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The efficacy of short wave diathermy in decreasing knee pain in female patients with knee osteoarthritis

Disciplines

Physical Therapy

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Laurel Charbonneau

CRITICALLY APPRAISED TOPIC

Title: The efficacy of short wave diathermy in decreasing knee pain in female patients with knee osteoarthritis.

Clinical Scenario: A female patient in her mid 80s was admitted to a skilled nursing facility due to a non-displaced acetabular fracture following a fall. She was referred to physical therapy to address her functional mobility deficits but was having difficulty participating in therapy due to increased left knee pain caused by osteoarthritis (OA). Diathermy is used throughout the skilled nursing facility, and it was suggested by the occupational therapist that I could use this modality to reduce our patient's knee pain so she could better participate in therapy.

Brief introduction: The goal of this paper is to examine whether using diathermy is an effective use of the patient's therapy time and if it would be effective for reducing the knee pain caused by OA. Diathermy was first used therapeutically in 1892 and became popular in the United States in the 1930's for its ability to treat infections. It fell out of favor in the 1950's due to the availability of antibiotics, and because of the potential hazard to the patient and operator (Cameron, 2009). Currently, use of diathermy in clinics is on the rise due to improved technology. It is being used for its thermal effects and ability to access a larger/deeper area than ultrasound/hot packs, and for its non-thermal effects to aid in soft tissue healing (Cameron, 2009). Diathermy uses shortwaves of about 1.8 to 30MHz frequency and 3 to 200 meter wavelength to produce deep heat and changes within the tissues including vasodilation, elevation of pain threshold, increased tissue extensibility and increased enzymatic activity (Cameron, 2009). To provide non-thermal effects, a low duty cycle is used that allows heat to diffuse within the tissues. Proposed non-thermal effects within the tissue include modification of ion binding, increased microvascular perfusion and altered cellular function and activity. One of the proposed clinical uses of diathermy is for knee osteoarthritis (Fukada, 2011). Diathermy is contraindicated if there is a transcutaneous neural stimulator, including cardiac pacemaker, or the individual is pregnant. Contraindications for thermal level diathermy include metal implants, malignancy, and over eyes, testes or growing epiphyses. Non-thermal pulsed diathermy is contraindicated over deep tissues such as organs. Possible effects of pulsed shortwave diathermy (PSWD) for knee OA include decreasing inflammation and improving ROM, pain, stiffness, functional ability, mobility and synovial thickness (Cameron, 2009). Diathermy is also proposed as a treatment for edema, nerve healing, bone healing, ischemic skin flaps, cerebellar disease, and myocardial disease (Cameron, 2009). However, the efficacy of diathermy remains controversial, especially in people with knee OA (Fukada, 2011).

My Clinical question: Is diathermy effective for reducing pain for a patient with knee osteoarthritis?

Clinical Question PICO:

Population – Female, over 65 years old, with knee osteoarthritis

Intervention – Pulsed short wave diathermy applied as a part of physical therapy treatment

Comparison – Physical therapy treatment including therapeutic exercise and knee functional mobility training

Outcome – Pain as measured by patient reporting on the visual analog scale (VAS)

Overall Clinical Bottom Line:

There was conflicting evidence between the two articles analyzed. Fukada *et al.* revealed that PSWD used alone, especially low dose as compared to high dose, is effective for reducing pain in older adult patients with knee osteoarthritis compared to sham PSWD. A number needed to treat (NNT) of 2-3 was determined for PSWD to result in one additional person meeting the MCID for pain compared to the control or placebo groups. Atamaz *et al.* did not find a significant difference in pain scores between the SWD plus exercise group and a sham SWD plus exercise group. Both groups made statistically significant and clinically meaningful changes in pain. Because both groups received exercise, it is unknown if similar gains may be made with exercise alone, or if the sham SWD had a placebo effect. A comparison group that received exercise only would be needed to make this determination. They did, however, find a significant decrease in the amount of pain medication used in the SWD group compared to the sham group, which may suggest that diathermy is effective for decreasing pain. Both studies had strong internal validity, and good methodological quality, but the results should be cautiously applied to larger populations due to strict inclusion and exclusion criteria. Areas for further research include a study directly comparing an exercise control group, a placebo/sham group and a diathermy treatment group to truly assess if diathermy is more effective than activity and exercise for reducing pain caused by knee osteoarthritis.

