuscular electrical stimulation, resistance against exercise, and control

	NMES (n = 8)		RAE (n = 9)		Control (n = 6)	
	Pre	Post	Pre	Post	Pre	Post
KES (N.m)	68 ± 36	84 ± 32 *	64 ± 30	71 ± 26	66 ± 40	71 ± 41
Pain	9 ± 3	4 ± 2 *	12 ± 3	8 ± 3 *	10 ± 2	9 ± 5
Motor function	28 ± 9	17 ± 5	40 ± 15	32 ± 11	35 ± 12	34 ± 16

Legend: * P < 0.05 intra-group, KES = Knee extensor strength; NMES = neuromuscular electrical stimulation; RAE = resistance against exercise.
Source: Research.data



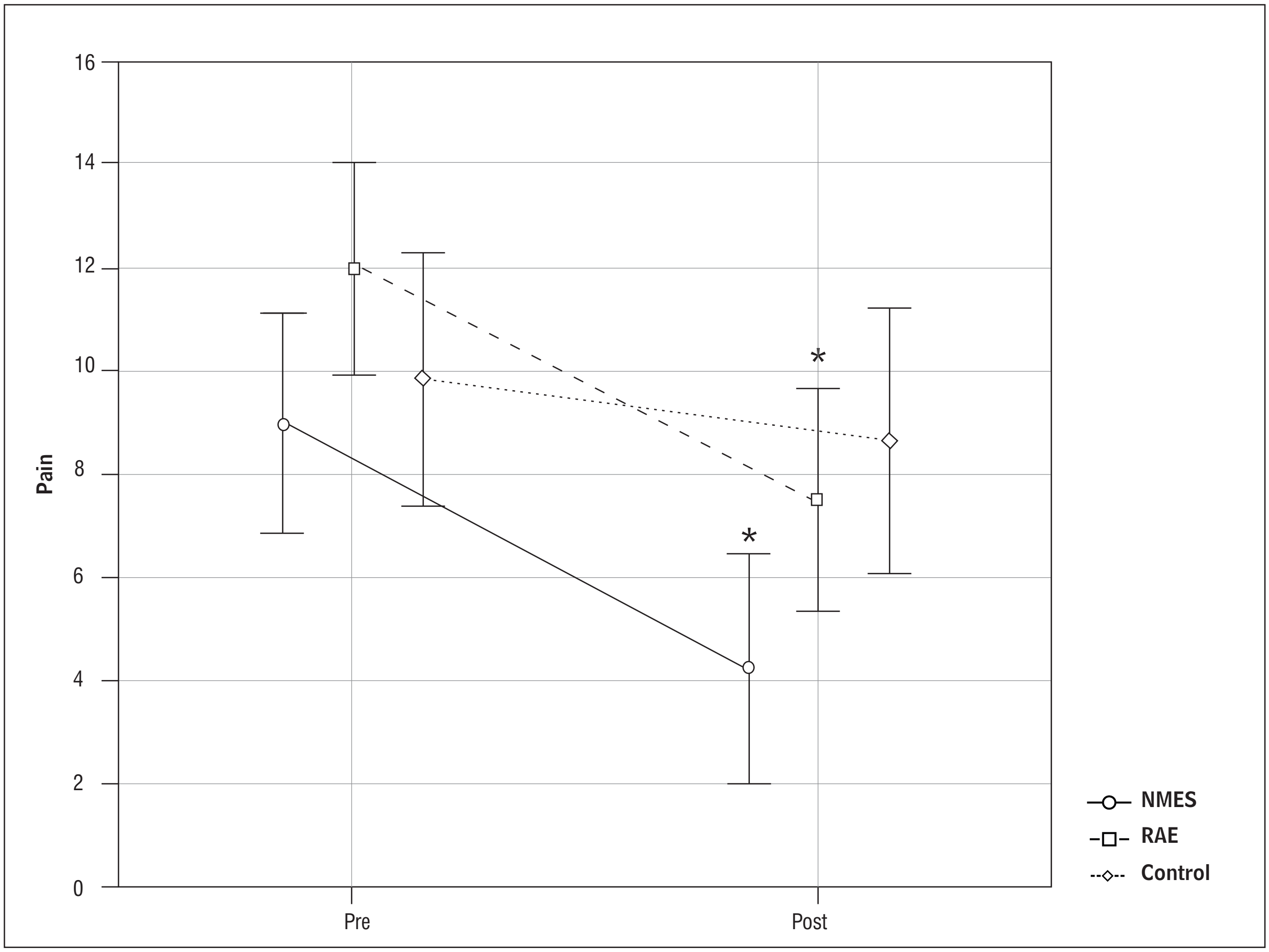
Graph 1 - Knee extensor strength before and after the 24-session program for neuromuscular electrical stimulation (NMES), resistance against exercise (RAE), and control (bars represent a confidence interval of 95%)
Legend: * = P < 0.05 intra-group.
Source: Research data.

