Scand J Rehab Med 21: 55–57, 1989

INTRA-ARTICULAR TEMPERATURE MEASUREMENTS AFTER SUPERFICIAL HEATING

A. Weinberger,[1] R. Fadilah,[1] A. Lev[2] and J. Pinkhas[1]

From the [1]Department of Internal Medicine D, Beilinson Medical Center, Petah Tiqva and Tel Aviv University Sackler School of Medicine and the [2]Department of Electronics, Weizmann Institute of Science, Rehovot, Israel

ABSTRACT. Superficial heating of the joint is widely used in various rheumatic conditions and is considered as decreasing the intra-articular temperature. This study shows that heating the joint with hot pack significantly increases the articular temperature from 35.2±1.5°C (mean ± SD) to 36.4±1.0°C ($p<0.001$), while intra-cavity temperature of the contralateral unheated knee joint did not change significantly. Since such elevation of temperature of one degree C is liable to enhance the inflammatory process, the use of superficial heating has to be carefully reconsidered in acute and chronic inflammatory joint diseases.

Key words: joint temperature, heating.

Superficial heat such as that supplied by hot packs rarely penetrates the skin more than a few millimeters and, thus, does not raise intra-articular temperature (4). Horvath & Hollander (3) found that the application of hot packs for less than 20 min to the knee joints resulted in a decrease of intra-articular temperature by a reflex mechanism. Later studies, using various other modalities of heat therapy, such as microwave energy and short wave diathermy, failed to show such a reflex cooling effect (2, 6). In this study we re-evaluate the effect of superficial heat on the joint cavity temperature and the heating effect on the contralateral (unheated) knee temperature.

PATIENTS AND METHODS

Temperature studies were performed on the knee joints of five patients with bilateral knee effusions who signed informed consent forms. Four patients had rheumatoid arthritis and one suffered from osteoarthritis. All studies were carried out at a room temperature of 22°C. The patients were asked to recline for 8 hours prior to the studies. The skin was cleaned with an antiseptic solution and the medial aspect of each knee surface was anaesthetized with ethyl chloride spray. A 19-gauge I. V. Venflon® cannula with Teflon catheter was inserted into the joint space beneath the patella by a medial approach. The cannula had a temperature thermocouple at its end and was connected to a Bailey® temperature recorder. Surface temperature probes were placed on each knee 1.5 cm lateral to the lateral border of the patella. All probes were connected to the temperature recorder.

A hot pack was placed on the right knee at 42°C for 30 min, while the left knee served as a control. Intra-articular temperature, skin temperature and oral temperature were simultaneously monitored before, during and after the heating process.

Student's paired *t*-test was used for statistical analysis.

RESULTS

Intra-articular temperature of the heated knees rapidly increased parallel to the increase of skin temperature (Fig. 1). Intra-articular temperature of the heated knees remained stable after removal of the hot packs. The skin and joint cavity temperatures of the tested knees did not return to their baseline values until 55 min after cessation of heating, whereas the surface temperature recordings of the untreated knee increased significantly and remained as such during the experiment (Fig. 1). Intra-cavity temperature of the contralateral unheated knee joint did not change significantly and oral temperature measurements were stable in all patients. No adverse reactions could be noted during or within several days after the procedure.

DISCUSSION

Horvath & Hollander (3) noticed already 40 years ago that the application of hot packs to joints increased their surface temperature markedly, but at the same time, decreased the deep temperature; this phenomenon was termed as "cooling reflex". These investigators made their observations on both normal and inflamed joints (six experiments). The application of hot packs invariably resulted in a depression of intra-articular temperature of as

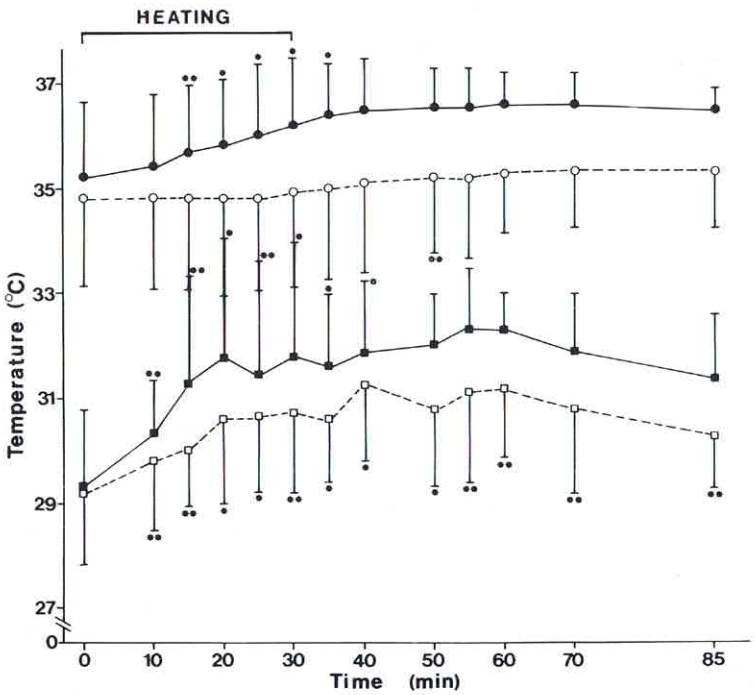

Fig. 1. Temperature recordings (mean ± SD) before, during and after superficial heating of joints. Closed circles are for intra-articular temperature of heated joints. Open circles are for intra-articular temperature of unheated joints. Closed squares demonstrate surface temperature of the heated joints and open squares give skin temperature of unheated joints. * $p<0.01$ when compared to time zero. ** $p<0.05$ when compared to time 35 min (after heating).

much as 2.2°F. They also noted that the internal temperature quickly returned to control levels after discontinuation of the packs and five to ten minutes later the values were slightly higher, a positive reflex effect. Hot packs applied to one knee produced reflex effects in the opposite knee of similar character. They also noted that the packs' removal was followed by a secondary rise in the joint temperatures.