Search Terms: Diathermy, pulsed short wave diathermy, skilled nursing facility, older adults, pain, knee osteoarthritis, randomized control trial

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Rationale for your chosen articles

Medline, CINAHL, Google, Google Scholar, and PubMed were used to find articles to answer the clinical question. Search terms that yielded relevant articles included diathermy, knee osteoarthritis, and randomized control trial. After finding four articles that pertained to the topic, the article PICO was compared to the clinical PICO and the studies were examined for methodological quality. The articles listed below closely matched the clinical PICO and were found to have relatively high PEDro scores (Table 1).

Table 1. Comparison of PEDro Scores; taken from pedro.org.au

	Fukada <i>et al.</i>	Atamaz <i>et al.</i>	Laufer <i>et al.</i>
Random	Yes	Yes	No
Concealed allocation	Yes	Yes	No
Baseline comparability	Yes	Yes	Yes
Blind Subjects	Yes	Yes	Yes
Blind Therapists	No	No	No
Blind Assessors	Yes	Yes	Yes
Adequate Follow-up	Yes	Yes	Yes
Intention-to-Treat	Yes	Yes	No
Between Group	Yes	Yes	Yes
Point Estimates & Variability	Yes	Yes	Yes
Total Score	9/10	9/10	6/10

(1) Fukuda TY, Alves da Cunha R, Fukuda VO, Rienzo FA, Cazarini C, Carvalho NAA, Centini AA. Pulsed shortwave treatment in women with knee osteoarthritis: a multicenter, randomized, placebo-controlled clinical trial. *Physical Therapy* 2011; 91(7):1009-1017.

PEDro Score: 9/10

Population: 121 women with a mean age of 60 ± 9 years old, with a diagnosis of knee osteoarthritis

Intervention: Low dose pulsed shortwave diathermy (PSWD) and high dose PSWD, and the advice to stay active

Comparison: Placebo PSWD treatment and a control group who just received the advice to stay active

Outcome measures: An 11 point numerical pain rating scale and the Knee Osteoarthritis Outcome Score (KOOS) measured pretreatment, immediately after the three weeks of treatment, and 12 months after treatment

(2) Atamaz FC, Durmaz B, Baydar M, Demircioglu OY, Iliyapici A, Kuran B, Oncel S, Sendur OF. Comparison of the efficacy of transcutaneous electrical stimulation, interferential currents, and shortwave diathermy in knee osteoarthritis: a double-blind, randomized controlled, multicenter study. *Archives of Physical Medicine and Rehabilitation* 2012; 93(5):748-756.

PEDro: 9/10

Population: Two hundred and three patients aged 50-80 years old with knee osteoarthritis

Intervention: Three groups receiving transcutaneous electrical stimulation (TENS), interferential currents (IFC), and shortwave diathermy (SWD)

Comparison: Sham TENS, IFC and SWD treatment groups, who also received exercise and education

Outcome measures: Visual Analog Scale (0-100mm), time to walk 15m, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Nottingham Health Profile, and paracetamol intake in grams, at 1 month, 3 months, and 6 months from baseline

(3) Laufer Y, Ziberman R, Poat R, Nahir AM. Effect of pulsed short-wave diathermy on pain and function of subjects with osteoarthritis of the knee: a placebo-controlled double blind clinical trial. *Clinical Rehabilitation* 2005; 19:255-263.

PEDro: 6/10

Population: One hundred and three patients with mean age of 73.7 ± 6 years old, with knee osteoarthritis for at least three months.

Intervention: Pulsed SWD with a mean power of 18W for thermal effect, and 1.8W for a-thermal effect.

Comparison: Sham SWD

Outcome measures: WOMAC Osteoarthritis Index, Timed Up and Go (TUG), stair climbing, stair descending, and a 3-minute walk test, measured at the end of the three week treatment and 12 weeks post treatment.

