Effect of phonophoresis on selected gait parameters in patients with knee osteoarthritis

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Abstract: The purpose of this study was to examine the effect of phonophoresis in the management of patients with knee osteoarthritis (OA). **Subjects:** Sixty male patients with knee OA were assigned randomly into two equal groups .Their ages were ranged from 40-50 years old. **Methods:** The patients were evaluated for the following parameters: Pain and knee joints kinematics, kinetics and spatiotemporal parameters by 3-D motion analysis Lab before and after three months of treatment program. patients in the control group received selected physical therapy program in the form of stretching exercises, strengthening exercises, transcutaneous electrical nerve stimulation (TENS), ultrasound whereas patients in the study group received the same selected physical therapy program in addition to phonophoresis therapy. The data were collected and analyzed using a paired and un-paired t-test to compare the difference between the results within each group pre test and post test and between the two groups. **Results**: this study revealed that there were significant differences ($p<0.05$) of all of the measured variables (pain score, cadence, stride length, knee flexion ROM at stance and swing phase, knee flexion and extension moment) between pre test and post test in the control and experimental groups for right and left knees. There were significant differences between post test of control and experimental groups for right and left knees except knee extension moment there was no significant differences. **Conclusion:** Phonophoresis has got clear effect when added to treatment program in reducing the pain and improving mechanics of knee joint in patients with osteoarthritis.
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1. Introduction

Osteoarthritis (OA) is a disease characterized by degeneration of cartilage and its underlying bone within a joint as well as bony overgrowth. The breakdown of these tissues eventually leads to pain and joint stiffness. The joints most commonly affected are the knees, hips, and those in the hands and spine. The specific causes of OA are unknown, but are believed to be a result of both mechanical and molecular events in the affected joint. Disease onset is gradual and usually begins after the age of 40. There is currently no cure for OA. Treatment for OA focuses on relieving symptoms and improving function, and can include a combination of patient education, physical therapy, weight control, and use of medications (Lawrence et al. 2008).

OA is the most common form of arthritis. There is no cure for OA and today this disease is usually managed by a combination of several treatments. The goal of treatment is to control pain, with accompanying increase in the ability to perform daily activities secondary to decreased pain. The therapeutic approach is mainly directed at symptoms, and many treatment options, including non-pharmacological and pharmacological measures, are recommended in the management of OA. Although non-steroidal anti-inflammatory drugs (NSAIDs) are widely used in symptomatic treatment of OA, NSAID therapy involves potential hazards including gastrointestinal side effects (Deniz et al. 2009).

In the last two decades, many advances have been made in the field of drug delivery, with resulting enhancements in the efficacy and safety of treatment, some of the more dramatic developments are technologies that allow the non-invasive transdermal delivery of several ionizable drugs (Huang et al. 2005). Many treatment options, including non-pharmacological and pharmacological measures, have been recommended in the management of OA. Among the non-pharmacological approach is physiotherapy, which involves the use of physical modalities like, heat therapy, exercise therapy, electrical stimulation, therapeutic ultrasound, iontophoresis, and phonophoresis (John et al. 2011).

Patients with osteoarthritis have demonstrated a lower walking speed, lower cadence, shorter step length, and shorter single stance phase of the involved leg, while a shorter double stance phase of the involved leg has been observed when compared to the normal group (Bejek et al.2006). These findings are reported in all of these previous studies (Al- Zahrani and Bakheit 2002, Baliunas et al., 2002, Börjesson et al., 2005, Gök et al., 2002, Hurwitz et al., 2000, Kaufmann et al., 2001, McGibbon and Krebs, 2002). According to Hurwitz et al. 2000, the different spatial-temporal parameters were part of the adaptive mechanism to reduce pain.

Normal walking patterns are adversely affected by lower extremity joint disease. The results of joint angle kinematics show that the minimal value of knee motion was increased, which represents a decreased knee extension; the maximal value of knee motion decreased, which means a decreased knee flexion; and the ROM of the knee joint decreased on both sides, as compared to that of the healthy subjects (Bejek et al. 2006). OA of the knee causes the subjects to limit their activity level, which results in an overall reduction in flexibility and dynamic range of motion (Messier et al. 1992). Therefore, the abnormalities observed in measurements of joint angles seem to reflect mechanical changes secondary to osteoarthritis rather than underlying factors involved in the pathogenesis. These findings were also noted by other researchers (Gök et al., 2002, Kaufmann et al., 2001, McGibbon and Krebs, 2002, Messier et al., 1992).

