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Superficial Heat and Cold Applications in the Treatment of Knee Osteoarthritis

Çalışkan Nurcan and Mevlüde Karadağ

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1. Introduction

There is information related to the need to perform heat and cold applications as non-pharmacological methods for the pain control in patients with knee osteoarthritis available in the literature. However, the basis of scientific data supporting the therapeutic effect of the superficial heat and cold application in knee osteoarthritis is weak. The purpose of this study is to consider the basic information about the evidence for the superficial heat and cold application in the treatment of knee osteoarthritis.

2. Body

Heat and cold applications for the purpose of treatment are applied to a part or whole of the body and cause local or systemic effects [1]. In general, the physiological effects of heat are vasodilatation, increased capillary permeability, acceleration of cell metabolism, muscle relaxation, acceleration of inflammation, pain reduction by relaxing muscles, sedative effect, and reducing the viscosity of the synovial fluid to decrease joint stiffness. The physiological effects of cold are generally the opposite of warm effects. The effects of cold are vasoconstriction, a slowdown in cell metabolism, local anesthesia, decrease in blood flow, reduction of the arrival of oxygen and metabolites to the area and the reduction of residuum removal (Table 1) [1-4].

When applying heat to a local and large area of the body, low blood pressure can be seen due to the excessive peripheral vasodilation. This reduction in blood pressure can cause

fainting if it is serious. This effect of heat application in individuals with heart, lung or circulatory system diseases, such as arteriosclerosis, develops more frequently than healthy individuals.

Heat Application Effects	Therapeutic Benefits
Vasodilatation	Accelerates the transport of nutrients and the removal of the residuum by increasing blood flow to the injured area of the body. It reduces the accumulation of venous blood in the region.
Decrease in blood viscosity.	Accelerates the transport of leucocyte and antibody to the injured area
Decrease in blood spasm	Reduces the pain caused by muscle relaxation, muscle spasm or stiffness
Increase in tissue metabolism	Blood flow increases due to the increased local temperature
Increase in capillary permeability	Transition of nutrients and residuum increases
Cold Application Effects	Therapeutic Benefits
Vasoconstriction	Blood flow to the injured area decreases, edema formation is prevented, inflammation reduces
Local anesthesia	Reduces the localized pain
Slowdown in cell metabolism	Decreases the oxygen requirement of the tissues
Increase of blood viscosity	Increases blood coagulation in injured area
Decrease the blood spasm	Reduce the pain

Table 1. The effects of heat and cold application [4]

The prolonged cold application and vasoconstriction may cause an increase in the blood pressure. Because, the way of blood flow changes towards the internal blood vessels from the surface (cutaneous) due to the vasoconstriction. Shivering is another general effect of long stay in the cold and a response of the body to warm itself [5].

3. Physiological tolerance to heat and cold

The tolerations to the heat and cold applications of individuals are quite different (See Table 2). In some cases, when performing the heat and cold applications, precautions are required to reduce the risk of injury. Conditions that increase the risk of injury are given in Table 3.

Condition	Risk factors
Part of the body where the application is done	Back of the hands and feet are not very sensitive to temperature changes. The inner face of the forearm and wrist, neck and perineum are sensitive to temperature changes.
The size of the body area where the application is done	When the areas exposed to heat or cold tolerance grows, tolerance decreases When the areas exposed to heat or cold tolerance get smaller, tolerance increases
Individual tolerance	Tolerance in infants and elderlies are generally very low. Tolerance to heat or cold is high in individuals with Sensory and nervous system disorders. However, warm or cold damage risks of these people are too much.
The duration of administration	Individual feels heat or cold severely until the skin temperature changes, however, later tolerance increases.
The integrity of the skin	Impaired skin integrity is more sensitive to temperature changes.

Table 2. Factors affecting physiological tolerance to heat and cold [5]

Condition	Risk factors
Age (infants, children and elderly individuals)	Having a thin skin layer in children, decreasing the sensitivity to pain in the elderly increases the risk of burns
Disruption of skin integrity, open wound, stoma	Subcutaneous and deep tissues are more sensitive to temperature changes. Because they do not contain the heat receptors and their pain receptors are few.
Edema or scar regions	Intracellular accumulation of fluid or thickening caused by scar tissue reduces the sensitivity to heat.
Peripheral vascular disease (diabetes mellitus, arteriosclerosis, etc.).	Sensitivity to temperature and pain in the extremities decrease due to the circulatory disorders and local tissue damage. Cold application further reduces the blood flow.
Confusion, loss of consciousness	Sensory stimuli or the perception of pain decrease
Spinal cord injury	Sensory stimuli and the perception of pain is prevented due to the changes in the nerves transmit pathway