The study by Fukada *et al.* does not directly compare PSWD to exercise, but examines the overall efficacy of the modality for decreasing pain as compared to a placebo and control group who were told to maintain their normal activity levels. While the study does not match the PICO exactly due to the different comparison groups and a slightly younger population, the study has strong methodological quality with a PEDro score of 9/10 and directly addressed the question of whether PSW diathermy is effective for decreasing pain. The study conducted by Atamaz *et al.* includes a population that is also slightly younger than the clinical population and includes other treatment groups that do not pertain to the clinical question. However, the study did directly compare SWD to exercise, and the outcome measures are very similar to the outcome of interest. The study has a high PEDro score, 9/10, representing a stronger study design. The study by Laufer *et al.* had a lower PEDro score, is the oldest date of publication, and the article PICO did not closely match the clinical PICO. The comparison group did not include exercise or advice to stay active, and the outcome measures did not include patient reporting on the VAS or other pain scale. Based on the reasons listed above the studies performed by Fukada *et al.* and Atamaz *et al.* were selected to answer the clinical question in regards to the efficacy of diathermy to decrease knee OA pain.

Article: Fukuda TY, Alves da Cunha R, Fukuda VO, Rienzo FA, Cazarini C, Carvalho NAA, Centini AA. Pulsed shortwave treatment in women with knee osteoarthritis: a multicenter, randomized, placebo-controlled clinical trial. *Physical Therapy* 2011; 91(7):1009-1017

Clinical Bottom Line: According to Fukuda *et al.* there is moderate evidence to suggest that both high and low dose pulsed shortwave diathermy, compared to a placebo or a control, is an effective way to decrease pain caused by knee OA in adult females. Using the NPRS scores, there were statistically significant and clinically meaningful decreases in pain scores following 3 weeks (9 sessions) of intervention. Seventy five percent of the low dose PSWD group achieved the minimum clinically important difference (MCID) of two points on the NPRS scale where as only 15% of the placebo group and the control group met the MCID. This results in a number needed to treat (NNT) of two people, meaning that two people would need to be treated with low dose PSWD to have one additional person meet the MCID. The high dose PSWD group had 50% meet the MCID, resulting in a number needed to treat of three, compared to the placebo or control group. The study had good internal validity. There is a relatively low cost to use PSWD if there is already a machine present, and the risk to the patient is very low if all contraindications and precautions are followed. The external validity was fair, and given the strict inclusion/exclusion criteria the results should cautiously be applied to a wider population.

Article PICO:

Population: One hundred twenty-one women with a mean age of 60 ± 9 years old, with a diagnosis of knee osteoarthritis

Intervention: Low dose pulsed shortwave diathermy (PSWD) or high dose PSWD, and the advice to stay active

Comparison: Placebo PSWD treatment and a control group who both received the advice to stay active

Outcome measures: An 11 point numerical pain rating scale (0-10), measured pretreatment, immediately after the three weeks of treatment, and 12 months after treatment

Blinding: The examiner was blinded to group assignment and was responsible for pre-treatment and post-treatment evaluations. Patients were also blinded, however the physical therapists performing the treatment were not blinded.

Controls: There was a true control group of 35 individuals included in this study. They did not receive any treatment. There was also a placebo group included. The placebo group had the machine positioned but placed in standby mode for 19 minutes. All groups included in the study were instructed to remain active. The control group had

less contact time with therapists and researchers in the study as compared to the placebo and two treatment groups. Otherwise the groups were treated similarly.

Randomization: The 121 participants were randomly assigned to one of the four treatment groups. Assignment was concealed using sealed opaque envelopes and an individual who was not involved in the study assigned participants a group. Randomization was successful as there were no differences between the groups at baseline ($p>0.05$).

Study: The authors of the article utilized a prospective, randomized, placebo-controlled, multicenter study design. The study took place at University of Sao Paulo Medical School in Brazil between August of 2006 and December of 2008. One hundred twenty-one women met the inclusion criteria of being over 40 years old, having primary grade II or III knee OA based on Gupta and colleagues' radiographic criteria, and had joint or anterior knee pain for at least three months. Participants were excluded if they had knee surgery or any other invasive procedure that affected the knee, physical therapy for knee injuries, any medication that had changed within the last 3 months, any other diseases affecting function, or patients who presented with any of the contraindications for PSWD treatment including metallic implants, pacemakers, lack of sensitivity or a tumor.