of the effect was 0.36 between the groups NMES and control and 0.00 between the groups RAE and control.

The absolute and relative TME obtained for knee extensor strength were 7 N.m and 12%, respectively.

The 3 x 2 ANOVA with repeated measures showed F (2,20) = 2.53; P = 0.10 for the interaction of pain with the groups. For initial and final pain, the Bonferroni adjustment for a 3 x 2 ANOVA with repeated measurements showed P = 0.01 within the groups NMES and RAE; and P = 1.00 within the control group (Graph 2).

The size of the pain effect within the NMES group was -1.66; within the RAE group it was -1.33; and within the control group it was -0.5. The size of the



Graph 2 - Knee pain before and after the 24-session program for neuromuscular electrical stimulation (NMES), resistance against exercise (RAE), and control (bars represent a confidence interval of 95%)

Legend: * = $P < 0.05$ intra-group.

Source: Research data.

effect was -1.66 between the groups NMES and control, and -0.33 between the groups RAE and control.

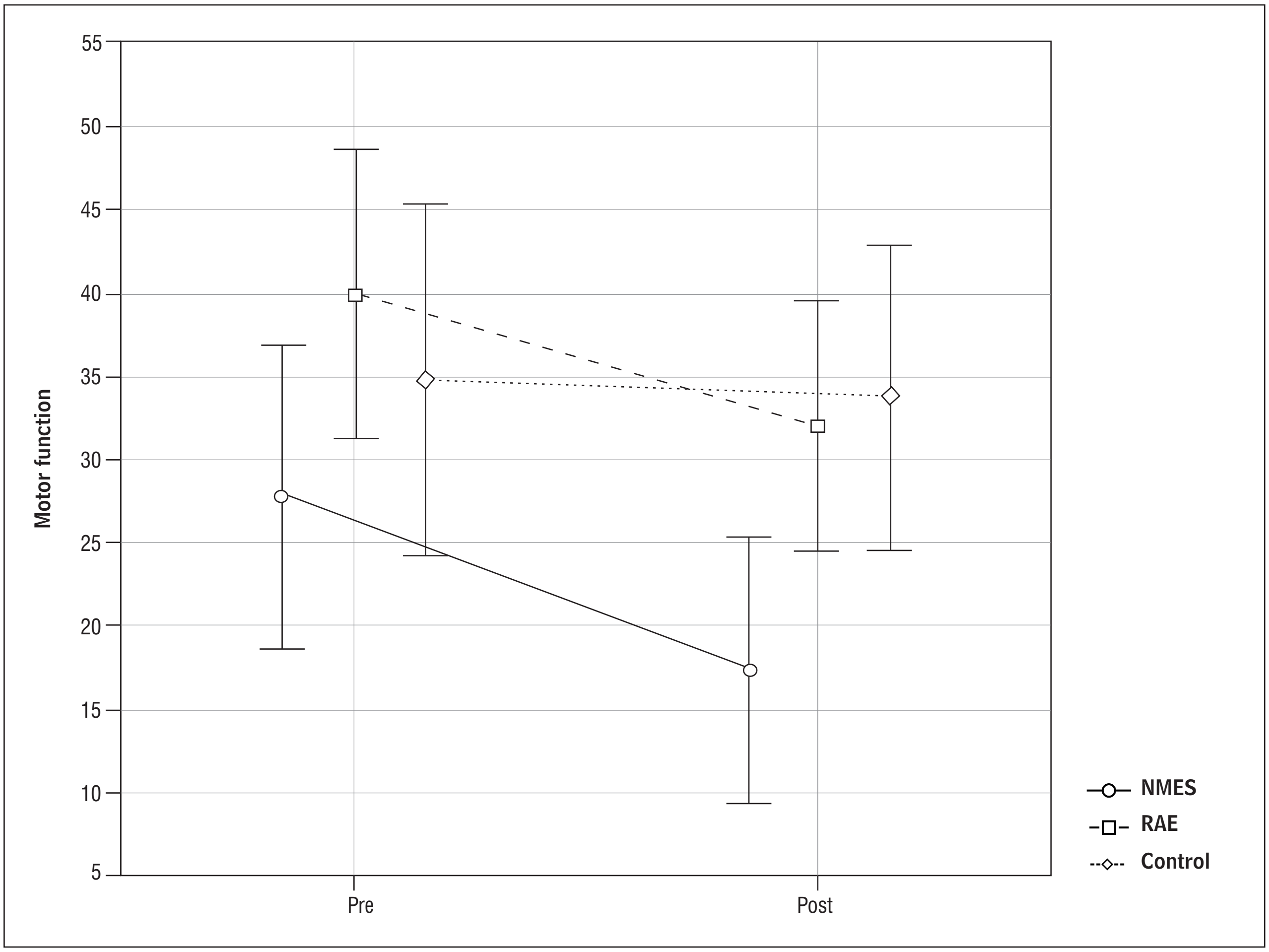
The 3 x 2 ANOVA with repeated measurements showed F (2.20) = 1.81; P = 0.19 for the interaction between motor function and the groups. Regarding the initial and final motor function, the Bonferroni adjustment for the 3 x 2 ANOVA with repeated measurements showed P = 0.08 within the NMES group; P = 0.29 within the RAE group; and P = 1.00 within the control group (Graph 3).

The size of the motor function effect within the NMES group was -1.22; within the group RAE it was -0.53; and within the control group it was -0.08. The size of the effect between the groups NMES and control was 1.54 and between the groups RAE and control was 0.15.

Discussion

