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The effectiveness of whirlpool for patients with neuropathic pain due to knee osteoarthritis

Diz osteoartritine bağlı nöropatik ağrısı olan hastalarda whirlpool'un etkinliği

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Abstract

Aim: Both neuropathic and nociceptive mechanisms may contribute to the OA pain experience. The aim of this study is to determine the efficacy of warm whirlpool on pain, disability, quality of life (QoL) and sleep for patients with neuropathic pain.

Methods: This is a randomized, placebo controlled prospective study. Sixty patients with neuropathic pain due to knee OA were included and randomized into two groups. Group 1 (n=30) were treated with warm whirlpool and Group 2 (n=30) were treated with placebo for 20 minutes during 15 sessions. Patients were evaluated according to pain, knee range of motions (ROM), quality of life (QoL) and sleep quality. The primer outcome measure was pain severity and was assessed using a visual analogue scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). WOMAC disability and functional scores for functional ability, Short Form-36 Health Survey (SF-36) for QoL, Pittsburgh Sleep Quality Index (PSQI) for sleep, DN4 for neuropathic pain were used for assessments. Patients were evaluated at baseline and the end of the 15 day intervention.

Results: At the end of the therapy, there were statistically significant improvements in SF-36, PSQI, DN4 and knee ROM (active and passive) scores ($p<0.05$) for both groups. Also there were a statistically significant improvement for SF-36 scores except for general health score, PSQI and DN4 scores between groups ($p<0.05$);but this improvement was not statistically significant for VAS, WOMAC, SF-36 general health score and knee ROM between groups ($p>0.05$).

Conclusion: Whirlpool provided significant improvements in QoL, sleep, neuropathic pain and disability for patients with neuropathic pain due to knee OA.

Keywords: Neuropathic pain, Osteoarthritis, Sleep, Quality of life, Whirlpool

Öz

Amaç: Hem nöropatik hem de nosiseptif mekanizmalar osteoartritteki ağrıya neden olabilir. Bu çalışmanın amacı diz osteoartritine bağlı nöropatik ağrısı olan hastalarda whirlpool uygulamasının ağrı, dizabilite, yaşam kalitesi ve uyku üzerine olan etkinliğini değerlendirmektir.

Yöntemler: Bu çalışma randomize, placebo kontrollü prospektif bir çalışmadır. Diz osteoartritine bağlı nöropatik ağrısı olan 60 hasta çalışmaya alındı ve iki gruba randomize edildi. Grup 1'deki hastalar (n=30) sıcak whirlpool, Grup 2'deki hastalar (n=30) plasebo whirlpool ile 20 dakika süreyle 15 seans boyunca tedavi edildi. Primer sonuç ölçütü ağrı idi ve görsel analog skala (GAS) ve Western Ontario and McMaster Universities Osteoarthritis (WOMAC) indeksi ağrı skoru ile değerlendirildi. Fonksiyonel abilite için WOMAC dizabilite ve fiziksel fonksiyon skorları, yaşam kalitesi için Kısa-Form 36 (KF-36) ile; uyku, için Pittsburgh Uyku Kalitesi İndeksi (PUKİ) kullanıldı. Nöropatik ağrı varlığı DN4 anketi ile belirlendi. Değerlendirmeler tedavi öncesi ve sonrası yapıldı.

Bulgular: Tedavinin sonunda her iki grupta da KF-36, PUKİ ve DN4 skorları ile diz EHA değerlerindeki düzelme istatiksel olarak anlamlı bulundu ($p<0.05$). Gruplar arasında, KF-36'nın genel sağlık skoru dışındaki tüm alt bileşenleri, PUKİ ve DN4 skorlarındaki düzelme açısından istatiksel olarak anlamlı farklılık saptanırken ($p<0.05$); GAS, WOMAC indeksi ve KF-36 genel sağlık skoru ile diz EHA değerlerinde istatiksel olarak anlamlı farklılık saptanmadı ($p>0.05$).

Sonuç: Diz osteoartritine bağlı nöropatik ağrısı olan hastalarda whirlpool tedavisinin yaşam kalitesi, uyku, nöropatik ağrı ve dizabilite üzerine olumlu etkileri mevcuttur.

Anahtar kelimeler: Nöropatik ağrı, Osteoartrit, Uyku, Yaşam Kalitesi, Whirlpool

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Introduction

Osteoarthritis (OA) of the knee is the most common cause of knee pain in middle-aged and older persons and its known that prevalence of this condition is increasing [1,2]. OA-related pain has been attributed to local tissue injury and this injury can cause nociceptive pain [3]. However some studies showed that both neuropathic and nociceptive mechanisms may contribute to the OA pain experience [4-6].