Phonophoresis is the migration of drug molecules through the skin using ultrasound (US) therapy, which is used to enhance percutaneous absorption of drugs. This technique is a noninvasive, well tolerated and involves minimal risk of hepatic and renal injury (Descoins et al.2006). So, the purpose of this study was to examine the effect of phonophoresis on selected gait parameters in patients with knee osteoarthritis.

2. Material and Methods

Study Design:

This study was a randomized controlled trial, performed over the period from October 2012 to May 2013 at the physiotherapy outpatient clinic in college of applied medical sciences, Salman bin Abdullaziz University, Saudi Arabia.

Subjects:

Sixty male patients with mild to moderate osteoarthritis for both knees participated in this study. Subjects were divided into two groups; control and experimental groups. Inclusion criteria were that patients' age were 40-50 years, mild to moderate knee osteoarthritis. Exclusion criteria were that any other types of arthritis, rheumatic arthritis, congenital deformities, and cardiovascular abnormalities were excluded.

Procedures:

Outcome measures:

All outcome measures were recorded pre and post intervention for both control and experimental groups and for right and left sides of knee. These were pain score which gained from visual analogue scale. Spatiotemporal, kinematic, and kinetic data obtained from 3D motion analysis system.

Evaluative procedures:

1- The diagnosis of (Ostoearthritis) OA: was based on orthopedist or orthopedic surgeon referral according to radiographic evidence of joint space narrowing, osteophyte formation, subchondral sclerosis and knee pain for more than 6 months as well as at least one of the following: mild swelling, tenderness on palpation, crepitus on motion or stiffness in the morning or after long periods of inactivity.

2- Pain assessment: The patient marked on the line the point that they feel represents their perception of their current state. The **VAS** score was determined by measuring in millimeters from the left hand end of the line to the point that the patient marks. Measurement of pain score was done pre treatment and post treatment for two groups.

3- Analysis of gait parameters: Before gait analysis, all subjects gave informed consent as advised by the Ethics Committee. Both groups underwent gait analysis with the same protocol by one and the same therapist. Measurements of gait parameters were done pre treatment and post treatment for two groups.

A: Instrumentation:

Vicon Motion Measurement and Analysis System using **Plug-in gait** for gait analysis is used. This system consisted of 8 infrared cameras, a computer system for data acquisition, processing and analysis and a data station. 16 photo-reflexive markers were placed on the subject's body in accordance with the procedure for Helen Hayes- Davis model. The experimental model idealized the lower extremity as a system of rigid links with spherical joints. The joints were assumed to have a fixed axis of rotation. Skeletal movement can be described using surface markers placed in precise anatomical positions.

Markers placement:

The markers were placed on anterior superior iliac spine of both sides, posterior superior iliac spine of both sides, the lower lateral 1/3 surface of the thigh of both sides, lateral epicondyle of the knee of both sides, lateral malleolus of both sides, lower 1/3 of the shank of tibia of both sides, over the second metatarsal head of both sides, and calceneus at the same height above the plantar surface of the foot as the toe marker of both sides.

Force plate form:

All patients were instructed to walk at a self selected speed along the walkway and to practice until they could consistently and naturally make contact with both feet on the force plate. Three acceptable trials were obtained for each foot and averaged to yield representative values.

Treatment procedures:

A: Stretching exercises (were applied for two groups):

1. Passive stretching of the iliotibial band and the calf muscle of the leg done while the patient lies on the unaffected side, the physiotherapist gently stretches the ankle into dorsiflexion, keeping the knee in extension and controlling hip adduction.
2. Passive stretching of the hamstring muscle of the thigh. While the patient lies in a supine position with the pelvis in anteversion, the physiotherapist maintains the legs at roughly 60° of hip flexion from the mat. The knees are kept in extension. The physiotherapist also applies gentle force to stretch the ankle in dorsiflexion.

B: Strengthening exercises (were applied for two groups):

1. Isometric quadriceps contraction. In a sitting position, the patient performs 10 quadriceps contractions while keeping the knee in extension.
2. Half squat with a ball against a wall. Standing with a ball pressed between the patient's back and the wall, the patient performs 10 times of half squats.

C: Electrotherapy (was applied for two groups):

1. The transcutaneous electrical nerve stimulation (TENS) was delivered by a transcutaneous electrical nerve stimulator. 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 and a length of application was 20 minutes. In the TENS protocol, the participants were stimulated in dorsal decubitus, adequately positioned with a roll under their knees. The percutaneous electrodes for the electrical stimulation were placed on the anterior medial and lateral portions of the knee (Jean et al, 2008).
2. The ultrasonic (US) protocol consisted of continuous ultrasonic waves of 1 MHz frequency and 0.8 W/cm power. The patients were placed in a supine position, and an acoustic gel that did not contain any pharmacologically active substance was applied. Ultrasound was then applied to the medial and lateral parts of the knee in circular movements with the probe at right angles to ensure maximum absorption of the energy. Each session lasted 5 minutes (Jean et al, 2008).

