

SHORT TERM EFFECTS OF LOW-FREQUENCY AND LOW INTENSITY ELECTROSTATIC FIELD IN PATIENTS WITH KNEE JOINT OSTEOARTHRITIS

Galina Mratskova

Department of Medical Rehabilitation and Ergotherapy, Physical Medicine and Sports, Medical Faculty, Trakia University, Stara Zagora, Bulgaria, galina.mratskova@trakia-uni.bg

Damyan Petrov

Medical Faculty, Trakia University, Stara Zagora, Bulgaria, damyan.petrov@gmail.com

Nedko Dimitrov

Clinic of Orthopedics and Traumatology, University Hospital "Prof. Dr. St. Kirkovich" PLC, Stara Zagora, Bulgaria, Department of Special Surgery, Medical Faculty, Trakia University, Stara Zagora, Bulgaria, dimitrovnedko@yahoo.com

Abstract: Introduction: Osteoarthritis (OA) is a widespread disease among adult population and is one of the major public health problems. OA is leading cause of disability the joints of lower limbs: knee and hip. As global life expectancy increases, it predicted that OA will be the leading cause of damage resulting in permanent disability. In cases of OA a reduction in cartilage tissue is observed, which is radiographically demonstrated by narrowing of the joint space and bone changes, osteophytes and subchondral bone sclerosis. However, a significant proportion of patients with radiological evidence of gonarthrosis do not report joint pain. It is important to evaluate the changes occurring in the surrounding tissues. Muscle weakness of m. quadriceps femoris may occur before pain and impaired joint function. The development and application of new non-pharmacological methods in the rehabilitation of degenerative joint diseases is particularly important.

Purpose: To establish the short-term therapeutic effects of treatment with Low-frequency and Low-intensive electrostatic field, applied through Deep Oscillation® method and complex of therapeutic exercises in rehabilitation of patients with osteoarthritis of the knee.

Materials and methods: We conducted a one-year observational study involving 23 patients with clinical symptoms and radiologically proven II and III stage according Kellgren-Lawrence gonarthrosis, aged between 42 and 78 years, were observed. 15 of them were women average age 61.73 ± 12.9 years vs 8 - males average age 61.75 ± 9.6 years ($p=0.997$). The duration of the current pain-episode was 1.7 ± 0.7 months. The treatment was conducted in 10 sessions and included: Low-frequency and Low-intensive electrostatic field and complex therapeutic exercises.

Results: The results were evaluated before and after completion of therapeutic course by assessing pain (VAS) at rest, when walking, climbing and descending on stairs, Manual Muscle Testing, Measurement of the knee joint circumference, Test Range of Motion and WOMAC Osteoarthritis Index, V.LK 3.1. were tracked. For processing statistical data SPSS v.13 was used. There was a statistically significant reduction of pain syndrome at rest ($p<0.001$), walking ($p<0.001$), descending stairs ($p<0.001$), climbing ($p<0.001$). Reduction of knee joint circumference ($p<0.001$). Increasing the range of flexion before Me (Range) from 105° (90° - 120°) versus 120° (100° - 125°) after therapy. Reduced deficiency at an extension from 3.48 ± 4.38 before therapy to recovery of the extension. Improved total WOMAC Index ($p<0.001$), Stiffness ($p<0.001$) and Function ($p<0.001$).

Conclusion: The short-term effects of the application of Low-frequency and Low-intensive electrostatic field in complex with therapeutic exercises show reduction of clinical symptoms and improvement of daily functional activity in patients with knee joint osteoarthritis. Reduction of pain of rest and physical activity (walking, descending and climbing stairs) is observed, oedema is reduced, joint range of motion increases, immediately after completion of the therapeutic course. Because of the small number of patients included in the study for better objectifying of the effects of the low-frequency and low-intensive electrostatic field, the studies should continue.

