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Chapter 13

Effect of Nonpharmacological Therapies on Pain and Health Perception in Patients with Knee Osteoarthritis

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Additional information is available at the end of the chapter

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Abstract

Objective: Comparing the efficiency of ultrasound therapy (US) versus extracorporeal shock wave therapy (ESWT) on pain and perceived health in men with bilateral knee osteoarthritis (OA). **Design**: A pilot randomized trial with concealed allocation, assessor blinding and intention-to-treat analysis was conducted.

Participants: 60 men, 44–66 years old were randomized to an experimental (US) and a control (ESWT) group. **Intervention:** The participants in both groups attended 5-week treatments. The experimental group received continuous US and a series of 10 treatments two times per week. The control group received 5 ESWT treatments once per week. **Outcome measures:** The primary outcome was visual analogue scale (VAS) pain ratings. The secondary outcome measured perceived health using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The examinations were taken before and after the treatment. **Results:** After 5-week treatment the experimental group had significantly worse scores than the control group on the VAS for pain, and on the WOMAC for perceived health. **Conclusion:** Patients with knee OA can achieve significant better health benefits caused by ESWT than by US.

Keywords: ultrasound, extracorporeal shock wave therapy, pain, perceived health, randomized trial

1. Introduction

Osteoarthritis (OA) is a chronic and degenerative disease and is considered to be one of the most common musculoskeletal disorders. Joints found in our body can be affected by OA. All

the patients with OA have almost the same symptoms, including pain, stiffness, articular instability, limitation of motion and physical activity, and muscle weakness [1, 2]. Physiotherapy is one of the treatments that provides effective nonpharmacological interventions for people with knee OA, and procedures prescribed by physiotherapists are considered to be important and to play a fundamental role in patients' treatment. The most common types of electrotherapy are ultrasound (US), transcutaneous electrical nerve stimulation (TENS), and now more often appearing extracorporeal shock wave therapy (ESWT). US, as a noninvasive treatment is used to create a controlled, microtrauma to local affected tissue in order to stimulate a healing response and microvascularization [3, 4]. The first use of ESWT was not for musculoskeletal disorders but to break up kidney stones. It was a coincident that someone noticed an osteoblastic response pattern during studies at animals in the 1980s [5]. Recently, ESWT has been used for pain relief and musculoskeletal disorders' treatment. It turned out that ESWT is also a noninvasive treatment, and the effectiveness of this method is comparable to surgery. It has not yet been fully explained how it exactly works, but it probably involves microdestructions—the application of ESWT causes microbreaks in avascular or poorly vascularized tissue, thus stimulating appropriate revascularization and stem cell growth. It also induces the release of enzymes, which affect nociceptors, resulting in localized analgesia, giving the significant reduction of activity limitations and short duration of the treatment [6].

Despite the advances in the treatment, there is lack of comparative studies on the effects of US and ESWT in patients with knee OA. Therefore, the purpose of this study was to evaluate the effects of US versus ESWT protocol on pain measured by visual analogue scale (VAS), and on perceived health measured by WOMAC [7, 8] in men suffering from bilateral knee OA.

In our study we took hypothesis: there are differences between US and ESWT in reducing of pain, and improving perceived health in men suffering from bilateral knee OA.

Therefore the research question was

1. Is US more effective than ESWT on pain and perceived health in men with bilateral knee OA?

2. Method

2.1. Design

It was a randomized trial with concealed allocation, assessor blinding, and intention-to-treat analysis. The participants with knee OA were assessed for eligibility by an independent physician who was not involved into the study. The randomization into an experimental group (US) and a control group (ESWT) with a 1:1 ratio was generated by permuted block randomization using the website www.random.org. The randomization was achieved by having the participant selected one from 60 sealed opaque envelopes, each containing a group allocation, which had been prepared and shuffled by an independent investigator who was not involved into the recruitment or assessment of the participants. The researchers responsible for assessing the outcomes and analyzing the data were blinded to the type of the treatment procedure.