Neuropathic pain may be caused by a lesion or a disease of the somatosensory system and the management of neuropathic pain is challenging because the response to most drugs remains unpredictable despite attempts to develop a more rational therapeutic approach [7-10]. So it has become the subject of research for alternative treatments of neuropathic pain for clinicians.

Hydrotherapy is a superficial heating or cooling process and it is an external application of water to the body parts for therapeutic purposes [11]. Whirlpool treatment method is used for medical and surgical conditions; also widely for musculoskeletal disorders [12]. This treatment is especially useful to decrease muscle spasm and pain [13-16]. In literature there are studies which recommend whirlpool therapy as a treatment for reducing pain in patients with osteoarthritis [16]. But we couldn't find any reports in the literature about the use of whirlpool for treatment of patients with neuropathic pain due to knee OA. The aim of this study was to determine the efficacy of warm whirlpool on pain, disability, quality of life (QoL) and sleep for patients with neuropathic pain.

Materials and methods

Study Design

This placebo randomized controlled trial was conducted in a university hospital. The study protocol was approved by the Institutional Review Board of the university ethics committee with 30112015-6 registry number. The Declaration of Helsinki protocols were followed. All participants were informed about the study and signed written informed consent before interventions. The study was carried out from December 2015 through March 2016.

Participants and Randomization

A total of 60 patients with neuropathic pain due to knee OA were randomized into either intervention (warm whirlpool) (n=30) or placebo (n=30) groups. Knee OA diagnosis was made based on American College of Rheumatology criteria [17]. Severity of knee OA was determined radiologically by Kellgren-Lawrence scoring system [18]. Neuropathic pain diagnosis was considered if Douleur Neuropathique 4 (DN4) score was ≥4. Individuals were included in the study if they were between 50-75 years and have been suffering from knee pain at least 3 months, whose radiological manifestations considering were consistent with grade 3 and 4 knee OA due to Kellgren and Lawrence criteria had DN4 scores ≥4. Individuals were excluded if they had lower extremity surgery history, knee infection, inflammatory disease like rheumatoid arthritis, back or pelvic pain related with knee pain, another cause of polyneuropathy (diabetes mellitus, vitamin B 12 deficiency, toxic or neurological disease like stroke, spinal cord injury), lumbar disc herniation, malignancy or active systemic disease.

After physical examination all patients received knee anteroposterior and lateral radiography; also full blood count, erythrocyte sedimentation rate (ESR), C- reactive protein (CRP) and biochemical markers were evaluated.

With numbered envelopes method participants were randomly assigned into two groups. All of the patients were blinded to treatment allocation but the physiotherapist who applied the therapy was aware of the procedure.

Intervention and control

Patients were asked to sit on an adjustable chair beside the whirlpool and submerse their legs in the water to mid-femoral level.

Intervention group (n=30) were treated with warm whirlpool. Warm whirlpool administered at temperatures between 30.0°C and 40.0°C.

Control group (n=30) were treated with warm water at temperatures between 30.0°C and 40.0°C when whirlpool machine was turned off. Both groups received 15 sessions for 20 minutes during 15 days.

A home-based exercise program including isometric-isotonic knee exercises and hip extensor stretching exercises were given to all patients every day during the treatment. No medications including analgesic drugs or non-steroidal anti-inflammatory drugs were allowed during the treatment process.

Outcome Measures

Patients were evaluated at baseline and the end of the 15 day intervention. The primary outcome measure of the study was pain intensity and the secondary outcome measures of the study were Western Ontario and McMaster Universities Osteoarthritis (WOMAC) index, Short-Form 36 (SF-36) Survey, Pittsburgh Sleep Quality Index (PSQI), Douleur Neuropathique 4 scores and knee active and passive range of motion values.

Pain Intensity

Pain intensity was measured on visual analog scale (VAS), where 0 = no pain and 10 = worst possible pain. VAS revealed three mean scores for both knees; at rest, on movement and pain at night scores. This scale was completed by the patients.

Western Ontario and McMaster Universities Osteoarthritis (WOMAC) Index

WOMAC is a self-administered measure that assesses the dimensions of pain, stiffness and function in patients with OA of the hip or knee [19]. The 24-item WOMAC is divided into 3 subscales including pain (5 questions, score range: 0–20), joint stiffness (2 questions, score range: 0–8), and physical functionality (17 questions, score range: 0–68). It produces three subscale scores (pain, stiffness and physical function) and a total score (WOMAC index) that reflects disability overall. The reliability and validity study of the scale in the Turkish population was carried out by Tüzün et al. [20].