The 121 participants were randomized into four groups with 35 people in the control group receiving no treatment, 23 in the placebo group, 32 in the low dose PSWD group and 31 in the high dose PSWD group. The treatment groups received three applications of PSWD per week, for three weeks, for a total of 9 sessions. The low PSWD group received the treatment for 19 minutes with approximately 17 kJ of energy each session, whereas the high PSW group received 38 minutes of treatment with a total of 33 kJ of energy. The pulse frequency was 145 Hz, with the mean power of 14.5W. The machines used in the study were previously calibrated Diathermed II machines. One electrode was placed on the anterior area of the thigh 5 cm above the superior border of the patella and the second electrode was applied on the posterior area of the leg. The participant was positioned in supine for the treatment, with the knee in 20 degrees of flexion and the physical therapists did not remain with the participants to avoid influencing the results. All the participants received the advice to maintain their daily activities and to avoid anti-inflammatory drugs.

Outcome measures: The participants were analyzed using an 11-point numerical pain rating scale (NPRS) with 0 corresponding to "no pain" and 10 corresponding to "worst imaginable pain." The participants were analyzed pre-treatment, immediately post-treatment after the 3 weeks, and again at 12-month follow up. According to the authors the NPRS has been shown to be reliable and valid, and has a MCID of 2 points.

Study losses: The control group initially had 35 individuals, and after the three weeks of treatment three were lost representing a 9% loss. The control group did not take part in the 12-month follow up because after the treatment period they were referred for traditional physical therapy treatment. The placebo group started with 23 individuals and lost two people after the three weeks of treatment, representing a 9% loss. An additional

seven individuals were lost at the 12-month follow up representing an additional 33% loss. The low-dose PSWD group began with 32 individuals; two were lost following treatment, a 6% loss, and an additional 11 people were lost at the 12-month follow up evaluation, a 37% loss. The high-dose PSWD group lost two individuals initially post-treatment, representing a 6% loss, and an additional 11 people at the 12-month follow up representing a 38% loss. Individuals that were lost within the three weeks of treatment were due to missing two or more treatment sessions. The reasons that people dropped out the study by the 12-month follow up included seeking out other treatment, having a total knee replacement, or not able to be contacted.

From the pretreatment to the initial post-treatment analysis nine participants dropped out of the study. According to the authors an intention to treat analysis was not needed because this represents less than a 10% loss and did not compromise the effect size of interest. According to the authors the sample size calculations were conducted to detect an 8-point difference on the KOOS scale, which was not of interest to this paper, and 20% difference between groups, assuming 13 point standard deviation, two tailed distribution, with 80% power, and an alpha value of 0.05. The specific number of participants that was calculated to be needed was not included in the article. A total of 29 participants out of the 112 were lost from the initial post-treatment analysis to the 12-month follow up so an intention to treat analysis was necessary. The authors carried forward the last known value to conduct the intention to treat analysis.

Summary of internal validity: The study has good internal validity. Randomization was successful as there were no statistically significant differences between the groups at baseline for demographic information or for the outcome measures. The authors utilized a strict protocol, and all the participants were evaluated within the groups to which they were randomized. The participants and evaluators were blinded to the treatment and the study utilized both a true control and a placebo group. One minor threat is that there was no intention to treat analysis performed for the data collected initially post-treatment. Even though the authors state that the intention to treat analysis was not needed, because the losses did not impact the effect size of interest, the losses still represented 6-9% of the participants. Also the reasons for the losses were not included for this time period; therefore, people may have missed appointments because they felt the treatment was not helping, they felt much better, etc. Another minor threat is that the physical therapists were not blinded because they had to perform the treatment. This threat was minimized by not allowing the physical therapists to remain with the participant, but there is still a threat of the therapist influencing the participant. Another minor threat to validity is that the control group was not measured at the 12-month follow up, meaning it is unknown if the improvements were seen due to time, but knowing the typical progression of OA, and also having a placebo group that was measured at all time points lessens the threat.

Evidence: The post-treatment analysis for low-dose PSWD group showed a significant improvement in pain scores on the NPRS as compared to the pretreatment score, $p < 0.001$ (Table 3). The posttreatment analysis for high-dose PSWD group also showed a significant improvement, $p < 0.01$ (Table 3). The amount of change the low and high-

dose PSWD groups made at the post-treatment evaluation met the MCID of two points, with values of 3.3, and 2.1 respectively (Table 2). There was no significant decrease in pain within the control group or placebo group.

Table 2: Numerical Pain Rating Scale Values \pm SD, at pretreatment, post-treatment, and at 12-month follow up.