To keep the assessors blinded the participants were reminded before each measurement not to reveal the nature of their treatment. The participants were considered to be unaware of the group allocation because they were informed about the existence of two intervention groups but not about the study hypothesis. The data were obtained at baseline and 5 weeks later (immediately after the intervention period).

2.2. Participants and center

The inclusion criteria for participation in the study were: minimum age of 40, not currently receiving any physical therapy treatments for the knee OA condition, medication compliance (all patients were taking glucocorticoids at the time of the study), and the diagnosis of bilateral knee OA according to the American College of Rheumatology criteria [9].

The exclusion criteria were: any rheumatic disease (with the exception of bilateral knee OA), unilateral knee OA, skin changes, neurological disorders, mental illness, cancer, endocrinology disease, or previous knee surgery.

The evaluations of this study were conducted at the Physiotherapy Outpatient Department of the Regional Hospital in Zywiec, Poland. This study was designed with respect for the rules of conducting experimental studies with humans after the approval by the Bioethical Committee at the Holycross College in Kielce, and were consistent with the Helsinki Declaration of 1975 as revised in 2000. All participants signed consent forms knowingly participation in the study.

2.3. Intervention

The participants in both groups attended 5-week treatments. The experimental group received continuous US waves: intensity, 0.8 W/cm^2; 100% fill; carrier frequency, 1 MHz. The patients received a series of 10 treatments 2 times per week. The treatments were performed using a US 13 EVO Cosmogamma (Emildue, Italy). The patients lied in a supine position. The acoustic gel, that was applied, did not contain any pharmacologically active substance. The medial and lateral parts of the knee were treated with US applied in circular movements. To ensure the best absorption of the energy the probe was put at right angles. Each treatment session did not last longer than 10 minutes. During the treatment the patients received neither any anesthetic nor other physical actions. No adverse events were observed during the treatment. The same therapist made US to all the participants.

The control group received ESWT − 1000 pulses during the first treatment, 1500 during the second and the third treatments, and 2000 during the fourth and the fifth treatments, respectively (pressure, 2.5 bar; frequency, 8 Hz; energy density, 0.4 mJ/mm^2). The patients received 5 ESWT treatments once per week. The treatments were performed using a Rosetta ESWT (CR Technology, Korea). The patients were placed in a supine position with the affected knee unbent or flexed at 90°, and an acoustic gel that did not contain any pharmacologically active substance was applied. The shockwave probe was held stationary on a trigger point around the knee or at the patellofemoral and tibiofemoral borders of the target knee, avoiding direct placement on the peroneal nerve or vessel. Each treatment session did not exceed 10 minutes. During the treatments, the patients did not receive any other physical method.

No adverse events were observed during the treatment. The same therapist made ESWT to all the participants.

All of the treatments were performed at the Physiotherapy Outpatient Department of the Regional Hospital in Zywiec, Poland. Once a week for 5 weeks, the treatments were administered by an independent researcher who was not involved into this study. The same physiotherapist with a postgraduate degree in physiotherapy and 10 years' experience provided all the interventions to both (the experimental and the control) groups, and remained blind to primary and secondary outcome measures throughout the trial. The independent researcher analyzed the results/data also being blind to all of outcome measures throughout the trial.

2.4. Outcome measures

Primary outcome: The pain was assessed using a visual analogue scale (VAS), and a Laitinen scale. VAS is a line of 10 cm, the leftmost side is 0 = no pain and the far right is 10 = unbearable pain. The participants marked the scale of their current level of pain after their usual daily activities. The values in centimeters were recorded for statistical analysis. The same therapist administrated the measurements of all the participants and was blinded to the treatment.