D: Phonophoresis (was applied for experimental group only):

1. 5cm long strip of gel containing dexamethasone sodium phosphate was applied from the tube over the target knee. Ultrasonic (US) was then applied to the superomedial and lateral parts of the knee by the same therapist stroking the applicator in circular movements. The transducer head was applied to the therapy region at right angles to ensure maximum absorption of the ultrasound energy. Continuous ultrasonic waves with 1 MHz frequency and 1 watt/cm2 power, and 5 minutes duration were applied (Akinbo et al.2011).

N.B: The all kinds of treatments were conducted three times a week for three months.

Data Analysis:

All statistics were calculated by using the statistical package of social sciences (SPSS) version 16. Descriptive statistics (mean and standard deviation) were computed for all outcomes measures which are pain score, cadence in (steps/min), stride length in meter (m), knee flexion during stance phase in degrees, knee flexion during swing phase in degrees, knee flexion moment in (Nm/kg), and knee extension moment (Nm/kg). Paired t- test was applied to determine changes between pre and post test for both right and left sides of knee in both groups. Unpaired t- test was applied for age, weight,

and height of patients between control and experimental groups. Unpaired t- test also was applied between control and experimental groups for both right and left sides of knee. A value of $P < 0.05$ was considered statistically significant.

3. Results

There were no significant differences between patient characteristics (age, weight, and height) between two groups of the study before the program . Control group the mean age, weight and height of the subjects was 45.7 ± 2.9 years, 80.4 ± 8.1kg, and 174.5 ± 4.9 cm respectively as shown in table 1. For experimental group the mean age, height, and weight of the subjects was 45.3 ± 2.3 years, 79.5 ± 9.5kg, and 174.8 ± 6.9cm respectively as shown in table 1.

Table 1: Demographic characteristics of control and experimental groups

Parameter	Control group Mean (SD)	Experimental group Mean (SD)	P value
Age (yrs)	45.7± (2.9)	45.3 (2.3)	0.632
Weight (kg)	80.4± (8.1)	79.5 (9.5)	0.684
Height (cm)	174.5 ± (4.9)	174.8 (6.9)	0.849

* Level of significant $p < 0.05$

1- Pain:

There were significant differences of pain score between pre and post test in control and experimental groups for right and left knees and also there were significant differences of pain score between post test of both control and experimental groups for right and left knees as shown in table 2 and Fig. 1.

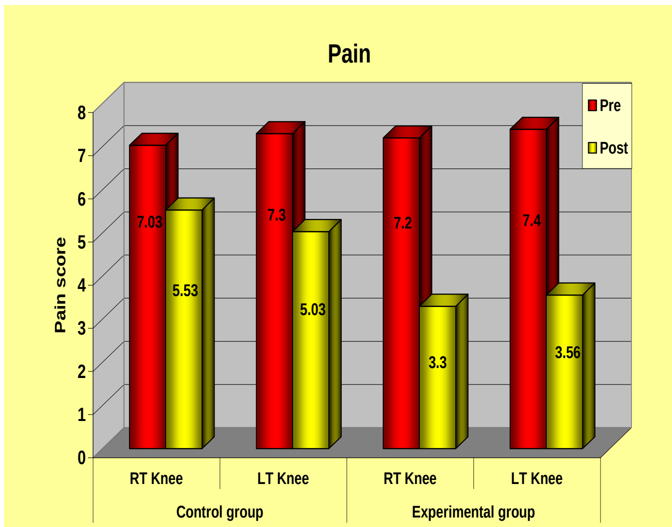

Fig. 1: Pain changes between two groups

Table 2. Changes of pain scores between two groups

Pain score	Right knee			Left knee		
	Pre Test	Post test	P- value	Pre Test	Post test	P- value
Control group	7.03±1.35	5.53±1.9	0.004	7.3±1.3	5.03±1.7	0.004
Experimental group	7.2±1.49	3.3±1.7	0.000	7.4±1.7	3.56±1.7	0.000
P value	P> 0.05	0.000		P>0.05	0.002	

* Level of significant $p < 0.05$

2- Cadence:

There were significant differences of cadence between pre and post test in control and experimental groups for right and left knees and also there were significant differences of cadence between post test of both control and experimental groups for right and left knees as shown in table 3 and Fig. 2.