This controlled, randomized, and double-blind experiment, by submitting patients with KO to 24 sessions of muscle strengthening through NMES, RAE, or no treatment, in the case of patients from the control group, did not find a significant difference for knee extensor strength, pain, and motor function between groups after treatment, contradicting the assumption that NMES or RAE show significant differences in all response variables when compared to control.

Perhaps, one reason for this was the heterogeneity among patients with regard to all response variables. This study used as inclusion criteria to homogenize patients the clinical and radiological criteria proposed by ACR for diagnosing KO (26), also used by 3 out of the 6 randomized controlled studies which



Graph 3 - Motor function before and after the 24-session program for neuromuscular electrical stimulation (NMES), resistance against exercise (RAE), and control (bars represent a confidence interval of 95%)
Source: Research data.

approached muscle strengthening in the treatment for KO selected due to the quality and scientific rigor (minimum score 6 of the PEDro scale) (23,32-34). However, this criterion seems to lack discriminatory power to achieve the required homogenization. In Table 1, we can observe that the standard deviations in the pre and post-treatment measurements were high for all response variables, generating a variation coefficient from 29% to 50% in the NMES group and from 34% to 38% in the RAE group, representing up to 1/3 to 1/2 of the average. Another criterion which could have been adopted in the study is the classification of KO severity by means of the radiographic degree proposed by Kelgreen and Lawrence (35), used in 4 out of the 6 studies with a minimum score of 6 on the PEDro scale. However, this classification was questioned with regard to the ability to classify the degree of joint impairment, because it showed only a moderate correlation to the degree of cartilage degeneration (r = 0.49; P = 0.065) (36).