Secondary outcome: In order to identify a specific index of disability there was used the WOMAC as a subjective measure of perceived health. It is a questionnaire that consists of three parts of questions and can be filled in a few minutes. There were 24 questions: about pain (5 questions), about stiffness (2 questions), and about physical function (17 questions) [10, 11]. In our study, we used a more detailed Likert scale version of the WOMAC, which includes a five-point scale for patients to mark (0 = none, 1 = mild, 2 = moderate, 3 = severe, and 4 = extreme). Achieving higher score means lower level of perceived health. All the scores were summed and coded. Answering the questions the patients described their stays during the past 3 days. The same therapist made the measurements to all the participants and was blinded to the treatment.

2.5. Data analysis

A priori sample size was determined in this study, giving the anticipated Cohen's d effect size of 0.8, the probability level of 5%, and the desired statistical test power level of 80%. We estimated that we needed minimum 26 participants in each group. The data were analyzed with descriptive as mean, standard deviation (SD) of two groups, mean (SD) within-group differences, 95% CI (95% confidence interval) of mean between-group differences, and inferential techniques. The mean within-group differences and the mean between-group differences (95% CI) were calculated for each of the outcomes based on the change scores (i.e., after minus before scores). The Shapiro-Wilk test identified the nonnormal distribution of the VAS and of the WOMAC data. The mean between-group differences for data was analyzed using the Mann-Whitney U test. To describe the differences in related treatments, the effect size between-group difference was calculated using Cohen's d, and classified as small (d = 0.2), moderate (d = 0.5), and large (d = 0.8) [12]. The level of statistical significance was set at a two-tailed p-value of 0.05. The analyses were performed by a blinded and independent statistician according to a prespecified statistical analysis plan on an intention-to-treat basis [13].

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3. Results

3.1. Flow of participants through the study

A total of 75 participants that were admitted with bilateral knee OA between February and March 2016 were screened for inclusion. Fifteen patients were excluded based on the eligibility criteria. Therefore, the study reports the data of 60 participants. All of them agreed to participate and they were subsequently randomized: 30 in the experimental group (US) and 30 in the control group (ESWT), as presented in **Figure 1**. The baseline characteristics of participants are shown in **Table 1** and in the first two columns of data in **Table 2** and **Table 3**. No important differences in these characteristics were noted between the experimental and control groups.

3.2. Compliance with the study protocol

During the treatments the patients did not receive any anesthetic or any other physical actions. No participants received the wrong intervention. No adverse events were observed during the treatment. All the participants were analyzed in the group to which they had been randomly allocated.

3.3. Effect of intervention

Primary outcome: After the intervention in both, the experimental (US) and the control (ESWT), groups reduce of pain severity on VAS were identified. Pain severity decreased in the right knee, as well as in the left knee by the mean of 3 cm (±1) in the US group, whereas the ESWT group decreased in the right knee by the mean of 4 cm (±2), and in the left knee by the mean of 5 cm (±2). The significant between-group differences on the VAS score in the right knee and the left one were found. The ESWT group had lower score of pain severity on the VAS in the right and the left knees, by the mean of 2 cm (95% CI 1–3, $p < 0.001$, Cohen d = 0.63), and (95% CI 1–3, $p < 0.000$, Cohen d = 1.26), respectively. The effect size for pain on VAS was medium in the right knee and large in the left one, as presented in **Table 1**.

Secondary outcome: Regarding secondary outcomes, after the intervention in both, the experimental (US) and the control (ESWT), groups improvement of perceived health on WOMAC were identified. The domain "pain" (P) improved by the mean of 4 points (±2), the domain "stiffness" (ST) improved by the mean of 2 points (±2), the domain "physical function" (PF) improved by the mean of 17 points (±10), and the total score on WOMAC improved by the mean of 22 points (±11) in the US group. The ESWT group improved domain P by the mean of 10 points (±4), improved domain ST by the mean of 5 points (±1), improved domain PF by the mean of 29 points (±17), and improved the total score on WOMAC by the mean of 43 points (±20). The significant between-group differences were found. The ESWT group had better scores on the WOMAC for the domain P, by the mean of 6 points (95% CI 3–9, $p < 0.000$, Cohen d = 1.90), for domain ST, by the mean of 3 points (95% CI 2–5, $p = 0.002$, Cohen d = 1.90), for domain PF, by the mean of 12 points (95% CI 1–22, $p = 0.001$, Cohen d = 0.86). Consequently, a significant between-group difference on WOMAC was identified for total score of perceived health, with the mean of 20 points (95% CI 7 to 33, $p = 0.002$, Cohen d = 1.30) in favor for the