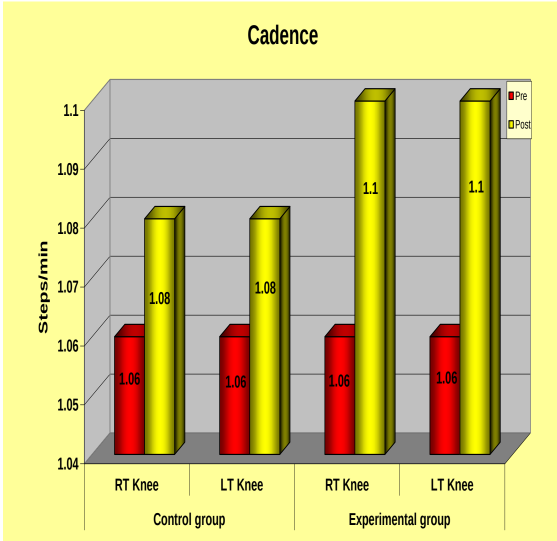

Fig. 2: Cadence changes between two groups

Table 3. Changes of cadence between two groups

Cadence(steps/min)	Right knee			Left knee		
	Pre Test	Post Test	P- value	Pre Test	Post test	P- value
Control group	1.06±2.2	1.08±3.8	0.02	1.06±2.9	1.08±4.1	0.04
Experimental group	1.06±2.3	1.1±2.9	0.000	1.06±2.8	1.1±3.1	0.000
P value	P>0.05	0.02		P>0.05	0.02	

* Level of significant p< 0.05

3- Stride length:

There were significant differences of stride length between pre and post test in control and experimental groups for right and left knees and also there were significant differences of stride length between post test of both control and experimental groups for right and left knees as shown in table 4 and Fig. 3.

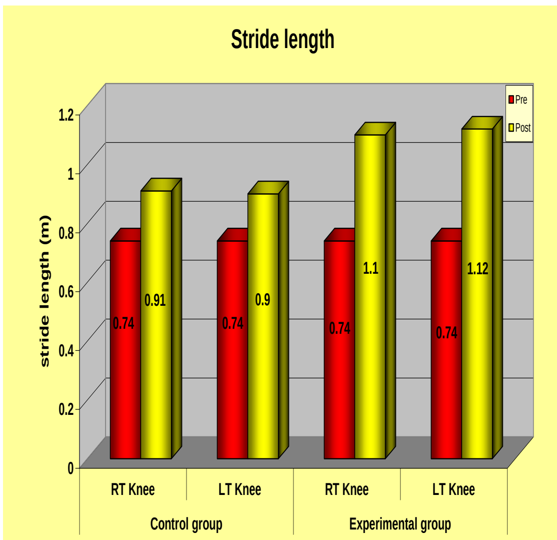

Fig. 3: Stride length changes between two groups

Table 4. Changes of stride length between two groups

Stride length (m)	Right knee			Left knee		
	Pre test	Post Test	P- value	Pre Test	Post Test	P- value
Control group	0.74±0.17	0.91±0.22	0.002	0.74±.18	0.9±0.23	0.01
Experimental group	0.74±0.15	1.1±0.21	0.000	0.74±.2	1.12±0.14	0.000
P value	P>0.05	0.001		P>0.05	0.000	

* Level of significant p< 0.05

4- Degrees of knee flexion (stance phase):

There were significant differences of knee flexion degrees between pre and post test in control and experimental groups for right and left knees and also there were significant differences of knee flexion degrees between post test of both control and experimental groups for right and left knees as shown in table 5 and Fig. 4.