Group	Time point 1: Pretreatment	Time Point 2: Posttreatment	Time Point 3: 12-Month Follow up	Mean difference (95%CI): Time Point 1 to 2, and 1 to 3
Control	6.1 \pm 2.1 (n=35)	5.6 \pm 2.1 (n=32)	NA	0.5 (-.59-1.59), NA
Placebo	7.7 \pm 1.4 (n=23)	6.9 \pm 2.0 (n=21)	7.5 \pm 1.6 (n=14)	0.8 (-.30-1.90), -0.2 (-0.83-1.23)
Low-dose PSW	7.1 \pm 2.8 (n=32)	3.8 \pm 2.2 (n=30)	5.7 \pm 3.0 (n=19)	3.3*(2.31-4.29), -1.4 (0.15-2.65)
High-dose PSW	6.7 \pm 2.5 (n=31)	4.6 \pm 3.5 (n=29)	5.2 \pm 2.1 (n=18)	2.1*(0.44-3.76), -1.5(0.07-2.93)

A (-) represents a decrease in pain score. *=clinically and statistically significant data.

Seventy-five percent of the low dose group and 50% of the high dose PSWD group met the MCID of two points and only 15% of the of the placebo group and 15% of the control group met the MCID. From this data, I calculated the number needed to treat to be two people for the low dose and three people for the high dose PSWD groups. This means that two people would need to be treated with low dose or three people treated with high dose PSWD to have one additional person meet the MCID for pain compared to the control or placebo groups.

There was a large effect size for the low-dose PSWD group (1.18) and the high-dose PSWD group (0.84) at the initial posttreatment evaluation (Table 3). At the 12 month follow-up there was a medium effect size for low-dose PSWD group (0.5) and high-dose PSWD group (0.60) (Table 3). The 95% percent confidence intervals included a wide range. The low end of the effect size for the low dose post-treatment was still large. The effect size for the high-dose at the post-treatment analysis was small. If the study were repeated the low dose diathermy would still have a large effect, but the high dose may only have a small effect. At 12 months post intervention the low end of the confidence interval crosses zero, meaning that if the study were to be repeated there may be no effect or possible a worsening effect (Table 3).

Table 3: Within group effect size scores with 95% Confidence Intervals (CI) for NPRS scores for the Control group, Placebo group, Low-Dose PSWD group, High-Dose PSWD group

Group	Effect size for pre	P values for	Effect size from	P values for
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	to post-treatment	pre to post-treatment	pretreatment to 12-month follow-up	pretreatment to 12-month follow-up
Control	NA	$p>0.05$	NA	NA
Placebo	NA	$p>0.05$	0.14 (-0.53-0.80)	$p>0.05$
Low-dose PSW	1.18 (0.76-1.85)	$p<0.001$	0.50 (-.09-1.06)	$p<0.05$
High-dose PSW	0.84 (0.17-1.22)	$p<0.01$	0.60 (-.04-1.23)	$p<0.05$

Effect size and CI are calculated data, p values are taken from the article

The between group comparison showed a significant improvement for the low-dose PSWD group compared to the placebo and control groups, $p<0.05$ and $p<0.01$ respectively, for the post-treatment analysis but there was no difference between groups at the 12 month follow up (Table 4). There was no difference between the high dose PSWD group and the placebo or control group at either time point.

Table 4: Between group comparison of NRPS at post-treatment evaluation.

Intervention NRPS score	Comparison NRPS Score	P value	Effect size (95% CI)
Low-dose PSW: 3.8±2.2 (n=30)	Placebo: 6.9±2.0 (n=21)	$p<0.05$	1.46 (0.84-2.09)
Low-dose PSW: 3.8±2.2 (n=30)	Control: 5.1±2.1 (n=32)	$p<0.01$	0.60 (0.03-1.17)

Benefits vs. Costs: There would be a significant financial cost if the clinic did not already own a diathermy machine. According P and P Cito the cost of the Diathermed II, the machine used in the study was \$4,600 and there would be additional costs to have the machine calibrated and serviced (<http://www.en.ppcito.com>). If the previously mentioned precautions and contraindications are followed then there is little risk to the patient. One possible adverse effect of diathermy, however, is burns. Fat layers are at the greatest risk, and because water is preferentially heated, sweat may scald the skin. Therefore a dry towel placed over the skin is recommended to prevent such an occurrence (Cameron, 2009). The authors reported that use of PSWD resulted in no adverse events during the study. Overall, the study demonstrated that the treatment is effective for a meaningful decrease in pain in participants with knee OA. The treatment did not cost an inordinate amount of the patient's or therapist's time. Therefore, if the clinic already has access to a diathermy machine and caution is taken to avoid contraindications and precautions the benefits outweigh the costs. Additionally, results show that there is a greater positive effect using low-dose as compared to high dose diathermy. Therefore using low-dose diathermy has the greatest benefit for pain caused by knee OA.