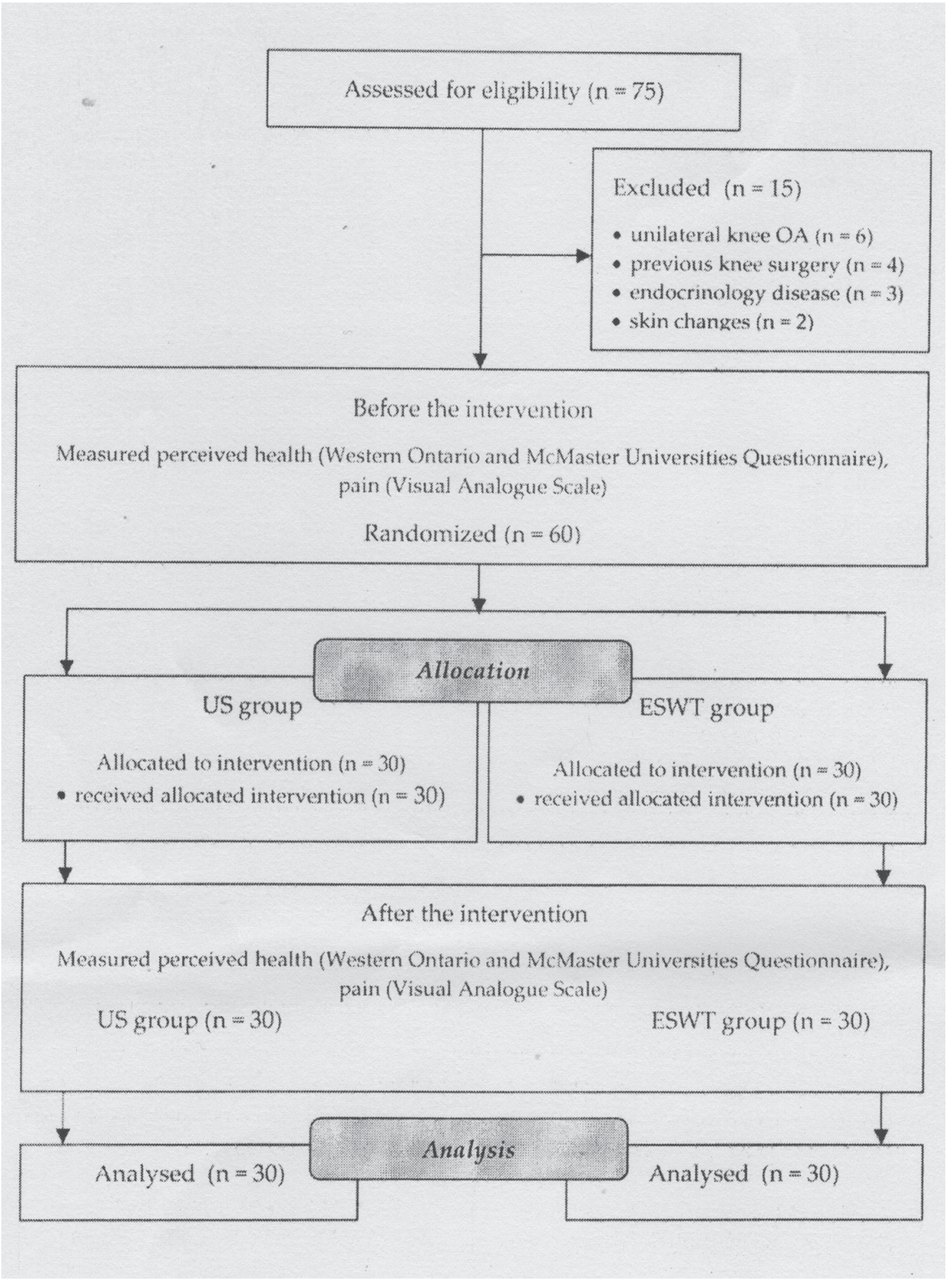

Figure 1. Recruitment and flow of participants through the trial.