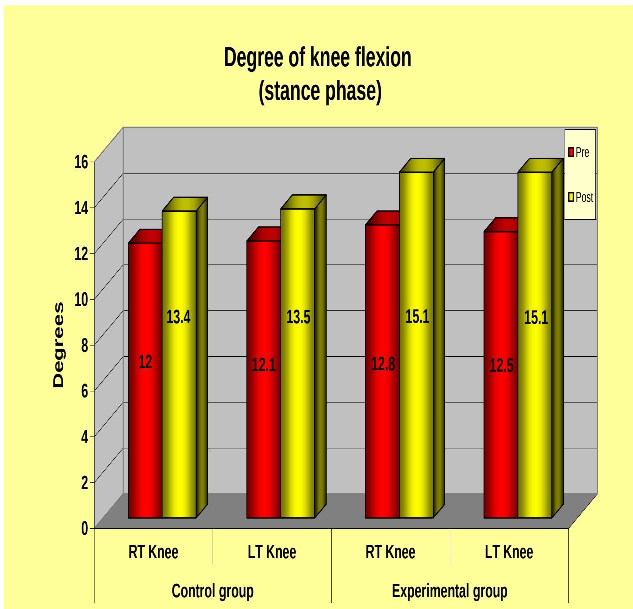

Fig. 4: Knee flexion changes (stance phase) between two groups

Table 5. Changes of degree of knee flexion between two groups

Degree of knee flexion (stance phase)	Right knee			Left knee		
	Pre Test	Post Test	P- value	Pre Test	Post test	P- value
Control group	12±1.59	13.4±2.4	0.006	12.1±1.56	13.5±2.1	0.01
Experimental group	12.8±2.1	15.1±1.7	0.000	12.5±1.94	15.1±1.54	0.000
P value	P>0.05	0.003		P>0.05	0.001	

* Level of significant p< 0.05

5- Degrees of knee flexion (swing phase):

There were significant differences of knee flexion degrees between pre and post test in control and experimental groups for right and left knees and also there were significant differences of knee flexion degrees between post test of both control and experimental groups for right and left knees as shown in table 6. and Fig. 5.

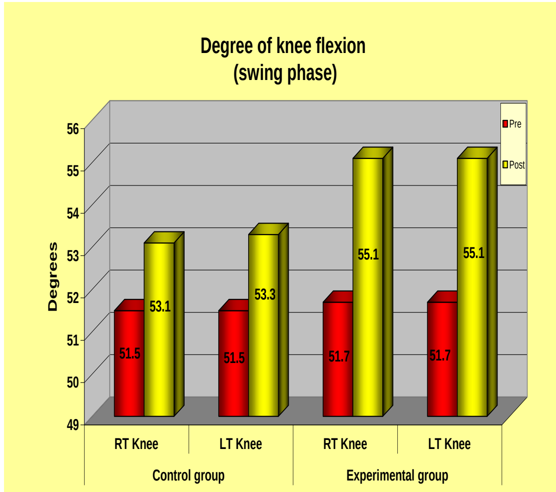

Fig. 5: Knee flexion changes (swing phase) between two groups

Table 6. Changes of degree of knee flexion between two groups

Degree of knee flexion (swing phase)	Right knee			Left knee		
	Pre Test	Post Test	P- value	Pre Test	Post test	P- value
Control group	51.5±2.2	53.1±3.2	0.02	51.5±2.1	53.3±3.5	0.024
Experimental group	51.7±2.8	55.1±2.4	0.000	51.7±2.5	55.1±2.3	0.000
P value	P>0.05	0.009		P>0.05	0.028	

* Level of significant p< 0.05

6- Knee extension moment in (early stance phase):

There were significant differences of knee extension moment between pre and post test in control and experimental groups for right and left knees however there were no significant differences of knee extension moment between post test of both control and experimental groups for right and left knees as shown in table 7. and Fig. 6.

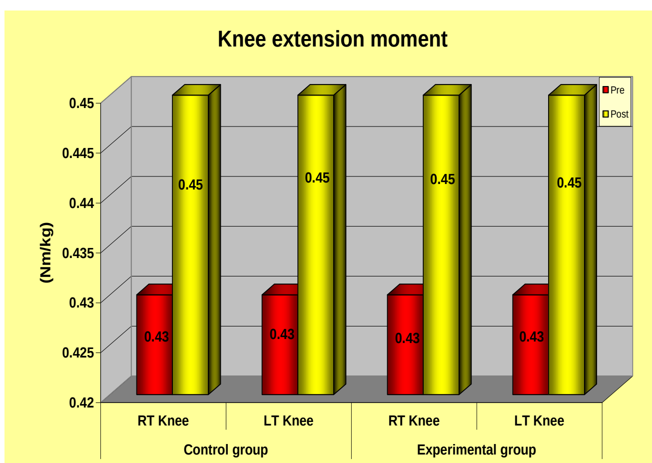

Fig. 6: Knee extension moment changes between two groups

Table 7. Changes of knee extension moment between two groups

Knee extension moment in early stance (Nm/kg)	Right knee			Left knee		
	Pre test	Post test	P-value	Pre Test	Post test	P-value
Control group	0.43±0.04	0.45±0.01	0.04	0.43±0.03	0.45±0.03	0.04
Experimental group	0.43±0.03	0.45±0.03	0.003	0.43±0.03	0.45±0.03	0.003
P value	P>0.05	0.823		P>0.05	0.633	

* Level of significant p< 0.05

7- Knee flexion moment in (late stance phase):

There were significant differences of knee flexion moment between pre and post test in control and experimental groups for right and left knees and also there were significant differences of knee flexion moment between post test of both control and experimental groups for right and left knees as shown in table 8. and Fig. 7.