Keywords: Knee osteoarthritis, Low-frequency and Low-intensive electrostatic field, Deep Oscillation® therapy, Pain, therapeutic exercises

1. INTRODUCTION

Osteoarthritis (OA) is a widespread disease among elderly people and is one of the major public health problems. OA is leading cause of disability the joints to lower limb: knee and hip. With the increase in life expectancy worldwide, it is estimated that by 2020 osteoarthritis will occupy the fourth position as a cause leading to permanent disability [1]. According to data from the National Statistical Institute of the Republic of Bulgaria from a survey carried out in 2008, in Health Status section, in total 41.4% of the respondents reported "general musculoskeletal pain", 16.1% reported joint pain as a reason for a visit to a doctor. In 2014, after a second study, 7.5% of the

respondents reported osteoarthritis (no inflammatory arthritis), 4.5% of them men and 10.2% female [2]. For the Region of Stara Zagora, according to the data from the Regional Health Inspectorate of Stara Zagora in 2016, 9.4% of all newly discovered diseases were in the musculoskeletal system [3]. The structural features of osteoarthritis are reduction of cartilage tissue, which is radiologically demonstrated by narrowing of the joint space and bone changes, osteophytes and subchondral bone sclerosis. However, structural changes are poorly related to the sensation of joint pain [4]. A significant proportion of patients with radiographic evidence of gonarthrosis, have no joint pain [5,6]. Important are not only the changes in intra-joint structures, but also changes occurring in the surrounding tissues. The degree of damages as a result of gonarthrosis is often judged only by radiographic data. Bones, ligaments, cartilage, joint capsule, muscles performing movement, and nerve structures that control it should be considered as a basic functional unit of the locomotory system. If any of these components is functionally incomplete, the function of the joint itself will be impaired [7,8,9,10,5]. Muscle weakness of m. quadriceps femoris in gonarthrosis occurs before joint pain and impaired joint function. The deficiency of muscle strength and proprioception in OA of the knee joint is probably caused by the limited function of the quadriceps muscle in order to reduce the pain. Improving of the muscle function, and especially the muscle force by exercise, is associated with a reduction of pain and an improved knee joint function in OA [11]. The development and application of new non-pharmacological methods in the complex treatment and rehabilitation of degenerative joint diseases are among the priorities of modern physical and rehabilitation medicine.

2. OBJECTIVE

To establish the short-term therapeutic effects of Low frequency and Low intensity Electrostatic field therapy applied by Deep Oscillation® method and a complex of therapeutic exercises in the rehabilitation of patients with knee osteoarthritis.

3. MATERIALS AND METHODS

23 patients with clinical symptoms, diagnosed with II and III stage of gonarthrosis according to Kellgren-Lawrence, aged between 42 and 78 years, were included in the study for a period of one year. Of these, 15 were women with average age of 61.73 ± 12.9 years vs 8 males with an average age of 61.75 ± 9.6 years ($p = 0.997$). The duration of current pain-episode was 1.7 ± 0.7 months. In 8 of the patients the left and in 15-right knee joint (KJ) were affected (KJ). There was no statistical relationship between the type of knee joint affected (right or left KJ) and the degree of osteoarthritis ($\chi^2=0.212$; $p=0.685$). The treatment was conducted in 10 sessions. All patients underwent a therapeutic course with Low-frequency and Low-intensity electrostatic field and complex of therapeutic exercises. Results were tracked at the beginning and in the end of the treatment course by VAS pain test at rest, at move, climbing and descending stairs, Manual Muscle Test, Measurement of the knee joint circumference, Test Range of Motion and WOMAC Osteoarthritis Index /Western Ontario and McMaster University Osteoarthritis Index/, developed for adult patients with osteoarthritis. Modification V.LK3.1 has been used. *Statistical analysis:* Quantitative data is represented as Mean and Standard Deviation (SD) if the distribution is either normal or Median (Me) and Range if different than normal. The normality was tested by the Shapiro-Wilk test. Comparisons of quantitative data before and after therapy were performed by the One sample Student t-test or the Wilcoxon Signed Ranks test. The category data was presented in percentages and analyzed by Fisher's Exact Test. Statistical significance was at $p<0.05$. The data was analyzed with SPSS for Windows v.13.