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Characteristic	Group Exp (n = 30)	Group Con (n = 30)
Age (yr) mean (SD)	55.2 (6.3)	55.8 (5.8)
Height (m) mean (SD)	1.75 (0.06)	1.77 (0.05)
Mass (kg) mean (SD)	74.5 (3.9)	75.8 (3.6)
BMI (kg/m^2) mean (SD)	24.15 (0.95)	24.35 (0.90)
Obese patients yes/no (n)	0/15	0/15
Level of education (n):		
Primary school graduates	3	5
Secondary school graduates	7	6
University graduates	5	4
Occupation:		
Physical worker/white-collar worker (n)	10/5	8/7
Duration of work (yr) mean (SD)	19.8 (6.1)	21.8 (5.6)
Duration of symptoms (yr) mean (SD)	8.9 (1.7)	8.3 (1.1)

Exp = ultrasound, US; Con = extracorporeal shock wave therapy (ESWT).

Table 1. Characteristics of the participants.

ESWT group. The effect size was large for perceived health on WOMAC, as presented in **Table 1**.

All of the outcomes show that greater reduce of pain severity leads to the better perceived health, which promotes generally better quality of life in the participants from the ESWT group than in the participants from the US group, as presented in **Tables 2** and **3**.

4. Discussion

A number of researches considered several aspects related to muscle function, such as strength and aerobic capacity as well as other clinical aspects, such as pain, stiffness, range of motion of the knee, and WOMAC in patients with OA [14–20].

Pain is one of the most common complaints and disability symptoms in patients with knee OA. The positive effects of nonpharmacologic management on knee pain and health status in OA patients were examined. Mascarin et al. [4] studied 40 patients and compared the TENS protocol with the US protocol. The TENS was applied using a frequency of 100 Hz, pulse width of 50 μs, intensity (mA) set at the individual subject's sensorial threshold, modulation up to 50% of variation frequency, quadratic biphasic symmetrical pulse and a length of application of 20 minutes. The US protocol consisted of continuous ultrasonic waves of 1

	Groups				Difference within groups		Difference between groups		
	Before		After		After–Before		After–Before		
	Exp (n = 30)	Con (n = 30)	Exp (n = 30)	Con (n = 30)	Exp (n = 30)	Con (n = 30)	Exp (n = 30)–Con (n = 30)	*p*	Effect size *(Cohen's d)*
VAS									
Right knee	6	6	3	2	–3	–4	2	0.001	0.63
	(1)	(2)	(1)	(2)	(1)	(2)	(1–3)		
Left knee	6	6	3	1	–3	–5	2	0.000	1.26
	(1)	(2)	(1)	(1)	(1)	(2)	(1–3)		

Exp = ultrasound, US; Con = extracorporeal shock wave therapy (ESWT); VAS = visual analogue scale.

Table 2. Mean (SD) of the groups, mean (SD) differences within the groups, and mean (95% CI) differences between the groups for VAS (in cm) outcomes.