Feasibility of treatment: The time and duration for the treatment is a reasonable amount that would be allowed by insurance. The procedure was well described so it is repeatable. As long as a clinic already had this device there is minimal additional

requirements for clinical expertise or time needed to provide the treatment, as long as the therapist has basic knowledge for using the machine. A correctly applied treatment should not cause discomfort and there were no pain/burns from treatment reported in the study. Additionally, the success of the treatment did not rely on patient participation. Overall the treatment protocol is feasible.

Summary of external validity: Overall the study has fair external validity. The population was slightly younger than the clinical population. The inclusion criteria were strict, so it may be difficult to generalize the results. For instance, participants were not included if they had received physical therapy previously, had any invasive knee procedures or if they had grade I OA. So it is unknown if the results can be extrapolated to individuals beyond their inclusion criteria. Additionally, the study also took place in Brazil so there may be some cultural difference that could impact the outcomes. Overall, because of the good internal validity and similarity to the clinical population the results can be extrapolated to a subset the clinical population that overlaps with the inclusion criteria.

Article: Atamaz FC, Durmaz B, Baydar M, Demircioglu OY, Iyyapici A, Kuran B, Oncel S, Sendur OF. Comparison of the efficacy of transcutaneous electrical stimulation, interferential currents, and shortwave diathermy in knee osteoarthritis: a double-blind, randomized controlled, multicenter study. *Archives of Physical Medicine and Rehabilitation* 2012; 93(5): 748-756.

Clinical Bottom Line: According to Atamaz *et al.* there is moderate evidence to suggest no significant difference in patient reported pain scores on the visual analog scale comparing SWD plus exercise/education to sham SWD plus exercise/education. Both groups made statistically significant and clinically meaningful decreases in pain. There was a significant decrease in the amount of the oral analgesic taken by the group that received SWD as compared to the group that received the sham SWD at the three-month assessment $p < 0.05$. Overall, the study had good internal validity and fair external validity. Due to the high level of exclusion criteria, these outcomes should be cautiously generalized to larger populations.

Article PICO:

Population: Two hundred and three patients aged 50-80 years old with knee osteoarthritis

Intervention: Shortwave diathermy (SWD) treatment given five times a week in addition to exercise and education

Comparison: Sham SWD treatment given 5 times a week and also received exercise and education

Outcome measures: Visual Analog Scale (VAS), 0-100mm measured at baseline, one month, three months, and six months.

Blinding: The patients, investigators and analysts were all blinded. The data and safety monitoring board members were not blinded but they did not participate in the assessment of patients or in writing the paper. The therapists were also not blinded.

Controls: There was a SWD sham group, which received the same education, exercise and instruction as the treatment group and were seen for the same frequency and duration as the treatment group but were set up with a sham treatment.

Randomization: Patients were assigned a unique two-part number and were randomly allocated to one of the six treatment groups. Randomization was successful as there were no significant differences between groups at baseline.

Study: The design was a double blind multicenter, randomized controlled study. The sample size was calculated at 28 individuals per group with 80% power to detect a 50%

improvement in VAS scores with a two-sided significance level ($p < 0.05$) with a 30% dropout rate. Participants 50-80 years old were included in the study and had to have OA with a Kellgren-Lawrence grade of two or three with radiographical confirmation. To be included in the study the participants had to have rated their pain at 40mm or greater on the VAS. Patients were excluded if they had previous experience with electrical stimulation, if treatment was contraindicated, if they had a corticosteroid or chondro-protective agent within the last 30 days, had viscosupplementation treatment within the last six months, or had a surgery such as a joint replacement or arthroscopy within in six months of the study. Patients were also excluded if they were pregnant, breast feeding, had joint infection, were diagnosed with a specific condition such as neoplasm, diabetes mellitus, paresis, osteonecrosis, recent trauma, etc., or poor general health that would interfere with the participants ability to complete the functional assessments.