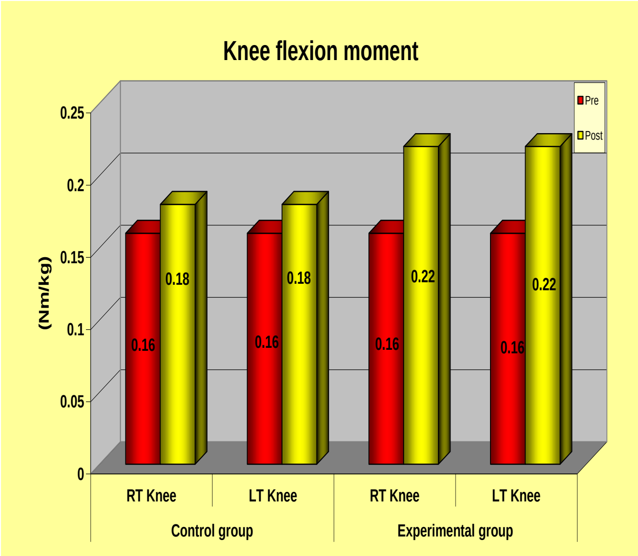

Fig. 7: Knee flexion moment changes between two groups

Table 8. Changes of knee flexion moment between two groups

Knee flexion moment in late stance (Nm/kg)	Right knee			Left knee		
	Pre Test	Post test	P-value	Pre Test	Post test	P-value
Control group	0.16±0.02	0.18±0.01	0.006	0.16±0.03	0.18±0.03	0.04
Experimental group	0.16±0.03	0.22±0.03	0.000	0.16±0.03	0.22±0.03	0.000
P value	P>0.05	0.000		P>0.05	0.000	

* Level of significant p< 0.05

4. Discussions

The purpose of this study was to examine the effect of PH in the management of patients with knee OA. The main findings of the current study showed that there were statistically significant differences between both groups, pre and post test with superiority improvement in experimental group more than the control group. This confirms the effectiveness of the PH as therapeutic modality enhancing the delivery of the drug hence improves patient's symptoms.

Regarding the Descriptive statistics for the participants' demographic data in the experimental and control groups; the insignificant differences between patient characteristics (age, weight, and height) between two study groups may be attributed to the homogeneity of the sample. It was observed that the experimental group was superior regarding VAS scores. These results may be attributed to the use of electrotherapeutic modalities such as TENS, US in addition to the effect of dexamethasone sodium phosphate which is considered as an anti-inflammatory medication. In this study we proposed that penetration of dexamethasone sodium phosphate to the deeper sites is enhanced by PH, resulting in benefits additional to those of conventional therapeutic US.

US is often used in physical therapy because of its deep-heat and pain-relieving effects. When US enters the body, it can affect the cells and tissues through its thermal and non thermal mechanisms. Thermal effect encourages regional blood flow and increases connective tissue extensibility. Non-thermal effects include molecular vibration, which increases cell membrane permeability and thereby enhances metabolic product transport. PH has been suggested by early studies to enhance the absorption of analgesics and anti-inflammatory agents. Effectively, medicines contained within or under the ultrasound gel are pushed by the sound waves of the US and driven to a much deeper level than those massaged by hand (Abd El Baky and Waked 2011).

Ultrasound is thought to enhance drug delivery through the induction of thermal, chemical, and/or mechanical alterations in the involved tissues. Hsieh 2006 suggested that ultrasound increased cell permeability and drug absorption by raising skin temperature. Tissue warming is directly proportional to wave reflection and occurs between tissues of different impedance. Differences in impedance are minimal between skin, fat, and muscle, with a more significant difference existing between soft tissue and bone, Therefore the latter experiences the greatest warming. Chemical changes reported to occur during phonophoresis include the induction of an increased number of oxidation reactions, inactivation of enzymes, and formation of small gaseous bubbles induced by molecular splitting within cells, known as cavitation. Increased adenosine triphosphate activity and increased cell membrane permeability are possible mechanisms. Increased tissue permeability has also been attributed to mechanical ultrasonic "stirring" and increased pore size. Other studies suggest that ultrasound increases percutaneous absorption by inducing changes in stratum corneum lipid structure. Ultrasound may increase cellular and vascular permeability by promoting movement of fluid across cell membranes, a process referred to as acoustic streaming.

