

Research article

Study on the effects of the use of therapeutic ultrasound in the treatment of osteoarticular diseases

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ABSTRACT: Introduction. The use of therapeutic ultrasounds is a method that proved its efficiency in articular and periarticular pathology, in the subacute and chronic stages. The biological effects of the ultrasound use are determined by their interaction with the cellular structures whereas the results depend on the used parameters. The purpose of the survey is to evaluate / identify the effects of using ultrasounds in the treatment of musculoskeletal conditions (lumbar discopathy), knee osteoarthritis). Material and method. The survey was conducted on an outpatient basis in a period of 7 months and it is of the longitudinal type. It included 151 patients diagnosed with low back pain and knee osteoarthritis. The evaluated parameters were: pain, functional skills, articular rigidity and the quality of life. Results. The effects of the use of ultrasounds is found in the decrease of pain, the stiffness of the joints and the contracture of the muscles, as shown by the results of several surveys. Our survey proves that the use of ultrasounds decreases pain and increases the functional skills, it influences the physical function more obviously in patients with knee osteoarthritis, which is an aspect found in others surveys. Discussion. The use of a complex ultrasound treatment (in the pulsed way to avoid thermal effects) and kinesiotherapy enabled in our research the decrease of the pain and of the rigidity in the joints, the increase of the functional skills and the quality of life, whereas these obtained results are in accordance with those of others surveys. Conclusions. The use of the therapeutic ultrasounds can have the following effects: the decrease of the pain and of the joint rigidity, the improvement of the physical capacity for daily activities and the improvement of the quality of life. The use of low intensity ultrasounds can determine biological effects with actions for a short period or for an average one.

Keywords: *therapeutic ultrasound, treatment, osteoarticular diseases, quality of life*

1. INTRODUCTION

Ultrasounds are mechanical waves oscillating with a frequency of 8×10^5 Hz, determining chemical, biological and thermal effects. As for the biological effects, they depend on the applied intensity (1) and they are represented by vasodilation, hyperemia and the growth of the permeability of the cellular membrane. Therapeutic ultrasounds find their applicability due to the physiological effects, namely the modification of the permeability of the cellular membrane, the stimulation of the blood circulation, the fibrolytic, anti-inflammatory and analgesic effects, and local vasodilation (2).

The use of therapeutic ultrasounds is a method that proved its efficiency in articular and periarticular pathology, in the subacute and chronic stages (1,3,4). They also have a role in the periosteal reconstruction, by the growth of the vascular permeability and by the local vasodilation (5).

There is a growing trend about the use of the therapeutic ultrasound in the management of the pain (6). The use of the therapeutic ultrasounds may determine: the intensification of the cellular metabolism by the improvement of the redox reactions and by the acceleration of the biochemical reactions (2,6), the increase in the local temperature, by enabling the blood flow by producing thermal and mechanical energy (7), the modification of the number of red blood cells (actually a false decrease), slowing down the blood coagulation process, the influence on the values of the total serum calcium (8), but all these according to the application method (pulsed or continuous) and the used frequency (3).

The ultrasound therapy may cause a thermal effects but also non-thermal ones (mechanical stress, cavitation) (3) whereas the ultrasound dosimetry is very important for the minimization of the side effects.

The important physical parameters in the recovery therapy by ultrasounds are: frequency (800 kHz), intensity (W/cm^2), the application mode (continuous or pulsed), the contact environment, the used dose, the duration of the applicability and the interval between the sessions for the treatment use (7, 9, 10).

The biological effects of the ultrasound use are determined by their interaction with the cellular structures whereas the results depend on the used parameters.

The therapeutic effects of ultrasounds are determined by the application parameters (the used frequency, the length of the waves, the intensity of the work, duration).

They cause thermal action (during the continuous use of the ultrasounds) and non-thermal action (during the pulsed use of the ultrasounds) (11).

The ultrasound used continuously determine thermal effects whose consequences are the growth of the capillary permeability and the growth of the tissue metabolism.

By the increase in the local temperature, analgesia occurs, the pain threshold increases and the tissue fiber is extensible. The used pulsed ultrasounds result in the modulation of the permeability of the cellular membrane, the increase in the protein synthesis and the activation of the local immune response by stimulating the regeneration of the tissue that is damaged (12).

Studies have shown that ultrasounds can produce energy which can be stored in tissues and may be determine biological effects (13).

The ultrasound therapy, in continuous form or pulsed, enables, according to the coupling environment, the transport of topical pharmacologist agents to teguments and we are talking about the method named sonophoresis (8, 14, 15).

A review of 2016 (16) showed that the beneficial effects of ultrasounds depended on the duration of the symptoms presented by patients, the period of using ultrasound therapy, the number of sessions and the total energy used in each session.