Six groups in total were included but only the SWD group and sham SWD group will be analyzed to address the clinical question. The average age in the SWD group was 61.6 ± 7.4 years, and the average age of the sham SWD group was 61.4 ± 8.2 years old. The physical therapists were trained to apply the treatments in a standardized way. All treatments were applied five times a week for three weeks. The SWD groups had a screen placed in front of them so they could not see the machine. The patient placed his or her leg on a table and received continuous diathermy with a 10 cm condenser plate at a frequency of 27.12MHz at 300W input and a 3.2W output for a total of 20 minutes. The sham group was positioned the exact same way except the power switch was off.

All the groups received therapeutic exercise and education. The exercise was completed in groups of four to five participants three times a week for three weeks. First, the participants jogged for five to six minutes, and then completed 10 minutes of stretching of lower extremity muscles in a standing position. Following the warm up, 10-15 sets of isometric quadriceps contractions of 10 second holds in long sitting/supine with a rolled towel under the knee, chair lifts, and mini squats were performed. Following the three weeks of interventions the participants were instructed to maintain the exercises at home. Everyone received pre-made exercise cards with instructions. All the participants also received a one-hour education class about knee OA, the progression, the function of the knee, joint protection, ergonomics, exercise and treatment approaches from a computer lesson given by the physician.

Outcome measures: The participants were assessed at baseline, one, three and six months post treatment utilizing a 100mm VAS to assess the patient's knee pain, with 0 equating to no pain, and 100 equating to severe pain. The authors did not include information about the validity, reliability or MCID for the pain VAS for patients with knee OA. According Tubach *et al.* a minimal clinically important improvement (MCII) for patients with knee OA is -19.9mm on the VAS (2005).

Study losses: The authors state that an intention to treat analysis was performed, but did not specify the method utilized. Two-hundred and three patients were included in the study. Of the treatment groups of interest 31 were in the SWD group and 32 were in the sham SWD group at the beginning of the trial. For the SWD group, no one dropped out at one month, three dropped out at three months, and one dropped out at six months.

Reasons for leaving the study include worsening of symptom (n=2), and health problems not related to knee pain, (n=2). For the sham SWD group two people dropped out at one month, one dropped out at three months, and four dropped out at six months. The reasons for leaving the study include worsening symptoms (n=5), and not enough time to attend (n=2). Twenty-five people out of 32 people completed the study in the SWD sham group which represents a 22% loss. Twenty-seven out of 31 people completed the study in the SWD group which represents a 12% loss.

Summary of internal validity: The study has good internal validity. There was blinding of subjects, assessors and investigators. There was an intention to treat analysis used, and successful randomization of subjects with all groups equal at baseline. There were three minor threats. One of the threats was not reporting how intention-to-treat analysis was conducted. Some of the participants dropped out of the study because of worsening conditions and the author do not state how they analyzed those values. Therapists were not blinded in the study, which could have affected the participants' perception of treatments, their condition, etc. Another minor risk to internal validity that was noted by the authors was the difficulty of blinding patients to the particular treatment. This is due to the sensory component associated with modality, but not felt with the sham. They tried to minimize this risk by selecting participants that had never received the treatment before.

Evidence: The results were analyzed using a paired t-test to compare the treatment group to the sham treatment. There was no significant difference in pain VAS scores between the SWD treatment and SWD sham group at any of the assessment points, but both the sham and the treatment group showed significant improvement from baseline ($p < 0.05$). The authors did not include an MCID but if the MCII established by Tubach *et al.* of -19.9mm is used then the values at each point exceed the MCII. (Table 5)

Table 5: Mean difference on VAS scores from baseline VAS scores.

Mean difference	1 month	3 months	6 months
SWD sham	-26mm	-29.8mm	-29.2mm
SWD	-28.7mm	-30mm	-25.7mm

While it was not the primary outcome measure of interest, the study did show that the SWD group used less of the analgesic, paracetamol (acetaminophen), than the sham group during the first three months, $p < 0.05$. The exact values, however, were not included so effect size and confidence intervals cannot be calculated.