A second reason may have been the small sample size. Out of the 6 studies showing a significant difference in muscle strength between groups, 5 had at least a sample of 79 patients, something which represents about, at least, 3 times the sample used in this study. It is worth stressing that there is a study with a sample of 23 patients which also obtained a significant difference in muscle strength. However, this study may have compromised the error type I by inflating it at the time of data analysis using many t-Student tests instead of an ANOVA.

In addition to the two reasons mentioned above, patients took between 8 and 13 weeks to complete the 24 treatment sessions. Only 3 patients strictly complied with the ideal 24 sessions in 8 weeks; 4 patients completed the 24 sessions in 12 weeks or more. Compensating a missed class was an attempt to prevent experimental mortality, but this may have contributed to the rejection of the hypothesis mentioned above.

Although between the groups this study accepted the null hypothesis, the result was different within groups. The knee extensor strength was significantly higher in the group treated with NMES. Peripheral muscle stimulation by means of NMES increases the excitability of spinal routes (37) changes the pattern of cortical activation (38) and improves the recruitment of muscle fibers which are responsible both for strength, more difficult to recruit through voluntary contraction, and for the resistance to fatigue (39), some neural adaptations that increase the capacity of voluntary muscle contraction (40), impaired in patients with KO (41).

Despite the fact that muscle strength test on an isokinetic device showed a high test/retest reliability in patients with KO (42, 43) and a recent study with patients with moderate and severe KO (Kelgreen and Lawrence degrees 2, 3, and 4) found an absolute TME of 14.6 N.m and a relative TME of 4.7%, as well as a minimum absolute difference in intra-group detectable muscle strength between tests of 33.9 N.m and a minimum relative difference of 6.6%, this study was careful by also measuring the TME of knee extensor strength. In this study, the absolute and relative TME were 7 N.m and 12%, respectively. The differences in knee extensor strength found in this study were of 16 N.m in the NMES group, 7 N.m in the RAE group, and 5 N.m in the control group. It may be seen that the difference in the knee extensor strength obtained by the NMES group was 9 N.m greater, while in the RAE group it was equal and in the control group it was 2 N.m smaller than the TME, respectively.

The significant increase in knee extensor strength in the NMES group also led to a significant decrease in pain, confirming the findings of other studies, which showed that the muscle strengthening of knee extensors can reduce the pain caused by KO (23, 24-34). In another study, which compared a group undergoing NMES associated to core training to another group which underwent only the core training to treat low back pain, the pain in the NMES group associated to core training was significantly lower than in the core training group ($P = 0.03$), confirming the role played by NMES in the pain reduction identified in this study (44). The variables pain and motor function behaved in a similar way in the groups NMES and RAE, something which can be observed in the similarity between Graphs 1 and 2. These two variables are related and they are influenced by one another. In two studies, one with 544 and another with 2,940 subjects, the occurrence of pain was associated to decreased motor function in men and women (45, 46). KO is characterized by a mechanical pain, a pain which emerges during movement that causes motor abnormalities and influences on the performance of functional activities (8).

In the RAE group there was a significant reduction in pain without any significant increase in knee extensor strength. This may be explained because there is also evidence that joint cartilage positively responds to the stimulation of moderate physical activity (47, 48) and that physical activity increases the interleukin-10 levels, an anti-inflammatory cytokine, and decreases the levels of the oligomeric protein which protects cartilage in the synovial fluid, a marker of cartilage metabolism (49, 50), and this may have interfered with the pain mechanism of the RAE group.

Contrary to the association between the variables pain and motor function mentioned above, in the groups NMES and RAE there was a significant decrease in pain, but this does not mean significant improvement of motor function. This may be explained by the great coefficient of variation of 29 and 34%, respectively, in the results of motor function, probably due to the heterogeneity explained above.