Table 3. Situations enhancing the injury risk in heat and cold applications [4]

4. The adaptation of heat and cold receptors

Heat and cold receptors (thermo receptors) are attuned to the changes of temperatures. Receptors are initially and strongly stimulated when exposed to sudden temperature changes. This stimulation is strong at the first few seconds, and stimulation continues more slowly during the following half an hour. Thus, receptors are adapted to the new temperature. This adaptation explains why an individual feels very cold when suddenly comes out of a cold environment to a warm room, or vice a versa, why the individual feels so hot when suddenly comes out of a warm environment to a cold room.

An understanding of this adaptation mechanism is very important when heat and cold applications are performed. Patients cannot evaluate the temperature of the heat or cold applications developed right after adaptation. When heat applications are performed, serious burns after performing adaptation can develop. On the contrary, when the cold application is performed, this may result in pain, or blood circulation may be impaired in the area of application [5].

4.1. Rebound phenomenon

Rebound phenomenon is a situation that is developed by exceeding the maximum time of therapeutic effect in heat and cold applications, and in which an opposite effect of the practice other than the desired effect occurs. The heat generates vasodilation maximum 20-30 minutes. If the application continues more than 30-45 minutes, the congestion occurs in tissue, and the blood vessels react to this case by constricting. The reason of this reaction is unknown. If heat applications further extend, burn risks are likely to occur, since the constricted blood vessels cannot deliver the heat application to the other parts of the body by circulation enough [5].

In cold applications, when the skin temperature falls to 15 °C (60 °F), vasoconstriction gets the maximum level, and vasodilatation starts below 15 °C. In normal conditions, this is a protective mechanism that prevents the body tissues such as the nasal and ear from freezing when exposed to cold. This is due to this mechanism that a person's skin becomes red when walking at cold weather. Heat and cold applications must be completed before a rebound phenomenon initiates [5].

5. Heat and cold applications

The use of hot and cold applications in medicine history goes back to the ancient times. For example, Hippocrates, in his book titled "Management of Acute Disease ", recommended the application of the hot water -filled caps made of clay or metal for the pain in the costal joints, and to place a soft material between skin and cap to prevent the burns. In addition, he mentioned the dry and heat applications that consisted of a heated corn in the blanket made of wool [6]. Different types of materials related to general and local heat and cold applications have been produced by the medical technology since Hippocrates.

Patients should be considered before performing heat or cold applications. The application area should be checked for the tolerance of application, skin integrity of the patient, bleeding, and circulatory disorder, and the information about the application to the patient should be provided. The conditions in which heat application must be avoided are shown in Box 1.

Box 1. The conditions in which heat and cold applications must be avoided:

The conditions in which heat applications must be avoided [5]:

- *Within the first 24 hours after traumatic injury.* Temperature increases bleeding and edema.
- *In active bleedings.* Temperature causes vasodilation and increases bleeding.
- *Edema not caused by inflammation.* Temperature increases capillary permeability and edema.
- *In localized malignant tumors.* Temperature increases the risk of metastasis by accelerating the cell metabolic rate, cell growth and circulation.
- *In the skin problems characterized by redness and blistering.* Temperature can cause severe damage or skin burns.

The conditions in which cold applications must be avoided:

- *In an open wound.* Cold decreases the blood flow, so the tissue damage may increase.
- *In the patients with circulatory disorders.* Cold disrupts the nutrition of the tissue and can cause tissue damage. In patients with Raynaud's disease, cold increases arterial spasm.
- *In the patients with cold allergy or hypersensitivity to cold.* Inflammatory response begins in some patients that have cold allergy. Erythema, urticaria, edema, joint pain, and muscle spasms may occur. If individuals have hypersensitivity, some of the inflammatory responses may cause a sudden rise of the blood pressure.

6. Selecting wet or dry applications

Heat and cold applications can be applied in two ways: dry and wet. The type of wound or injury, the part of the body that application will be carried out, and the presence of inflammation are the factors affecting the choice of dry or wet application (Table 4).

Multiple treatment options are available for patients with OA of the knee including the use of superficial heat or cold, transcutaneous electrical nerve stimulation (TENS), oral medications, the injection of hyaluronic acid or a corticosteroid, or ultimately knee joint replacement surgery. Common ways of superficial heat-cold application are thermoforms, electrical heating pads, aquathermia pads, hot-cold packs, hot water bath, ice bags or collars, and warm – cold soaks, combined cold compression system [1, 3 -5, 7-10].