Benefits vs. Costs: A benefit of using SWD may be decreased intake of the analgesic medication, as compared to the sham SWD group. Both the SWD and the sham SWD were combined with an exercise program and resulted in a clinically meaningful decrease in pain. No difference in the overall pain reported on the VAS was found between the groups. It is unknown if the similarity between groups is due to a placebo effect from the sham diathermy, or if the SWD had no impact and the improvements

were from the exercises that both groups received. There was no group that received exercise only, so this cannot be determined. Costs of the treatment include the cost to purchase and maintain the machine and cost to the patient to attend therapy. There is a slight risk of burns to the patient, but if the therapist is in compliance with the indications, contraindications and precautions, there is overall low risk to the patient (Cameron, 2009). Overall, the time and cost needed for treatment and the expense of purchasing the needed equipment is greater than the benefits received from the treatment.

Feasibility of treatment: The treatment was performed five times per week, which is more than a typical out-patient treatment would include but is similar for an inpatient population, which matches the clinical population. The exercise included a warm up of jogging for five to six minutes. While this was perhaps a mistranslation, I find it hard to believe that people with knee OA with a starting pain score of 40mm were appropriate to jog as a warm up. I do feel that jogging may not be feasible for the clinical population. Overall SWD treatment itself is a feasible treatment in that it does not take too much time, effort, or include harm for the patient.

Summary of external validity: The article population was similar to the clinical population. There were some differences as the age range included subjects that were younger and they included males and females. Additionally the study took place in Turkey, so there may be cultural difference that would affect the application of the results to the clinical population. Overall the article PICO matched the clinical PICO relatively well so the results can be applied to a subset of the clinical population. There were very strict exclusion criteria to participate in the study such as individuals with diabetes mellitus, knee arthroscopy, etc. so I cannot confidently determine if the results can be applied to a larger population.

Synthesis/Discussion

The purpose of this paper was to determine if SWD was effective in reducing pain in people with knee OA. There was a discrepancy in the findings of the two studies reviewed. Fukada *et al.* found a significant decrease in pain scores in the PSWD treatment group compared to a placebo and a control group. Atamaz *et al.* did not find a significant change in pain scores in the SWD group as compared to a sham SWD group. They did, however, find a significant decrease in the use of pain medication in the SWD group compared to the sham group at the three-month follow-up. Both studies had equivocal internal validity (PEDro scores of 9/10), so evidence for one study will not be weighted higher than the other.

The populations used within both studies were slightly younger than the population in question of individuals 65 years and older. The average age range in Fukada *et al.* was 60 years old including people as young as 40 years old, and the average in the study by Atamaz *et al.* was 61 years old with people as young as 50 years old. Additionally

Atamaz *et al.* included males and females in the study. Being that populations within the two studies were very similar I do not believe that this contributed to the varying results. Since the age averages were 60 and 61 years old, and the population in question was patients 65 years and older, I am more cautious to apply the result to older populations.

The treatments used did not appear to be markedly different. Both studies utilize a standardized diathermy treatment for a similar duration of three weeks, and had a similar amount of participants per group. Some differences, however, did exist. There were different treatment parameters used. The treatment group in Atamaz's *et al.* study received continuous diathermy five days a week for three weeks for a total of 15 sessions, whereas the group in the study by Fukada *et al.* received continuous diathermy three sessions per week for three weeks for a total on nine sessions. The difference between treatment groups (pulsed vs. continuous diathermy) may have contributed to the difference seen in the results of the two studies.

The comparison groups were different between studies. Fukuda *et al.* had a sham PSWD group and a true control group, so efficacy of the PSWD could be isolated. With Atamaz *et al.*, however, both groups received exercise and education, so the effects of SWD alone could not be determined. Only its benefits combined with exercise could be determined. So it is unknown if there was no significant difference between groups because of the placebo effect of the sham diathermy, or because the exercise was what was effective for reducing pain. The difference in the comparison groups may have directly impacted the results of the study. The group that included exercise in the treatment and comparison group found no significant difference, whereas the group that had a true sham, control and treatment group did find a significant difference. This could suggest that if diathermy could have been isolated a difference between the groups may have been seen in the second study as well.

Recommendations for future research include the efficacy of pulsed diathermy compared to continuous diathermy treatment for knee osteoarthritis pain in older adults. Additionally, areas for further research may include a study directly comparing an exercise control group, a placebo/sham group and a diathermy treatment group to truly assess if diathermy is more effective than exercise for reducing pain caused by knee osteoarthritis.

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