Clinical and radiographic criteria for inclusion in the study were as follows: age 38 or over, knee pain in most of the days of recent months, crepitus in joint when moving, morning stiffness (30 minutes or less), radiographic data for OA in KJ according to Kellgren - Lawrence II and III. The study excludes patients under 38 years of age, patients with OA of KJ and severe joint trauma of the same, general contra-indications for electrotherapy (decompensated cardiovascular diseases, including pacemaker, acute infectious conditions, sensitivity to electric fields, etc.), radiographic data for the I and IV stage of OA of KJ according to the Kellgren - Lawrence. The therapeutic goals of the rehabilitation of patients with symptomatic gonarthrosis with Low-frequency and Low-intensity electrostatic field and complex therapeutic exercises were: reduction of pain and stiffness, reduction of edema of the around joint tissues and muscular weakness, improvement of the range of motion in affected joint and locomotive function, increase of the daily functional activity. In the studied group, the Low frequency and Low-intensity electrostatic field was applied by the Deep Oscillation® method using a 9.5 cm hand applicator (Deep Oscillation Evident®). The procedure involves treatment of KJ, surrounding tissues and the m. Quadriceps femoris area. Therapeutic Modality: Variable Frequency 100-144 Hz 5 min. Permanent frequency 85 Hz 5min. Variable frequency 14-20 Hz 4 min. Modulation mode 1:1 (light vibrations). The complex of therapeutic exercises was carried out immediately after the electrical procedure. It included aerobic exercise, analytical exercise for femur muscles, focusing on Vstus

medialis et lateralis m Quadriceps femoris, relaxation techniques for shortened muscles, resistance exercises, exercises to increase the range of motion in the knee joint. All patients included in the study gave informed consent to participate in the treatment course and could give up at any time from the treatment course.

4. RESULTS

The study included 23 patients with symptomatic osteoarthritis of the knee joint in a subacute and chronic phase without clinical evidence stage of active inflammation. In 15 of them the right knee joint (KJ) was affected, and in 8 - left KJ. No statistical relationship was found between the type of knee joint (right or left) and X-ray stages of osteoarthritis ($\chi^2=0.212$; $p=0.685$). After the course of complex rehabilitation, a reduction in the pain syndrome was reported. The results were monitored by measuring the subjective sensation of pain before and after the treatment course, VAS (Visual-Analogue Pain Scale). From 0- without pain, 2-3 mild pain, 4-5 moderate pain, 6-7 severe pain, 8-9 very severe pain to 10-insufferable pain. Pain at rest, movement, climbing and descending stairs has been evaluated. Statistical dependence ($Z=4.169$, $p<0.001$) was observed, which was expressed as a reduction in pain at rest before $Me=3(2-5)$ and after $Me=1(0-3)$. After the complex rehabilitation, a reduction in pain was observed in: walking ($Z=4.319$, $p<0.001$), before $Me=4(2-8)$ and after treatment $Me=2(1-5)$; descending ($Z=4.250$, $p<0.001$), initially $Me=8(5-8)$ and after the physiotherapy course $Me=4(2-6)$; climbing stairs ($Z=4.255$, $p<0.001$), baseline pain $Me=7(5-8)$, at the end of treatment $Me=3(1-5)$. There was a statistically significant reduction in knee joint circumference and a reduction in swelling by measuring of the affected joint in cm after treatment ($t(22)=7.598$, $p<0.001$). Prior to physiotherapeutic treatment, the average the circumference of the joint was 40.35 ± 3.85 , and after treatment 39.09 ± 3.91 . The range of motion the KJ was assessed by goniometry in angular degrees. An increase in range of flexion in the knee joint was observed after completion of physiotherapy(FT). A statistically significant difference was recorded before and after therapy ($Z=4.272$, $p<0.001$), at the beginning of treatment $Me=105^\circ(90^\circ-120^\circ)$ and after $Me=120^\circ(100^\circ-125^\circ)$. To determine the degree of muscle weakness of m. Quadriceps femoris a Manual Muscle Testing was used. The patients were divided into 4 groups depending on the degree of muscle weakness (2 Poor, 3 Fair, 4 Good, 5 Normal). A statistically significant reduction in muscle weakness before $Me=3(2-4)$, and after $Me=4(3-5)$, ($Z=3.286$, $p=0.001$) was observed. In the beginning of the treatment course, 4.3% of patients were rated with Poor (2) for m. Quadriceps femoris, 91.3% with Fair (3) and only 4.3% with a Dood (4). After the completion of rehabilitation, patients with rate Good were 34.8% and Normal 21.7% 43.5%, table 1.