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	Groups				Difference within groups		Difference between groups		
	Before		After		After–Before		After–Before		
	Exp (n = 30)	Con (n = 30)	Exp (n = 30)	Con (n = 30)	Exp (n = 30)	Con (n = 30)	Exp (n = 30)–Con (n = 30)	*p*	Effect size *(Cohen's d)*
WOMAC									
P	14	14	10	4	–4	–10	6	0.000	1.90
	(4)	(5)	(5)	(2)	(2)	(4)	(3–9)		
ST	7	7	5	2	–2	–5	3	0.002	1.90
	(1)	(2)	(3)	(1)	(2)	(1)	(2–5)		
PF	52	52	34	23	–17	–29	12	0.001	0.86
	(14)	(18)	(15)	(13)	(10)	(17)	(1–22)		
Total	72	73	50	29	–22	–43	20	0.002	1.30
	(18)	(23)	(21)	(15)	(11)	(20)	(7–33)		

Exp = ultrasound, US; Con = extracorporeal shock wave therapy (ESWT); WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index; *P* = pain; *ST* = stiffness; *PF* = physical function.

Table 3. Mean (SD) of the groups, mean (SD) differences within the groups, and mean (95% CI) differences between the groups for WOMAC (in points) outcomes.

wMHz frequency and 0.8 W/cm^2 power, applied with a 5-cm diameter applicator. The study results showed that TENS, as well as US, are effective for reducing pain and improving the WOMAC score. Ng et al. [21] studied 24 patients and compared electroacupuncture treatment and TENS, using the same parameters for both (low frequency = 2 Hz, continuous mode, pulsation of 200 μs for 20 minutes of application) and showed that either electroacupuncture treatment or TENS is effective in pain reduction because a prolonged analgesic effect maintained in the two groups.

Recently, ESWT has become one of the leading therapeutic alternatives. It can treat such diseases as chronic tendinopathies, nonunion of long bone fracture, and early stage of avascular necrosis of the formal head [22]. Moreover, ESWT diffused to the treatment of OA in animals [23, 24]. It improved the rats' walking ability [23]. It significantly improved the lameness degree in horses [24].

The results achieved in people only confirm these findings. Zhao et al. [25] used ESWT to treat knee OA over 12 weeks and compared it with placebo treatment. Seventy patients were randomized to receive either placebo (n = 36) or ESWT (n = 34). In the ESWT group, the patients received 4000 pulses of shockwave at 0.25 mJ/mm^2 a week during 4 weeks. In the placebo group, the patients got shockwave at 0 mJ/mm^2 in the same area for the same time. The authors found the effect on OA by pain on VAS and perceived of health on WOMAC. The evaluation was performed at baseline and after 1, 4, and 12 weeks. The authors found that ESWT was more effective than placebo in reducing pain and improving perceived of health at each time assessment of the research.

In our study following 5 weeks of the treatment the results were similar to the results of the other authors, although we applied another treatment protocol. We found that pain in knees decreased in both the experimental (US) and the control (ESWT) groups, but there were the significant between-group differences after the intervention in favor for ESWT, and also the effects sizes were always more far-reaching in the patients treated with ESWT, than those ones in the patients treated with US. In this study, we also found that both treatment methods improved the total score of WOMAC, but the health benefits in the patients treated with ESWT and their effect size were also more important than those ones in the patients from the US group.

Our study had as strengths as limitations. The strengths included the fact that the study was analyzed using the intention-to-treat principle, the patients were randomly assigned to the two groups—an experimental and a control one. The interventions were provided by the same blinded to outcome measures experienced physiotherapist. Also, they were administered by the same assistant, blind to the group allocation.

The major limitation was the short follow-up period. Therefore, the future study ought to be a minimal follow up of 1–2 years for all subjects, it would significantly increase the impact of this kind of the study, unfortunately we had no chances to prolong the study. The second limitation is the small sample size. Our findings are therefore to be read as preliminary ones in view of possible future long-term studies with a larger sample size to confirm these results

and assess the impact of US and ESWT on pain and on perceived health in people suffering from knee OA.

5. Conclusion

Despite all the limitations of this study, the obtained results may be valuable for doctors, physiotherapists, and patients with knee OA in choosing the most appropriate types of treatment based on the patients' preference and convenience. Among the people, who were treated for knee OA, ESWT led to greater benefits in reduce pain and perception of health, than a protocol which included US.

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