Advantages	Disadvantages
<i>Wet applications</i>	<i>Wet applications</i>
Wet application prevents drying of the skin and softens the wound exudates.	Softening of the skin (maceration) occurs in the long-term application.
Wet compresses are suitable for many part of the body.	Quick cooling appears due to the evaporation in wet heat applications.
Wet heat applications affect the deep tissues.	Burn risk is high because moisture transmits the temperature in wet heat applications.
Slightly wet and heat application does not increase the perspiration and insensible fluid loss.	<i>Dry applications</i>
<i>Dry applications</i>	Dry heat increases fluid loss by perspiration.
Dry heat application has less risk of burns than Wet heat application.	Dry application is not effective in deep tissues.
Dry application does not cause the skin softening (maceration).	Dry heat can cause drying of the skin.
Temperature is retained longer because there is no evaporation of water in dry heat application.	

Table 4. Selecting Wet or Dry Application[4]

6.1. Thermophore

Thermophore (hot water bag) is widely used, especially for dry heat application at home. It is cheap and easy to use, but there are some disadvantages. Leaking of the bag of hot water or using the bag in appropriate circumstances can cause burns. The temperature of the water in adults and children 2 years of age should be 46-52 °C (115-125 °F). The temperature of the water in unconscious, weak persons and the children under the age of 2 should be 40.5 - 46 °C (105-115 °F) [5, 9].

6.2. Aquathermic pad (Pillow)

Aquathermic or aquamatic (also named K-pad) pads consist of tubes that provide water circulation inside (See Figure 1). Some pads are water-resistant, and some pads have absorbent surface that allows applying wet application. There are various sizes of pads depending on the body parts to be treated. Pads should be applied to the skin in a cover. If pads are directly applied to the skin, they can cause burns. Patients should never lie down on the pad and should be observed for the signs of skin burns during application. While aquathermic pad is applied, the temperature should be 40.5 - 43 °C (105-110 °F) for adults, and the application period is usually 20 - 30 minutes [4, 5].

6.3. Electric heating pad

Electric Heating Pads are utilized for the purpose of local heat application. They are easy to use, relatively reliable, and provide warmth of the same value and can easily get shape of the body part they are applied to. There are a variety of sizes depending on the body area to be treated. There are water resistant covers to make application to the wet dressing in some models [1, 5].



Figure 1. Aquatermic pad [1]

Electric heating pads provide as much temperature as the heat packs with silicindioxyte (hot packs) do. They do not require reheating between the applications, and can be used more than 20 minutes. Furthermore, it has been emphasized that electric heating pads are more suitable for the home use [11].

There are some rules that should be attended by the practitioner when electric heating pad application is performed, otherwise serious burns can occur. These rules are;

- Do not stich the drilling tools such as needle to the pad. The needle may damage the electrical system of the pad and may cause electric shock.
- Application area should be dry if pad does not have a water resistant coating. The presence of water may cause an electric shock.
- Pad should be applied with heating pad key to prevent the patient from increasing the temperature of the pad.
- The patient should not lie on the pad. Burns can occur if the temperature is not spread [5].

The utilization of electric heating pad is limited in hospitals due to the security problems caused by not paying attention to these rules in crowded places such as hospitals [1, 12].

6.4. Hot – Cold pack

Hot - cold packs are used for heat or cold applications and are the bags filled with the silicate gel (Figure 2). The use and preparation of hot and cold packs varies according to the manufacturing company. Therefore, the preparation of the pack and the application time must be done as specified in the user guide. The pack should be prepared by waiting in hot water or microwave if it will be used for the purpose of heat application. Otherwise, the pack should be prepared by waiting in the fridge at least 1.5 hours if it will be used for the purpose of cold application. When disposable quick hot or cold packs are pressurized, the chemical mixture in the package and the heat are released and warming / cooling begins. These packages cannot be used again. These packages should not be tightened, and should be protected from kneaded and shock until the time of use [4, 5, 13].

Hot packs are used for the purpose of dry heat applications, however there are some varieties that are used for wet heat applications. These packages are made of impermeable fabric, and there are special heating units to heat (Figure 3). Silica gel in the fabric bag swells by absorbing large amounts of heat and water. Therefore, the extra water must be filtered; dry towel should be wrapped to the package, and the package should not be placed under the patients, but should be placed over the patients [10, 14].