Knee osteoarthritis affects approximately 250 million people worldwide (17), it determines economic, social and medical consequences (18), it is a frequent cause of pain, disability and the decrease in the functional skills of the adults (19,20). Ultrasounds can be beneficial for patients with knee osteoarthritis. Ultrasounds may decrease the muscular pain and reduce spasms, by facilitating the repair of tissues through the increase in the local blood flow and the stimulation of the inflammatory mediators (21).

The use of therapeutic ultrasound enables, due to the mechanical vibrations, the penetration of these waves in the tissues, it has a fibrinolytic role and it relaxes the muscles (8,19,22). In order to be able to penetrate the tegument, the anti-inflammatory for the topical administration must have a certain active concentration in terms of pharmacodynamics, which depends on the molecular weight, water solubility, small molecules that are more hydrophilic, but also lipophilic properties to enable the easy transfer through layers (23, 24). Osteoarthritis has an inflammatory component (18,25), and the pain is the result of the inflammatory ways that produce an increased answer of the nociceptors from the peripheral joints (26).

Ultrasounds intervene through the attenuation of the inflammatory process, by potentiating the repair phase and having a role in healing (14). This procedure may be a conservative therapeutic option in the treatment of the knee osteoarthritis (27, 28).

The low back pain is a suffering of the lower axial lumbosacral segment caused by the musculo-ligamentous imbalance and static behavior not adapted to the daily needs.

The optimal frequency for ultrasound therapy is 1 MHz because at high frequency, the energy is largely absorbed on the surface and it does not reach the depth, whereas at low frequency ultrasounds penetrate deeply, but with great energy dissipation.

The best results for the body are obtained for values of the intensity of the ultrasound between 0.1-0.8 W /cm² (1). The deficitary posture in childhood and adolescence is accompanied by frequent pain at the level of the dorsal and lumbar spine, with a higher incidence of dorsalgia during the growth period (29).

The lack of physical activity, the sedentary lifestyle, carrying a heavy schoolbag, the endocrine and metabolic disorders in adolescence, the improper nutrition are factors that can aggravate the vertebral static disorders, with consequences in adulthood, respectively back pain (30). The low back pain is felt by the occurrence of muscular contractions and by issues in the propagation of the nerve pulse. Calcium and magnesium ions play a vital role as they are necessary for the determination of the total calcium and magnesium in the serum (32,33). In low back pain, ultrasounds were used for analgesic, myorelaxing and hyperemic effect (34). The purpose of the survey is to evaluate / identify the effects of using ultrasounds in the treatment of musculoskeletal conditions (lumbar discopathy), knee osteoarthritis).

Material and method

The survey was conducted on an outpatient basis in a period of 7 months and it is of the longitudinal type. It included 151 patients diagnosed with low back pain and knee osteoarthritis. The inclusion criteria in the study were: the age over 35, algic and functional symptoms determined clinically and radiologically, in the lower area and in the knees, without comorbidities, patients who agreed to participate in the survey.

The exclusion criteria were: the age below 35, suggestive symptoms of neurological disorders, physiotherapy treatment in the past 5 months, dermatologic diseases, epilepsy, decompensated chronic conditions, neuropsychiatric disorders, non-cooperating patients.

The patients who accepted to participate in the survey and to which were applied ultrasounds were divided into two groups:

- a group of patients diagnosed with low back pain
- a group of patients diagnosed with knee osteoarthritis

All the patients also made physiotherapy.

The evaluation of all the patients was made at the beginning of the treatment, 2 weeks after the beginning of the treatment and at the control, 5 weeks after the end of the application therapy. The demographic variables were registered (age, sex, height) and the body weight. The evaluated parameters were: pain, functional skills, articular rigidity and the quality of life.

The pain was evaluated by using the VAS scale (values between 0 = no pain and 10 = unbearable pain) and the subscale of pain in the WOMAC Index (it contains 5 questions, the score between 0 = no pain and 20 = maximum pain).

In order to evaluate the functional skills, the subscales were used: rigidity (2 questions, value 0 = no rigidity and 8 = maximum rigidity) and the physical function (17 questions, scor 0 = normal, scor 68- severe functional limitation) for knee osteoarthritis and the Roland-Morris Disability Assessment Questionnaire for the low back pain (the minimum score is 0 = no disability and the maximum score is 24 = disability). In order to evaluate the quality of life, was used Quality of life QOL scale (with 16 questions, score 16 = "unhappy" and score 112 = "delighted").

The demographic variables were registered (age, sex, height) and the body weight).

The equipment used for the ultrasounds was Chattanooga Intellect Mobile Ultrasound that produces ultrasound with the frequency of 1 MHz.

This was the chosen frequency because it is known the fact that there is a connection between energy absorption and application frequency.

Thus, at high frequency, the energy is absorbed especially on the surface and it does not reach the target area whereas at the too low frequency, the ultrasounds reach deeply with energy dissipation along the way.