Other studies, using deep heat, did not confirm this observation (2, 6). Mainardi et al. (6) measured intra-articular temperature in normal metacarpophalangeal joint. Cavity temperature rapidly increased parallel to the rise in skin temperature. After stopping the heat, a rapid decline in temperature levels of the skin and intra-articular was noted. Heating the joint by application of high frequency electrical energy was studied in six patients, two with Reiter syndrome and four with rheumatoid arthritis (2). Skin and intra-cavity temperature measurements were elevated during heating. In addition, study of the relative rate of cooling the joints after passive heating was more rapid in a normal subject than in six patients with rheumatoid arthritis or two patients with osteoarthritis. In our study, knee heating by hot packs resulted in a rapid rise in the intra-articular temperature which paralleled the surface change and no "cooling reflex" could be observed. On the other hand, we noted an increase in surface temperatures in the contralateral (unheated) knees, a fact which can be attributed to a "heating reflex".

One reconciliation of the contradictory results of the studies here introduced can be attributed to the difference in the heating modalities used: hot packs vs. microwave energy and short-wave diathermy. Superficial heating probably does not penetrate to the deep structures, while microwave electromagnetic energy can elevate the joint cavity temperature (4, 5, 7). It should be emphasized that the investigation of Mainardi et al. (6) contradicting the classical observation of Horvath & Hollander (3) was performed on normal metacarpophalangeal joints and it has not been proven by any investigation that a similar effect could be observed in the rheumatoid hand. In addition, Horvath and Hollander had studied knee joints containing larger amounts of soft tissue between the skin and the joint space, whereas Mainardi's determinations were concluded following a performance in the small joints of the hand (6).

As a rule, every organ or tissue can be selectively heated if possessing higher water content and/or small blood flow than the adjacent tissues. Thus,

articular effusion, in our patient as well as that of Horvath and Hollander, benefited from a selective heating when using the hot packs. Moreover, using this modality enables distribution of heat to all joint structures which are in close contact with synovial fluid.

There is a general consensus of opinion that in acute inflammatory arthritic processes the use of local cooling or superficial diathermy should be preferred (8). Harris & McCroskery (1), who demonstrated that collagenolysis is four times more intensive at 36°C than at 33°C, added scientific support to this approach. Thus, part of the benefit of the physical modalities therapy in inflammatory arthritides can be attributed to a decrease in intra-articular temperature, thereby lowering the rate at which collagenase degrades cartilage collagen. On the other hand, a moderate increase in joint temperature following movement during normal weight- bearing might cause a slow progression joint damage through activation collagenolysis. Indeed, the response of synovial fluid enzymes and proteins to different levels of physical activity still wait to be explained.

According to this approach, deep thermotherapy might cause exacerbation of the local inflammatory process and is therefore not recommended in inflammatory arthritis.

Contrary to widespread opinion, thermotherapy applied in inflammatory rheumatic diseases was recently shown to provoke no exacerbation and objective improvement of acute phase reactants occurred (9). This study was performed by application of superficial thermotherapy in the form of mud packs heated at 42°C. Thus, the present work together with other evidence bring again to our attention the fact that physical modalities should not be used routinely without consideration of possible side effects. Further studies are underway to determine possible side effects of various heating modalities on the inflammatory processes of arthritis.

REFERENCES

1. Harris, E. D. & McCroskery, P. A.: The influence of temperature and fibril stability on degradation of cartilage collagen by rheumatoidal synovial collagenase. New Engl J Med *290:* 1, 1974.
2. Hollander, J. L. & Horvath, S. M.: The influence of physical therapy procedures on the intra-articular temperature of normal arthritic subjects. Am J Med Sci *218:* 543, 1949.
3. Horvath, S. M. & Hollander, J. L.: Intra-articular temperature as a measure of joint reaction. J Clin Invest *28:* 469, 1949.
4. Lehman, J. F., Brunner, G. D. & Stow, R. W.: Pain threshold measurements after therapeutic application of ultrasound, microwave and infrared. Arch Phys Med Rehabil *39:* 560, 1958.
5. Lehman, J. F.: Diathermy. *In* Handbook of Physical Medicine and Rehabilitation, 2nd ed. (ed. F. H. Krusen, F. Kattke and P. M. Ellwood). W. B. Saunders, Philadelphia, 1971.
6. Mainardi, C. L., Walter, J. M., Spiegel, P. K., Goldkamp, O. G. & Harris, E. D., Jr: Rheumatoid arthritis: failure of daily heat therapy to affect its progression. Arch Phys Med Rehabil *60:* 390, 1979.
7. Schwan, H. P. & Piersol, G. M.: The absorption of electromagnetic energy in body tissues: review and critical analysis. Physiological and clinical aspects. Am J Phys Med *34:* 425, 1955.
8. Swezey, R. L.: Therapeutic modalities for pain relief. *In* Arthritis Rational Therapy and Rehabilitation. W. B. Saunders, Philadelphia, 1978.
9. Zivkovic, M., Cvigetkovic, S. & Jovic, D. L.: Effects of thermotherapy on acute phase reactants in rheumatoid arthritis. Arthritis Rheum *29:* S57 (Suppl.), 1986.

Address for offprints:

Prof. A. Weinberger, M.D.
Head, Rheumatology Unit
Beilinson Medical Center
Petah Tiqva 49 100
Israel