Physical inactivity can be harmful for patients with KO (51). This can be observed in the control group, which did not obtain significant differences in any of the response variables, explained by the fact that patients did not undergo any form of muscle strengthening and physical activity within the period of 8 weeks. Exercise is beneficial to patients with KO because of the relation between increased muscle strength to decreased pain and improved motor function (45).

The size of the effect within the NMES group, classified as moderate for knee extensor strength, too great for pain, and great for motor function (30) was higher for all response variables when compared to the groups RAE and control. This also occurred in the size of the effect between groups. In the NMES group, patients underwent electrical stimulation causing passive muscle contraction and performed voluntary isometric contraction associated to the same muscles. Passive contraction of the quadriceps associated to voluntary contraction without joint movement allowed the increase in knee extensor strength and the consequent improvement of active stability, without subjecting the unprepared joint to compressive and shear stress.

Six randomized and controlled trials, out of which four underwent blind review, selected due to their quality and scientific rigor, which focused on muscle strengthening exercise as a treatment for KO, with a design similar to this study, i.e. with two treatment groups and a control group, with pre- and post-treatment measurements, with 8 weeks of treatment and frequency of 3 times a week; muscle strength was measured on an isokinetic machine and it showed a significant increase in muscle strength intra- and inter-groups (23, 24, 32-34), except for a group which performed aquatic exercises (33). In this study, a significant difference in muscle strength was found only in the pre- and post-treatment measurement of muscle strengthening by NMES.

Four of these studies also showed a significant decrease in pain within and between groups, except for one study (23), which did not evaluate pain and another one (33), which found no decrease in pain when comparing floor exercises and aquatic exercise compared to control. The same 6 studies, by evaluating motor function, also found a significant difference within and between groups, exception one study (33), which showed no significant improvement of motor function. To evaluate pain and motor function, 3 out of these 6 studies used the Questionnaire Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (23, 32, 34) also used in this study, which found a significant decrease in pain and a significant improvement of motor function within the NMES group.

Three previous studies addressed muscle strengthening through NMES in the treatment for KO. Non-blind uncontrolled studies (52, 53) found a significant increase in muscle strength of the quadriceps inter- and intra-groups treated with NMES, with no improvement in pain or motor function. Another study (54) conducted a non-blind randomized controlled trial with regard to groups, with a design similar to this study, which compared a group undergoing NMES for quadriceps during 4 weeks, 3 times a week, to an untreated control group. The protocol for applying NMES was similar to that used in this study, differing by a longer time off (50 s) in a contraction cycle, as patient's position is sitting on a chair and because it discourages voluntary contraction associated to the passive muscle contraction caused by electrical stimulation. This study showed no significant difference inter- or intra-groups for knee muscle strength, pain, or motor function. In contrast, this study found a significant increase in knee extensor strength and a significant decrease in pain for the NMES group, with blind evaluation and analysis of results. The fact that one study (54) used only 4 weeks, i.e. half of the treatment sessions used in this study, and that it did not associate isometric contraction of the quadriceps may have contributed to the results found in that study.

The results of this study were limited because of the small sample size, and the lack of homogeneity of patients in the pre- and post-treatment evaluation may have been caused by the lack of discriminatory power in the clinical and radiological criteria of ACR for the diagnosis of KO (26). This makes us believe that a functional clinical classification could be a better option to select a more homogeneous sample than the criteria mentioned above or KO severity classification, by means of the radiographic degree proposed by Kelgreen and Lawrence (35), since the response variables under study have functional clinical characteristics.

Conclusion

Considering the results obtained here, we conclude that strengthening the knee extensor muscles can help decreasing pain in patients with KO. NMES, when applied in 24 sessions, 3 times a week, according to the protocol used in this study, may constitute an interesting therapy to improve the clinical status, since it protects the joint from compressive stress and shear produced by joint movement.

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Received: 06/22/2012
Recebido: 22/06/2012

Approved: 07/29/2012
Aprovado: 29/07/2012