Table 1. Dynamics of MMT m. Quadriceps femoris

MMTm. Quadriceps	2- Poor	3- Fair	4- Good	5- Normal
Before treatment	4.3%	91.3%	4.3%	
After treatment		43.5%	34.8%	21.8%

The WOMAC Osteoarthritis Index /Western Ontario and McMaster Universities Osteoarthritis Index/ has been developed to assess lower limb osteoarthritis in elderly patients. The study uses V.LK3.1 modification, which includes assessment of pain in 5 points, stiffness in 2 points and function in daily life in 17 points. The symptoms were assessed according to the verbal Likert scale in 5 points: 0-Missing; 1-Weak; 2-Moderate; 3-Strong; 4-Very strong. The higher the result, the more pronounced are the symptoms and the degree of functional impairment. Statistical dependence ($Z=4.201$, $p<0.001$) was observed, reducing the total WOMAC score before $Me=64(47-78)$ and after rehabilitation $Me=51.1 \pm 9.9$, table 2.

Table 2 Dynamics of the total WOMAC Score, subscale Stiffness and Function before and after the complex rehabilitation.

WOMAC Me(range))	Me before therapy	Me after therapy	Statistical dependance
WOMAC Score	64.0 (47.0-78.0)	52 (35.0-71.0)	$Z=4.201$, $p<0.001$
WOMAC Stiffness	5.0 (3.0-7.0)	3.0 (1.0-6.0)	$Z=4.070$, $p<0.001$
WOMAC Function	47.0 (36.0-65.0)	40.0 (29.0-53.0)	$Z=4.206$, $p<0.001$

Subscale Stiffness (0-8t points) is assessed by 2 qustions. A statistically significant reduction in stiffness was observed in affected KJ ($Z=4.070$; $p<0.001$). In the beginning of the course it was 5.0 (3.0-7.0) and after treatment it was 3.0 (1.0-6.0). The dynamics in functional activity was evaluated by a Subscale Function (0-68t points) with 17 questions. After the rehabilitation course, there was increase in functional activity in patients with osteoarthritis of KJ, expressed as a reduction in WOMAC Function. A statistically significant difference ($Z=4.206$, $p<0.001$) was reported before $Me=47.0$ (36.0-65.0) and after complete rehabilitation $Me=40.0(29.0-53.0)$.