Short-Form 36 (SF-36) Survey

The health-related life quality of the patients in both groups was evaluated by SF-36 survey. SF-36 is composed of eight health subsections (physical function, physical role, pain, general health, vitality, social function, emotional role, and mental health). The scale is scored between "0" as the worst

score and "100" as the best score. The validity and reliability of the Turkish version of this survey has been reported by Kocyigit et al. [21].

Pittsburgh Sleep Quality Index (PSQI)

Sleep quality of the patients was evaluated with PSQI. The scale includes 24 questions; 19 questions answered by the person him/herself and the remaining 5 answered by his/her bed partner. The first 19 self-answered questions evaluate 7 subscales, i.e. subjective sleep quality, sleep latency, duration of sleep, routine sleep activity, sleep disorders, the use of drugs for sleeping, and daytime dysfunction. Each item in the scale is scored between 0 and 3 (no difficulty to severe difficulty) [22]. The sum of the 7 subscale scores give the overall PSQI scores [23]. Sleep quality is evaluated as fine in those with an overall score of 5 or lower. The reliability and validity study of the scale in the Turkish population was carried out by Ağargün et al. [23].

Douleur Neuropathique 4 (DN4) scores

The DN4 questionnaire (Douleur Neuropathique 4 questions) was originally developed and validated for neuropathic pain diagnosis [24]. DN4 is a clinician-administered questionnaire; consists seven items related to symptoms and three related to clinical examination. For each item, a score of ''1'' is given if the answer is ''yes'' and a score of ''0'' is given if it is ''no.''. The patient is defined to have neuropathic pain if the total score is calculated to be 4 or more. The reliability and validity study of Turkish version of DN4 was made by Cevik et al. [25].

Knee Range of Motion

The active and passive knee range of motion (ROM) (right–left) was measured using a goniometer when the patient was in neutral supine position and mean values for both knees were included.

Statistical analysis

The means and standard deviations were given as descriptive statistics. All data for normality was tested by using Kolmogorov-Smirnov test. Wilcoxon test was used to calculate the pre and post-treatment value differences. To compare the differences between two groups, Mann Whitney U was used. A level of significance of $p<0.05$ was accepted. All analyses were performed using the SPSS for Windows 18.0 software program.

Results

A total of 60 patients were included the study. All of the participants completed the study protocol and none of participants had any side effects.

The results of full blood count, ESR, CRP and biochemical markers were in normal ranges for all groups. 36 of patients had Kellgren- Lawrence grade 3 OA and 24 of patients had Kellgren- Lawrence grade 4 OA.

The demographic characteristics and baseline values of the outcome measures of the patients are presented in Table 1. No statistically significant differences were detected between the groups at baseline values ($p>0.05$) except age, weight and WOMAC total score values ($p<0.05$) (Table 1).

For both intervention and placebo groups, statistically significant improvement in VAS (p=0.00); WOMAC pain, stiffness, physical function and total scores (p=0.00) (Table 2); SF-36 physical function (p=0.00 and p=0.01 respectively), SF-36 role limitation (physical) (p=0.00 and p=0.01 respectively), SF-36 bodily pain (p=0.00 and p=0.01 respectively), SF-36 general health perceptions (p=0.00), SF-36 vitality (p=0.00), SF-36 social role function (p=0.00 and p=0.02 respectively), SF-36 role limitation (emotional) (p=0.00 and p=0.02 respectively) and SF-36 mental health (p=0.00 and p=0.03 respectively) scores, PSQI (p=0.00), DN4 score (p=0.00) and knee active and passive ROM (p=0.00) were found after 15 days of intervention (Table 3).