In a critical review investigating the use of therapeutic US in the treatment and/or management of osteoarthritis, an accumulating body of literature demonstrates that ultrasound evokes a broad spectrum of bio effects which may be therapeutically beneficial in the management of a variety of clinical conditions. A total of 17 articles met the researchers' criteria; one study (Huang et al.2005) was excluded due to poor methodology. Of a total of five review papers, two concluded that ultrasound had positive therapeutic effects, two did not demonstrate any benefit and one was inconclusive. The remaining eleven studies consistently reported that ultrasound has therapeutically beneficial effects on pain and functional outcomes. Five studies reported that ultrasound has positive cartilage healing properties and one experimental study demonstrated increased intra-articular absorption of high molecular weight molecules using ultrasound PH (Welch et al 2001, Philadelphia et al. 2001, Hinton et al. 2002, Huang et al. 2005, Choi et al.2006). The investigator concluded that ultrasound demonstrates the ability to evoke a broad range of therapeutically beneficial effects which may provide safe and effective applications in the management of osteoarthritis (Srbely 2008).

Moreover, in joints, endogenous opioid peptides have been identified in human inflamed synovium, where they are thought to act on intraarticular opioid receptors to reduce joint pain. Activated opioid receptors inhibit the local release of sensitizing neuromediators such as substance-P, and joint pain is alleviated (Srbely 2008). Dexamethasone sodium phosphate inhibits presynaptic noradrenaline and serotonin reuptake in addition to its weak opioid receptor agonist effect. Thus, it is thought to potentialize the endogenous analgesia system via both its opioid agonist mechanism and monoaminergic effect. Recently, dexamethasone sodium phosphate was shown to result in significant reduction in propofol injection pain, and was also suggested to have a local anesthetic effect when given intradermally. Intraarticular injection of dexamethasone sodium phosphate was found superior to placebo in patients with OA (Srbely, 2008).

The International Association for the Study of Pain defines pain as a multidimensional entity that involves nociception, afferents to the central nervous system, modulation, affective responses, endogenous analgesia, behavioral adjustments, and changes of social roles (Jorge et al.2011). The direct effects of ultrasound (US) and phonophoresis of a nonsteroidal anti-inflammatory drug (NSAID) on injured peripheral tissue have been widely investigated, but evidence concerning the effects of central spinal nociceptive modulation seems to be lacking. The purpose of Hsieh 2006 study was to investigate the peripheral influences of US and phonophoresis on the modulation of spinal inducible nitric oxide synthase (iNOS) expression elicited by hind paw stimulation with an ankle injection of complete Freund adjuvant (CFA)**.** Following the CFA injection, all animals' paw diameters and ankle circumferences ipsilateral to the injected leg were significantly increased compared with the values prior to injection. The rearing behavior of arthritic animals had improved significantly after US and diclofenac phonophoresis treatments. The author concluded that Ultrasound and phonophoresis treatments probably modulate and prevent the CFA-insult–induced increase in total and regional iNOS-LI neurons. Peripheral use of diclofenac phonophoresis offers little advantage over US alone in affecting the central mechanisms of nociception. The peripheral influences of US and phonophoresis on the central modulation of the spinal nociceptive processing system are important and may reflect the work being done through the neuroplasticity of spinal cord in response to peripheral input of US and phonophoresis.

The results of the present study come in agreement with Akinbo et al.2011 who reported that there were significant improvements in pain, stiffness, physical function, walking time and knee ROM post phonophoretic intervention. His study aims to investigate and compare the effectiveness of diclofenac sodium phonophoresis (DSPH), methyl salicylate phonophoresis (MSPH) and conventional therapeutic ultrasound (TUS) in patients with knee osteoarthritis (OA). Forty-five patients were included in this study and randomly assigned to three groups: DSPH, MSPH and TUS. Ultrasound waves of 1 MHz frequency and 1 watts/cm2 were applied to the target knee with either of two topical pain relieving gels as a coupling medium. Acoustic gel without any active pharmacological agent was applied in the TUS group. Ten treatment sessions were performed in all patients in the three groups. Western Ontario McMaster University Osteoarthritis Index (WOMAC) scores, 20-meter walking time and knee range of motion (ROM) were evaluated before and after the treatment using paired t-test and analysis of variance (ANOVA). The clinical outcome measures improved significantly in the three groups post-treatment ($p<0.05$). However, patients in the DSPH group had more improvement in all outcome variables compared with the other two groups ($p<0.05$) except for knee stiffness between DSPH and MSPH ($p>0.05$). No significant differences were observed in the mean changes in any of the outcome variables between MSPH and TUS therapy ($p>0.05$) (Akinbo et al.2011).