5. DISCUSSION

Following the observational study a statistically significant reduction in pain at rest and physical activity (walking, descending and climbing stairs), reduction of edema of the around joint tissues, muscle weakness of m. Quadriceps femoris and increased movement in the knee joint were observed. The values of the total WOMAC Index and Subscales Stiffness and Function were reduced and the self-assessment of the functional activity in the day-to-day activities improved. The therapeutic effects achieved in treatment with Low-frequency and Low- intensity electrostatic field depend directly on the applied constant or variable frequency [12]. The analgesic effect was manifested rapidly and has a long-lasting effect [13]. The Gate control of pain impulses was activated [14] and a psychological effect of the procedure [15] appeared. The oxidation of the lipids is inhibited as well as the production of oxygen-containing radicals, which is in the basis of the anti-inflammatory effect [16,17]. Ineffective shunt blood flow, vasodilatation of the capillaries and subsequent microcirculation was improved [18,19]. The delivered from the mastocytes biologically active substances histamine, protease, serotonin, heparin provided prolonged vasodilation [19]. An reabsorption of edema and lymphodrainage effect is observed [16,20] occurs. The elasticity of tissues was increased - reduction and/or prevention of fibrosis was prevented. Increased joint mobility was observed [21]. The muscle spasm in the area of impact with the Low-frequency and Low-intensity electrostatic field by affecting nerve endings and nerve fibers was reduced. The trophic and regenerative processes based on activation of local mechanisms of tissue blood flow, increasing of local microhemodynamics, increasing of transport functions of blood, improving of trans-capillary exchange were improved. Many studies prove that patients with KJ osteoarthritis have weakness in the Quadriceps femoris muscle, impaired proprioception and balance and frequent falls tendency. The muscle weakness correlates with pain and impaired function and appears as a result of arthrogenic reductions in volitional contraction and reflex inhibition induced by pain and swelling [22]. There is significant evidence of the effect of kinesitherapy on osteoarthritis, especially in the knee joint. Systematic surveys prove its positive effect on pain, function and general condition [23,24]. M. Fransen and McConnell, on the base of a meta-analysis of 32 randomized controlled trials involving 3626 patients within Cochrane Collaboration, find platinum stage of evidence that exercise reduces pain and improves function in gonarthrosis, and the effect is comparable to that of non-steroidal anti-inflammatory agents [24,25]. Our study confirms the results obtained in the complex rehabilitation of patients with gonarthrosis involving the application of Deep Oscillation® therapy. Onose G. et al. reported reduction in pain and improved movement in patients with osteoarthritis in a complex with targeted kinesitherapy [26].

6. CONCLUSION

The short-term effects of the application of Low-frequency and Low-intensive electrostatic field in complex with therapeutic exercises show reduction of clinical symptoms and improvement of daily functional activity in patients with knee joint osteoarthritis. Reduction of pain of rest and physical activity (walking, descending and climbing stairs) is observed, oedema is reduced, joint range of motion increases, immediately after completion of the therapeutic course. Because of the small number of patients included in the study for better objectifying of the effects of the low-frequency and low-intensity electrostatic field, the studies should continue. However, the short-term results of the observational study show that Low-frequency and Low-intensive electrostatic field (Deep Oscillation® therapy) and therapeutic exercises could be an effective option for functional recovery in the complex treatment and rehabilitation of patients with knee joint osteoarthritis.

BIBLIOGRAPHY

- [1] A.D.Woolf, et al. Burden of major musculoskeletal conditions, *Bull World Health Organ.*, 81(9):646–656., 2003.
- [2] National statistical institute, Republic of Bulgaria, European health interview survey, EHIS wave 1 – 2008, EHIS wave 2 – 2014, <http://www.nsi.bg>
- [3] Regional Health Inspectorate of Stara Zagora, www.rzi-starazagora.org
- [4] E.M.Roos, et al. Muscle weakness, afferent sensory dysfunction and exercise in knee osteoarthritis., *Rheumatology*, 7:57–63., 2011.
- [5] C.Slemenda, K.D.Brandt, Heilman D.K. et al. Quadriceps weakness and osteoarthritis of the knee. – *Ann Intern Med*, 127(2):97–104., 1997.
- [6] J.S.Lawrence, J.M.Bremner, F.Bier, Osteoarthrosis Prevalence in the population and relationship between symptoms and x-ray changes. – *Ann Rheum Dis.*, 25:1–24., 1966.
- [7] M.V.Hurley, The role of muscle weakness in the pathogenesis of osteoarthritis. – *Rheumatic Disease Clinics of North America*, 1999, 25(2):283–298.
- [8] K. Brandt, Putting some muscle into osteoarthritis. – *Ann Intern Med*, 127:154., 1997