Table 1: Demographic characteristics and baseline values of the outcome measures

Variables	Intervention Group (n=30) mean±SD	Placebo Group (n=30) mean±SD	p
Age	67.77±7.70	66.40±8.13	0.20
Sex (Female/Male)	24/6	22/8	0.00*
Height (cm)	162.77±9.28	163.50±10.04	0.00*
Weight (kg)	75.17±10.39	74.33±6.60	0.09
Duration of disease	9.43±4.48	9.37±6.31	0.00*
VAS at rest	5.40±1.00	5.00±1.01	0.00*
VAS on movement	7.50±1.13	7.37±0.61	0.00*
VAS pain at night	4.43±1.13	4.10±1.06	0.00*
WOMAC pain	10.46±3.00	10.60±3.14	0.00*
WOMAC stiffness	2.83±1.20	2.06±1.38	0.00*
WOMAC physical function	33.86±8.76	34.06±8.48	0.00*
WOMAC total	47.16±11.62	46.73±11.97	0.10
SF-36 physical function	51.00±20.56	41.67±26.50	0.00*
SF-36 role limitation (physical)	30.00±36.78	30.00±35.59	0.00*
SF-36 bodily pain	39.70±10.63	41.40±15.81	0.00*
SF-36 general health perceptions	54.03±17.23	48.93±21.73	0.00*
SF-36 vitality	53.17±17.83	52.83±22.54	0.00*
SF-36 social role function	51.32±17.42	53.75±21.81	0.00*
SF-36 role limitation (emotional)	55.57±49.79	57.78±48.68	0.00*
SF-36 mental health	63.60±14.93	59.07±21.04	0.00*
PSQI score	12.93±3.52	12.10±3.49	0.00*
DN4 score	6.87±1.13	6.03±1.56	0.00*
Knee ROM (active)	115.67±5.97	123.33±11.84	0.00*
Knee ROM (passive)	122.17±6.65	127.33±10.64	0.01*

*p<0.05, mean±SD; mean±standard deviation, VAS; visual analog scale, WOMAC; Western Ontario and McMaster Universities Osteoarthritis Index, SF-36;Short-Form 36, PSQI; Pittsburgh sleep quality index, DN4; Douleur Neuropathique 4, ROM; range of motion

Table 2: Comparison of the outcome measures in both groups and between the groups for VAS and WOMAC scores

Variable	Intervention Group (n=30) mean ±SD	Placebo Group (n=30) mean ±SD	p value
VAS at Rest			
Before treatment	5.40±1.00	5.00±1.01	0.34
After treatment	3.90±0.71	3.77±1.00	
p value	0.00*	0.00*	
VAS on Movement			
Before treatment	7.50±1.13	7.37±0.61	0.14
After treatment	5.60±1.00	5.93±0.94	
p value	0.00*	0.00*	
VAS Pain at Night			
Before treatment	4.43±1.13	4.10±1.06	0.34
After treatment	2.57±0.89	2.80±0.96	
p value	0.00*	0.00*	
WOMAC Pain			
Before treatment	10.46±3.00	10.60±3.14	0.20
After treatment	7.53±2.80	8.53±3.14	
p value	0.00*	0.00*	
WOMAC Stiffness			
Before treatment	2.83±1.20	2.06±1.38	0.38
After treatment	1.33±1.02	1.16±1.28	
p value	0.00*	0.00*	
WOMAC Physical Function			
Before treatment	33.86±8.76	34.06±8.48	0.15
After treatment	24.46±8.43	127.80±7.86	
p value	0.00*	0.00*	
WOMAC Total			
Before treatment	47.16±11.62	46.73±11.97	0.23
After treatment	33.33±10.91	37.5±11.28	
p value	0.00*	0.00*	

*p<0.05, mean±SD; mean±standard deviation, VAS; visual analog scale, WOMAC; Western Ontario and McMaster Universities Osteoarthritis Index

Table 3: Comparison of the outcome measures in both groups and between the groups for SF-36, PSQI and DN4 scores and knee ROM (active and passive) values