The intensity of the ultrasounds used in the survey was $0.6W / cm^2$, in a pulsed way, a dynamic method for 5 minutes, daily use for 2 weeks, by using a gel with therapeutic properties (non-steroidal anti-inflammatory for the topical administration).

It was not allowed the topical administration of another anti-inflammatory, the tegument was always cleaned with alcohol before the beginning of the procedure.

The kinesiotherapy program for the low back pain lasted for 30 minutes a session and monitored the muscle relaxation in the subacute phase, and toning the paravertebral muscles and the psoas-iliacus muscle.

In the chronic phase the emphasis was on toning the paravertebral muscles and the abdominal ones, by using Williams method. The objectives were: to reduce pain, to improve the functional skills, to increase the force for the abdominal muscles and for the paravertebral ones, to improve the quality of life. The kinesiotherapy program for knee osteoarthritis lasted for 30 minutes a session and included passive, active mobilizations and active with resistance, as well as coordination and balance exercises, useful in the recovery of the posture and gait. The objectives were: to decrease the pain, to improve the functional skills, to increase the force for the abdominal muscles and for the paravertebral ones, to increase stability, to recover the static and dynamic balance for the posture and gait, to improve the quality of life.

Demographic data

The group of patients diagnosed with low back pain included 78 patients, among which 40 (51.29%) were female and 38 (48.71%) were males, whereas the group of patients diagnosed with knee osteoarthritis included 73 patients among which 36 (49.31%) were female and 37 (50.69%) were males. The data were registered in Table no. 1.

It is found that most of the patients were in the age group of 35-49 years and 50-64 in the group with low back pain whereas in the group with knee osteoarthritis in the age group of 50-64 years and over 65 years. The variables and measurement time were identical in both groups.

Statistical analysis

The collected data were entered in the Microsoft Excel program and were calculated: the minimum, maximum and average values, the standard deviation.

In order to compare the average values of the quantity variables was used the "t-student" test to see if the hypothesis was confirmed.

Results

The pain decreased by 28.57% 2 weeks after the beginning of the treatment and 5 weeks after the completion of the therapeutic interventions, for both groups. From the beginning of the treatment until the control 7 weeks later, the pain improved by 57.14 % in both study groups. The functional skills that enable the daily activities were evaluated with the help of Roland Morris questionnaire, they improved 2 weeks after the beginning of the treatment and 5 weeks after the completion of the treatment with 14.28% in the group with low back pain.

In the group with knee osteoarthritis, the increase in the functional skills, evaluated with the help of WOMAC subscale, was of 33.33% 2 weeks after the beginning of the treatment and of 16.66% 5 weeks after the completion of the treatment.

From the beginning of the treatment until the control 7 weeks later, the functional skills improved by 28.57% in the patients with low back pain and by 50% in the patients with knee osteoarthritis.

Two weeks after the beginning of the treatment and five weeks after the completion of the therapeutic interventions, the group with knee osteoarthritis registered a decrease in the stiffness of the joints by 28.57%, and then, from the beginning of the treatment until the control 7 weeks later, the decrease was of 57.14%

The quality of life, another important parameter, increased 2 weeks after the beginning of the treatment by 11.49% in the group with low back pain and by 13.79% in the group with knee osteoarthritis.

Two weeks after the beginning of the treatment and 7 weeks after the completion of the treatment, the quality of life improved by 13.79% in the group with low back pain and by 21.83% in the group with knee osteoarthritis.

From the beginning of the treatment until the control 7 weeks later, the quality of life increased by 25.28 % in the group with low back pain and by 35.63% in the group with knee osteoarthritis (Table no. 2).

Discussions

The effects of the use of ultrasounds is found in the decrease of pain, the stiffness of the joints and the contracture of the muscles, as shown by the results of several surveys. (8) The method of using therapeutic ultrasounds is non- invasive, it is produced by sound waves, it has no side effects and it can be used in the recovery treatment. The effects of the use of ultrasounds in the pulsed way enabled the decrease of the inflammation, the relaxation of the muscles, the regeneration of the tissues, then the obtained results were similar to those in the specialty literature (9, 26). Sonophoresis favors the absorption in the skin of an inflammatory applied topically to the deep tissues, by influencing inflammation and by decreasing pain (14). The current survey proved that the use of the therapeutic ultrasounds is a safe treatment to decrease the pain and the rigidity of the joints, as well as to improve the physical activities of patients with KOA, results confirmed by the survey of Wu (15). The therapeutic use of the ultrasounds enabled the decrease of the pain and rigidity, the improvement of the functional skills in patients with knee osteoarthritis, which is confirmed by a systematic review and a meta-analysis published in 2019 (15), but also in other surveys (12, 19, 35-37). Our survey proves that the use of ultrasounds decreases pain and increases the functional skills, it influences the physical function more obviously in patients with knee osteoarthritis, which is an aspect found in others surveys (19). Even if there is evidence to support the nonpharmacological options for the treatment of knee osteoarthritis, the survey of Selten (38) suggests that these therapies are still unused. The therapeutic ultrasounds were used as a non-pharmacological option in the recovery treatment in our survey. They are useful for the management of pain, for the influence on the physical function (12,15,39,40), for the improvement of the functional skills, for the healing of soft tissues, results found in other surveys (12,41).