-
- [9] M.Hurley, D.L.Scott., J.Rees et al. Sensorimotor changes and functional performance in patients with knee osteoarthritis.,*Ann Rheum Dis*, 56:641.,1997
- [10] L.Sharma, Y.-C.Pai, K.Holtkamp et al. Is knee joint proprioception worse in the arthritic knee versus the unaffected knee in unilateral knee osteoarthritis?,*Arthritis Rheum*,40:1518., 1997.
- [11] K.L.Bennell, T.V Wrigley., M.A.Hunt, B.W.Lim, R.S.Hinman, Update on the role of muscle in the genesis and management of knee osteoarthritis.,*Rheum Dis Clin N Am.*,39, 145–176. 2013.
- [12] А.Г.Куликов,Е.В.Кузовлева, Применение низкочастотного электростатического поля в клинической практике. ,*Физиотерапия, бальнеология и реабилитация*, 4:44–54.,2013.
- [13] G.Fistetto et al. Deep Oscillation: therapeutic-rehabilitative experiences with a new electrostatic device. – *Minerva Med*,102(4):277–288,2011.
- [14].R.Trubulski,Using the Hivamat 200 system in the treatment of wounds. *Rehabilitacia W.Praktice*,1:28–33,2008.
- [15] И.Колева, Основи на физикалната медицина, физикалната терапия и рехабилитацията. София, 2013.
- [16] V.Gasbarro, et al. Role of Hivamat® (Deep Oscillation) in the treatment for the lymphedema of the limbs., *Eur J Lymphol*, 16:13–18.,2006.
- [17] E.Mikhailchik, et al. Effects on blood parameters of DEEP OSCILLATION®. – In: 1st International Conference on Skin and Environment, Moscow – St. Petersburg. Vol. 59. 2005.
- [18] L.Korkina, et al. Treatment of Gynoid Lipodystrophy (Cellulite) with Deep Oscillation®: A Pilot Clinical Study. – In: 29th Annual Meeting of The Bioelectromagnetics Society, Kanazawa, Japan. Vol. 2. 2007.
- [19] О.А.Старосветская, Д.Б. Кульчицкая, С.Н. Нагорнев, Г.А.Пузырева., Влияние курсового применения импульсного электростатического поля на показатели микроциркуляции у больных нейроциркуляторной дистонией по гипертоническому типу., *Вестник восстановительной медицины*, Vol. 1 (53), стр.10-13, 2013.
- [20] S.Jahr, et al. Effect of treatment with low-intensity and extremely low-frequency electrostatic fields (Deep Oscillation) on breast tissue and pain in patients with secondary breast lymphoedema. – *Journal of Rehabilitation Medicine*, 40(8): 645–650.,2008.
- [21] Therapy with Deep Oscillation® Evident Clinics Physiomed
- [22] Е.Илиева, Комплексна рехабилитация и ерготерапия след ендопротезиране на колянната става., *Клинична рехабилитация и бальнеология*, 6–9:10–15., 2007.
- [23] E.Roddy, M.Doherty, Changing life-styles and osteoarthritis: what is the evidence? – *Best Pract Res Clin Rheumatol*, 2006, 20(1):81–97.
- [24] Е.Илиева, Съвременен подход основан на доказателствената медицина в поведението и рехабилитацията при дегенеративни ставни заболявания. – *Физикална медицина, рехабилитация и здраве*, 3:19–24. 2009,
- [25] M.Fransen, S. McConnell. Exercise for osteoarthritis of the knee., *Cochrane collaboration*, 2,2009.
- [26] G.C.Onose Daia-Chendreau et al. Our experience concerning the use of deep oscillation in the therapy of the use of deep oscillation in the therapy of neurologic patients with associated pain and/or rheumatic – degenerative conditions. – *The proceedings from the National Conference of Neurosurgery and Neurorehabilitation, with international participation, 2nd edition*”, Mamaia, Romania, 9–12 septembrie, 2009; pp 173-176; supliment al “*Industria Textile Magazine*”cotat ISI, Ed. Certex, 2009