Variable	Intervention Group (n=30) mean ±SD	Placebo Group (n=30) mean ±SD	p value
SF-36 Physical Function			
Before treatment	51.00±20.56	41.67±26.50	0.01*
After treatment	67.50±9.07	52.17±22.50	
p value	0.00*	0.00*	
SF-36 Role Limitation (Physical)			
Before treatment	30.00±36.78	30.00±35.59	0.00*
After treatment	74.17±24.10	45.83±37.76	
p value	0.00*	0.01*	
SF-36 Bodily Pain			
Before treatment	39.70±10.63	41.40±15.81	0.00*
After treatment	56.00±6.61	47.90±8.58	
p value	0.00*	0.01	
SF-36 General Health Perceptions			
Before treatment	54.03±17.23	48.93±21.73	0.06
After treatment	65.87±6.21	59.80±12.02	
p value	0.00*	0.00*	
SF-36 Vitality			
Before treatment	53.17±17.83	52.83±22.54	0.02*
After treatment	71.17±8.97	62.83±14.30	
p value	0.00*	0.00*	
SF-36 Social Role Function			
Before treatment	51.32±17.42	53.75±21.81	0.05*
After treatment	68.55±14.43	62.53±14.68	
p value	0.00*	0.02*	
SF-36 Role Limitation (Emotional)			
Before treatment	55.57±49.79	57.78±48.68	0.00*
After treatment	98.90±6.02	80.02±35.65	
p value	0.00*	0.02*	
SF-36 Mental Health			
Before treatment	63.60±14.93	59.07±21.04	0.04*
After treatment	74.27±6.36	65.67±15.77	
p value	0.00*	0.03*	
PSQI Score			
Before treatment	12.93±3.52	12.10±3.49	0.04*
After treatment	7.27±3.01	9.27±3.29	
p value	0.00*	0.00*	
DN4 Score			
Before treatment	6.87±1.13	6.03±1.56	0.01*
After treatment	4.37±0.85	5.00±1.31	
p value	0.00*	0.00*	
Knee ROM (active)			
Before treatment	115.67±5.97	123.33±11.84	0.49
After treatment	135.00±7.65	133.00±9.96	
p value	0.00*	0.00*	
Knee ROM (passive)			
Before treatment	122.17±6.65	127.33±10.64	0.24
After treatment	138.83±6.78	136.33±8.50	
p value	0.00*	0.00*	

*p<0.05, mean±SD; mean±standard deviation, SF-36; short form- 36, PSQI; Pittsburgh sleep quality index, DN4; Douleur Neuropathique 4, ROM; range of motion

After the treatment, statistical differences in SF-36 physical function (p=0.01), SF-36 role limitation (physical) (p=0.00), SF-36 bodily pain (p=0.00), SF-36 vitality (p=0.02), SF-36 social role function (p=0.05), SF-36 role limitation (emotional) (p=0.00) and SF-36 mental health (p=0.04) scores; PSQI (p=0.04) and DN4 scores (p=0.01) were found between the groups (Table 2). There were no statistical difference in VAS at rest (p=0.34), VAS on movement (p=0.14), VAS pain at night (p=0,34), WOMAC pain (p=0.20), WOMAC stiffness (p=0,38),WOMAC physical function (p=0,15), WOMAC total scores (p=0,23) (Table 2) and SF-36 general health perceptions scores (p=0,06) and knee active and passive ROM (p=0,498 and 0,245 respectively) between the groups at the end of the treatment (Table 3).

Discussion

Osteoarthritis (OA) of the knee is the most common cause of knee pain and OA-related pain both neuropathic and nociceptive mechanisms may contribute to the OA pain experience [4-6]. Chronic nociceptor stimulation leads modification of central neurons; also neuropathic pain mechanism can occur from different mechanisms like a damage to a nerve innervating an affected joint [26]. While nerve damage is not a recognized feature of OA, there may be sub-clinical damage to small peripheral nerves innervating OA joints increased ectopic activity can occur and contribute to pain intensity [27,28]. Studies with some animal OA models have shown that nerves re-innervating damaged tissues had similar characteristics to that seen in nerve-injury models, including abnormal morphology and an excess of neuropeptides involved in pain transmission [28]. Comorbid pain conditions, psychological and cognitive factors, subclinical neuropathies may further alter central pain processing [26,29,30]. These factors can be missed if evaluation for neuropathic pain is not a part of the standard OA assessment.

In this study we aimed to determine the efficacy of warm whirlpool on pain, disability, quality of life (QoL) and sleep for patients with neuropathic pain. To the best of our knowledge this is the first study which evaluates the effectiveness of whirlpool for patients with neuropathic pain due to knee osteoarthritis.

Hydrotherapy is a superficial heating or cooling process and it is an external application of water to the body parts for therapeutic purposes [11]. Whirlpool treatment was first started by the French army at the First World War years. This treatment method is widely used for medical and surgical conditions [12]. Whirlpool treatment is especially useful to decrease muscle spasm and pain [11,14,15]. This therapy is also recommended as a treatment for reducing pain in patients with osteoarthritis [16]. Hydrostatic immersion combined with warm temperature provides recovery of the blood circulation [31]. Also with heat treatment; capillary permeability, nerve conduction and collagen elasticity increases through vasodilation [16]. Therefore in this research we used warm whirlpool at temperatures between 30.0°C and 40.0°C.