Moreover, in a recent study, Luksurapan and Boonhong 2013compare the effects of phonophoresis (PhP) and ultrasound therapy (UT) in patients with mild to moderate, symptomatic knee osteoarthritis (OA). Patients with knee OA (N=46; mean age ± SD, 58.91±10.50y) who had visual analog scale (VAS) scores of 50 to 92mm (mean, 71.5mm) for knee pain intensity and Kellgren-Lawrence grades of I to III were randomly allocated into 2 groups: PhP and UT (23 in each group). Both the PhP and UT groups were treated with an ultrasound program using the stroking technique, continuous mode, 1.0W/cm^2, 10 minutes per session, and 5 times per week for 2 weeks. Four grams of 0.5% piroxicam gel (20mg of piroxicam drug) was used in the PhP group, while the nondrug coupling gel was used in the UT group. A 100-mm VAS for usual pain and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) were evaluated before and after treatment in both groups using a double-blinded procedure. The VAS and total WOMAC scores were significantly improved after treatment in both groups ($P<.001$). The PhP group showed more significant effects than the UT group, both in reducing the VAS pain score ($P=.009$) and in improving the WOMAC score, although it did not reach the level of significance ($P=.143$). Their results indicated that PhP was significantly more effective than UT in reducing pain and tended to improve knee functioning in Kellgren-Lawrence grades I to III knee OA. PhP is suggested as a new, effective method for treatment of symptomatic knee OA.

On the other hand, in a randomized study (n = 60) comparing the effectiveness of ibuprofen phonophoresis with conventional ultrasound therapy in patients with knee osteoarthritis, Kozanoglu et al. (2003) found that ibuprofen phonophoresis was not superior to conventional ultrasound. Smith et al. 1986 compared ice massage, ultrasound alone, and iontophoresis and PH with dexamethasone and lidocaine. Although all of these therapies were more effective than the control treatment, none of them was found to be superior to any other.

Regarding the Spatiotemporal parameters; the findings of the current study revealed that there were significant increases in spatiotemporal parameters (cadence, stride length) in the "post" test compared with the "pre" one in both groups with the superiority in experimental group. These results may be attributed to the selected training program which successfully reducing the knee pain and therefore improve the gait parameters and knee ROM.

Regarding the knee joints kinematics; the findings of the current study revealed that there were significant increases in degree of knee flexion in both stance and swing phase in the "post" test compared with the "pre" one in both groups with the percentage of improvement in experimental group was more than the control group. These results may be attributed to the effectiveness of the training program in reducing the subject pain and subsequently improving the knee joint ROM. Several studies have established that the ROM of the knee joint has significantly decreased and the ROM of other joints of the lower extremities have increased significantly in patients with knee osteoarthritis (Bejek et al.2006). Therefore, the abnormalities observed in measurements of joint angles seem to reflect mechanical changes secondary to osteoarthrosis (Welch et al. 2001).

Regarding the knee joints kinetics; the results of this study revealed that there were significant improvement in knee extension moment in early stance phase between pre and post test in control and experimental groups for right and left knees. These results may be attributed to the treatment program as it includes stretching, strengthening exercise and electrotherapy. This program may improve mobility and flexibility of the knee joints. OA of the knee causes the subjects to limit their activity level, which results in an overall reduction in flexibility and dynamic ROM. The previous studies reported that, the osteoarthritis of the knee joint significantly influenced the muscle moments and muscle power. It can be assumed that the observed locomotor perturbation caused by compensatory or adaptive mechanisms comes as a result of osteoarthritis (Bejek et al.2006).

Gök et al.2002 compared the mechanics of gait in 13 patients with early medial OA of the knee and 13 normal controls, by measuring gait events, kinematic and kinetic parameters. They found that the extensor moment in the loading response was increased and the flexor moment at late stance reduced in the OA group. Similarly, Győry et al. (1976) found reduction in velocity, cadence and stride length in their study. They confirmed the relationship between these parameters and disability. According to Andriacchi et al. (1982), reduced walking speed and stride length were part of the adaptive mechanism to reduce pain by decreasing knee moments. These adaptive changes occurred relatively early in the course of the disease.

From the previous results, it was concluded that, Phonophoresis using Dexamethasone sodium phosphate, was an effective treatment method in decreasing pain and improving gait parameters in osteoarthritic patients.

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