Hot - cold packs are also utilized by wrapping in a wet towel. Water-resistant treatment cloth or plastic wrap should be used during application to prevent the loss of temperature as in the compressed application [5]. Steps for the application of hot packs:



Figure 2. Hot Packs A. Commercial Hot pack B. Single Use Hot pack



Figure 3. Hot Pack (used for wet heat applications)[13]

6.5. Hot compress

Sterile wet hot compress improves circulation in open wounds, helps to solve the edema, provides drainage and prevents the spread of infections. The temperature of the water in the hot compress applications varies according to the purpose, and it is sufficient to be 40.5 - 43 °C (105-110 °F). During the applications heat disperses quickly. Compresses should be changed frequently for the purpose of keeping the temperature at the same level, and compresses should be wrapped with a plastic cover or a dry towel. Wetness causes Vasodilatation and evaporates the heat from the skin's surface; therefore the patient may feel cold. The room temperature should be controlled [4, 5, 9].

6.6. Hot immersion bath

Hot immersion bath is performed by immersing a part of the body in a heated solution. Hot immersion bath accelerates the circulation, decreases the edema, and provides muscle relaxation. Immersion bath can also be applied to an area that is closed by dressing, and the bath is available with a heated solution. The position of the patient should be comfortable during the application and the solution should be heated up to 40.5 – 43 °C (105 - 110 °F) [4]. Surgical asepsis principles must be complied if the bath is applied with an open wound [5].

6.7. Sitz bath

Sitz bath is an operation by immersing the pelvic part into hot water or in some cases cold water. Sitz bath is useful in patients with painful hemorrhoids, vaginal inflammation, a history of rectal surgery, and opened episiotomy (incision made between the vagina and rectum to facilitate the birth and to prevent the tearing of the vagina) during childbirth. Application should take 15 - 20 minutes and the temperature of the water should be 40.5 - 43 ° C (105-110 °F). However, the time and temperature vary depending on the patient's health status. The patient sits in a tub or a special chair. A large part of the body is exposed to heat during the sitz bath so that the patient should be evaluated in terms of changes in consciousness, nausea, pallor in face, and increase in patient pulse rate [4, 5].

6.8. Cold compress

The application should take 20 minutes to reduce the edema and inflammation and the temperature should be 15 °C (59 °F). Surgical aseptic technique should be used for open wounds. When a cold compress is applied, some unwanted side effects such as burning or numbness, mottling of the skin, redness, extreme pallor, and bluish - purple mottled appearance on the skin can be observed. The procedure for the application of cold compress are the same as hot compress applications [4].

6.9. Cold immersion bath

The procedure for application of cold immersion bath are the same as hot immersion bath applications. The application should take 20 minutes and the temperature should be 15 °C (59 °F) [4].

6.10. Ice bag

Ice bag is made of plastic or rubber, and its mouth is wide enough to contain ice. The ice bag is used for sprains, localized bleeding or hematoma, preventing edema after dental surgery, controlling the bleeding, and creating a local anesthetic effect in the area [4]. An ice bag must be applied by wrapping with a towel or blanket [5].

6.11. Combined cold compress system

Combined Cold Compress System is capable of performing both compression and cold application. It consists of cuffs in the appropriate size of each body region, a refrigerator that is placed in into ice-water, a connecting pipe that provides ice water flows to cuff (Figure 4). Compression allows conductance by increasing the contact between the skin and ice water and reduces blood flow. Thus, it has been indicated that the co-administration of cold with compression in the therapy is more effective than only implementing cold. Combined Cold Compress System is preferred in the control of postoperative pain and the swelling after acute trauma [15].



Figure 4. Combined Cold Compress System

7. Superficial heat and cold application in the treatment of knee osteoarthritis: Is the evidence enough?

Rakel and Barr (2003) have stated that nurses/physicians, traditionally apply heat and cold applications and some massages, thus they should be informed about the strength of the evidence for the efficiency of these applications. The authors have expressed that the methodological evidence for the effect of heat and cold applications on chronic pain is limited [16]. Wright and Sluka (2001) have claimed that the information about the effect of superficial heat application on depressing the pain or improving the physical function are contradictory, and that there are different studies stating that heat application increased, decreased or did not change arthritis pain and other symptoms [17].