Whirlpool has been found useful for various pain syndromes. In a study with 41 subjects who have myofascial pain syndrome, the patients were randomly assigned into two groups: the whirlpool therapy group whose bodies were immersed in a whirlpool bath at 34°C-36°C for 30 minutes; the hydrocollator group who took a 30-minute application of a standard hot hydrocollator pack [32]. At the end of the study the improvement on pain and anxiety was significantly greater in the whirlpool group, compared to the hydrocollator group [32]. This result was explained by the gate theory; Due to the pressure and thermal temperature of hydrotherapy on the skin pain is relieved [33]. On the other hand thermal waters with temperatures above 34oC are considered to relax muscles, increase tendon extensibility; also dilate blood vessels and facilitate blood circulation. So a wash out of pain mediators and elevation of pain threshold occurs [34]. In a study by Devrimsel et al. [35] 60 patients with complex regional pain syndrome received whirlpool therapy and neuromuscular electrical stimulation for 15 sessions. At the end of the study authors concluded that both whirlpool bath and neuromuscular electrical stimulation were effective in the treatment of complex regional pain syndrome, but the efficacy of the whirlpool bath treatment was better. In a study with 58 women with symptomatic hand OA, patients were randomized into whirpool and parafin treatment groups and at the end of the study it was found that the improvement in pain,

hand functions and quality of life in the whirlpool group was significantly better [36]. In these studies the effect of whirlpool was explained by that whirlpool bath treatment improves regional perfusion, and nutrition; with this the oxygenation to the tissues increases and the skin softens. So as a result, pain and edema reduces and range of motion improves [37,38]. In a study the effects of a warm whirlpool bath on pain and stiffness of 44 patients with chronic stroke induced knee OA were evaluated and whirlpool was found beneficial for patients with chronic stroke induced knee OA [39]. After intervention the stiffness of the whirlpool group was found significantly lower than control group. The results in the studies mentioned above were consistent with our study. Also we determined significant improvement for pain intensity and disability measures at the end of treatment for both groups; as a power of our work we evaluated QoL, sleep and neuropathic pain components and found significant differences between the groups for pain, disability, QoL and neuropathic pain.

There are a number of high-quality studies have recently been published that examine the association between neuropathic pain and health-related quality of life [40]. QoL and sleep are frequently impaired in patients with neuropathic pain [40,41]. So the management of neuropathic pain gains importance regarding QoL. In our study we determined significant improvements at QoL for both groups but this improvement was more significant in whirlpool group and there were statistically significant difference QoL measures except SF-36 general health score. Based on these results of our study, we can conclude that whirlpool therapy can be used as an alternative therapy method in patients with neuropathic pain due to knee OA for improving QoL.

The treatment of neuropathic pain is important because disturbed sleep is common in neuropathic pain and effects on daytime functioning and quality of life of the patient [42]. In our study the improvements at sleep quality was more significant in whirlpool group. So we can conclude that whirlpool therapy is effective for improvement of sleep in patients with neuropathic pain due to knee OA.

In the literature it was mentioned that whirlpool therapy also increases joint ROM [43]. In a study by Kuligowski, et al. [43] 56 subjects with delayed-onset muscle soreness were randomized into cold whirlpool, warm whirlpool and contrast therapy and it was found that cold whirlpool and contrast therapy are more effective than warm whirlpool in terms of improving ROM. They concluded that this effect can be due the effect of cold by decreasing response of muscle spindles to stretch and increasing firing rates of Golgi tendon organs and so muscle relaxation occurs. We determined significant improvement for knee active and passive ROM at the end of treatment for both groups; but there were no statistical significant difference between the groups. This result can be due the use of only warm whirlpool in our study.

Whirlpool therapy is cheap, available and has little or no side effects mostly rather than pharmacotherapy and other modalities. So in people who have neuropathic pain due to knee OA, whirlpool can be an ideal treatment modality.

In this study we have some limitations. We evaluated the effects of only warm whirlpool, but not cold. Heat treatment also contributes the positive effects in a significant manner. It is known that blood flow, capillary permeability, nerve conduction and collagen extensibility increases through vasodilation as a result of heat treatment [16]. So to prove the effects of whirlpool clearly there should be studies with both warm and non-warm whirlpool groups. On the other hand, patients were evaluated only immediately after therapy, long term effects are unknown. So with long term follow up further studies should investigate the effects of both warm and cold whirlpool for neuropathic pain in knee OA.

Warm whirlpool provided significant improvements in pain, disability, QoL, sleep and neuropathic pain and can be used as an additional therapy method in the treatment of patients with neuropathic pain due to knee OA. We think that these effects were mediated by the increase on tendon extensibility, improvement on blood circulation and oxygenation; but further studies with larger samples are needed to better explain the effects of this therapy modality.

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