The surveys of Cochrane (42) show that ultrasounds have an important role in the patellar syndrome and knee osteoarthritis, acting on the biomolecules. In our survey we used low intensity ultrasounds ($0.6W/cm^2$) and we obtained the expected biological effects, as shown by the specialty literature. The survey of Ahmadi (43) points out that the biological effects of the ultrasounds are obtained when using low intensities. The use of a complex ultrasound treatment (in the pulsed way to avoid thermal effects) and kinesiotherapy enabled in our research the decrease of the pain and of the rigidity in the joints, the increase of the functional skills and the quality of life, whereas these obtained results are in accordance with those of others surveys (44). DURMUS (45) in his survey communicated the results of a survey in which he shows the role of using ultrasounds and pharmacological therapy, together with the physical exercises in order to decrease pain and

disability, to improve mobility and the quality of life for the people diagnosed with low back pain (46-52).

The limitations of the current survey are given by the relatively small number of patients included in the study. It is necessary to make clinical surveys on long periods in order to verify the persistence of the effects of the ultrasound therapy for the clinical and functional improvement of patients diagnosed with osteoarticular diseases.

Conclusions

The use of the therapeutic ultrasounds can have the following effects: the decrease of the pain and of the joint rigidity, the improvement of the physical capacity for daily activities and the improvement of the quality of life. The use of low intensity ultrasounds can determine biological effects with actions for a short period or for an average one. The statistically significant results were obtained after the use of the ultrasound therapy in knee osteoarthritis.

It is important to combine ultrasounds and kinesiotherapy in the management of the osteoarticular diseases.

Author contributions.

All the authors had the same contribution

Conflict of interest.

The authors declared no conflicting interest

Accordance to ethics standards.

The study complies with the rules of ethics and deontology according to the legislation in force.

Table no. 1. Distribution of patients in the two groups.

Variable	LBP group		KOA group	
	Baseline (mean, SD)(95% CI)		Baseline (mean, SD) (95% CI)	
Age (years)	52 ± 11.36 (35 to 75)		62 ± 12.27 (35 to 78)	
	Female	Male	Female	Male
35-49 years	15	18	10	10
50-64 years	16	14	13	12
> 65 years	7	8	13	15

Table no. 2. Evolution parameters evaluated for the 2 groups

VARIABLE	Baseline (mean, sd) (95% ci)	10 wk (mean, sd) (95% ci)	p - value *	Baseline (mean, sd) (95% ci)	20 wk (mean, sd) (95% ci)	p - value *
LBP group						
VAS	7 ± 1.61 (4 to 10)	5 ± 1.24 (2 to 7)	0.0229	7 ± 1.61 (4 to 10)	3 ± 0.63 (1 to 4)	0.0496
Roland-Morris	14 ± 2.13 (11 to 17)	12 ± 1.67 (9 to 15)	0.0042	14 ± 2.13 (11 to 17)	10 ± 2.11 (10 to 13)	0.0018
QOL	65 ± 6.43 (50 to 70)	75 ± 7.56 (56 to 80)	0.0032	65 ± 6.43 (50 to 70)	87 ± 11.98 (62 to 90)	0.0039
KOAgroup						
VAS scale	7 ± 1.59 (3 to 9)	3 ± 0.77 (2 to 6)	0.0231	7 ± 1.59 (3 to 9)	3 ± 0.77 (1 to 4)	0.0442
WOMAC pain	14 ± 1.04 (13 to 16)	10 ± 0.16 (10 to 11)	0.0154	14 ± 1.04 (13 to 16)	6 ± 0.56 (4 to 6)	0.0314
WOMAC stiffness	7 ± 0.49 (6 to 7)	5 ± 0.47 (4 to 5)	0.0157	7 ± 0.49 (6 to 7)	3 ± 0.49 (2 to 3)	0.0361
WOMAC daily activities	30 ± 10.31 (30 to 60)	20 ± 7.74 (15 to 40)	0.0452	30 ± 10.31 (30 to 60)	15 ± 2.69 (10 to 19)	0.0372
QOL	56 ± 7.54 (40 to 65)	68 ± 7.17 (50 to 75)	0.0059	56 ± 7.54 (40 to 65)	87 ± 11.68 (62 to 90)	0.0099

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