Brosseau et al. (2003) investigated the literature in The Cochrane Library for the purpose of determining the effectiveness of heat and cold applications in knee OA, and they found 3 randomized controlled trial involving 179 patients. In one of these studies, ice massage did not have a significant impact on the increase the quadriceps muscle strength (29% relative difference) for 20 minutes for 5 times a week, totally for three weeks compared with the clinical control group. However, ice massage in patients with knee OA was statistically significant different compared with the control group in physical function in and ROM. The role of ice in reducing the pain is uncertain. In another study, ice packs were applied to three days a week for three weeks and there was no positive effect of the treatment compared with the control group. It was suggested that cold packs could be used for reducing knee edema. Heat application had no significant effect compared with the control group or alternative application. Hot pack had no effect on edema compared with placebo or cold packs. The authors stated that a greater number of participants and well-planned researches should be required to determine heat and cold applications in the treatment of knee OA [18]. Jamtvedt et al. (2008) indicated that the above-mentioned studies had small samples and low quality of the work. Furthermore, the authors concluded that the effects of heat and cold applications were unclear [19].

Yıldırım et al. (2010) studied the effect of superficial local heat application that was performed with digital moist heating pad for 20 minutes every other day for 4 weeks. The results showed that heat application reduce pain and increase physical function in patients with knee OA, however it had no effect on stiffness. In this study, patients were followed for routine treatment plan suggested by the physician [20].

Mazzuca et al. (2004) investigated the comparison of warm maintaining kneepad and an elastic kneepad made of cotton. The difference between them was insignificant. The patients in this study continued to pharmacological treatment [21].

Shereif and Hassa (2011) determined that when therapeutic exercise and heat application performed together, pain and stiffness reduced, and physical function improved. However, objective measurement criteria were not used in the evaluation. The patients in this study continued to pharmacological treatment, as well [22].

According to Brandt (1998), although the effect of heat or cold application was not well-researched, approximately 60% of patients diagnosed with rheumatoid arthritis (RA) and OA preferred heat application on their aching joints, while 20% of the patients preferred cold application [23]. Veitiene & Tamulaitiene (2005) studied the applications preferred by the patients diagnosed with OA and RA and benefits obtained. They found that patients with OA specified exercise (55.7%), the use of assistive devices like walking sticks and walkers (29.6%), and heat application (25.9%) as the most effective; splint (3.7%), resting (3.7%) and joint protection (3.7%) as the least effective; and cold application (0%), not effective at all [24].

Davis and Atwood (1996) stated that the current knowledge on the therapeutic benefits of heat application is insufficient and the expected benefit from heat application is low in conditions of severe pain, but in their study with 82 patients with RA and OA, 70% expressed that they applied heat application [25].

Chandler et al. (2002) have found limited scientific evidence for the analgesic effects of heat although heat has been used to relieve pain for years. They attributed this to the lack of well-organized studies [12]. Similarly, Öneş et al. (2006) have mentioned that although heat application has been used extensively on outpatient treatment, the randomized controlled studies were limited in number and were not scientifically conducted [26].

As a result of the meta-analysis study by Philadelphia Panel (2001), which was randomized controlled and depended on the findings of observation studies; it was found that no evidence was present neither for the usage / not usage nor for the clinical usefulness of the physical rehabilitation applications like heat, cold, ultrasound, and massage in practical life [27].

The responsibility for providing better quality care requires decisions based on evidence. Evidence-based applications are important for the results such as improving quality of care and care outcomes, making a difference in the results in clinical practices and patient care results, and standardizing the care [28]. Application guidance is directive for the evidence-based practice. Osteoarthritis Research Society International (OARSI), which is the most comprehensive guide published on hip and knee OA treatment so far, has referred to the study by Brosseau et al. in 2003 as the first systematic review published regarding heat and cold applications [18]. Kirazlı (2011) stated that research evidences supporting the treatment of localized heat and cold applications were less, however this treatment method was widely used by the patients with OA, and it was recommended as a simple and reliable method for the relief of pain in most guidelines [29].

8. Conclusion

As discussed above, there is some information in the literature that heat and cold applications should be superficially performed in patients with knee OA as a non-pharmacological method for controlling pain. However, the basis of scientific data that supports heat and cold applications could be effective on chronic pains such as the knee OA is weak [16, 30]. Today, although the need for quality care based on evidence exists, the existing studies on the effectiveness of heat and cold applications on knee OA are not sufficient to cover it. As a result, in spite of the need for further research to determine the effectiveness of the superficial heat and cold applications, superficial heat and cold applications are available to help treatment due to the presence of very few side effects, ease of implementation, and their non-invasiveness [31].

Author details

Çalışkan Nurcan* and Mevlüde Karadağ

*Address all correspondence to: nurcany@gazi.edu.tr

Gazi University, Faculty of Health Sciences, Nursing Department, Ankara, Turkey

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