

EFFECTS OF LOCAL HEAT AND COLD TREATMENT ON SURFACE AND ARTICULAR TEMPERATURE OF ARTHRITIC KNEES

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Objective. To evaluate and compare the effects of locally applied heat and cold treatments on skin and intraarticular temperature in patients with arthritis.

Methods. Thirty-nine patients with arthritis of the knee were divided at random into 4 treatment groups (ice chips, nitrogen cold air, ligno-paraffin, and placebo short wave). A temperature probe was inserted into the knee joint cavity and another placed on the overlying skin, and changes in temperature over 3 hours were recorded for each treatment group.

Results. The mean temperature of the surface of the skin dropped from 32.2°C to 16.0°C after application of ice chips and from 32.6°C to 9.8°C after application of nitrogen cold air; the mean intraarticular temperature decreased from 35.5°C to 29.1°C and from 35.8°C to 32.5°C, respectively, after these treatments. Treatment with ligno-paraffin increased the surface temperature by 7.5°C and the temperature in the joint cavity by 1.7°C. No significant changes were observed with placebo short wave diathermy.

Conclusion. The traditional model, that intra-articular temperature is decreased by superficial heat and increased by superficial cold, must be discarded. In arthritis patients, intraarticular temperature is increased by superficial heat and decreased by superficial cold. This has clear consequences for treatment policy.

Locally applied heat and cold are frequently used to treat painful joints. Treatment policy with regard to changes in intraarticular temperature is still

based on the results of studies performed by Hollander and Horvath in the late 1940s (1-3). According to their investigations in patients with arthritis, joint temperature was increased by deep heat treatments, such as diathermy, short wave diathermy, and ultrasound therapy. Intraarticular temperature was believed by them to be decreased by superficially applied hot packs and increased by the application of superficial cold.

Until now, these investigations had not been carefully repeated in patients with arthritis. In the present study, we investigated the effects on the intraarticular and surface temperatures of the arthritic knee produced by 2 superficially applied cold treatments and 1 superficially applied heat treatment, and compared them with the effects of a placebo treatment.

PATIENTS AND METHODS

Patients. Patients with inflammation of a knee joint and either rheumatoid arthritis (RA) (4), osteoarthritis (OA) (5), or ankylosing spondylitis (6) were eligible for the study. Inflammation was defined as impaired joint function together with the presence of local heat, pain, and joint effusion. All patients in our practice during the period July 1989 to June 1992 who met inclusion criteria had been invited to participate in the study, and those who agreed were included. The study design was approved by the hospital's ethics committee. Informed consent was obtained from all patients who participated.

Physiotherapy treatment. Each patient was assigned at random to 1 of 4 treatment groups. Group 1 patients were treated with local applications of ice chips (0°C) for 30 minutes. The chips were produced in a Scotsman AF 2 ice machine (Doorgeest Koeltechniek, Raalte, The Netherlands) and applied in a plastic bag covering the anterior, medial, and lateral aspects of the knee. The average weight of the bags was 3 kg.

The knees of the patients in group 2 were cooled by a 6.5-minute application of nitrogen cold air issuing at -160°C from a Medivent NL (Hoek Loos Cryo Service, Schiedam, The Netherlands). Nitrogen cold air is made available for therapeutic purposes when liquid nitrogen that

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Table 1. Characteristics of the study population, by group*

	Treatment group			
	Ice chips (group 1)	Nitrogen (group 2)	Paraligno (group 3)	Placebo short wave (group 4)
No. of men/no. of women	6/4	6/4	7/3	3/6
Age (years)				
Mean \pm SD	57.7 \pm 12.6	59.8 \pm 11.5	63.2 \pm 10.4	66.9 \pm 11.6
Range	37-79	39-77	37-75	49-79
Body fat (%), mean \pm SD	32.1 \pm 5.6	32.4 \pm 7.4	31.8 \pm 6.5	35.0 \pm 6.7
Knee skinfold (mm), mean \pm SD	7.2 \pm 3.5	7.3 \pm 5.5	7.2 \pm 2.1	9.5 \pm 4.0
^{99m} Tc-pertechnetate index, mean \pm SD†	6.0 \pm 2.3	7.7 \pm 3.0	5.2 \pm 1.9	5.4 \pm 2.6
Diagnosis, no. of patients				
RF-positive RA	7	7	9	6
RF-negative RA	0	1	1	2
Osteoarthritis	2	1	0	1
Ankylosing spondylitis	1	1	0	0
Disease duration (years)				
Mean \pm SD	9.6 \pm 9.8	16.1 \pm 9.8	11.5 \pm 11.5	14.3 \pm 12.1
Range	1-32	2-31	1-36	1-34
Functional class, no. of patients‡				
Class I	0	0	0	1
Class II	3	3	6	5
Class III	4	5	4	2
Class IV	0	0	0	0

* ^{99m}Tc = ^{99m}technetium; RF = rheumatoid factor; RA = rheumatoid arthritis.

† See Patients and Methods.

‡ In RA patients only. Classification categories from ref. 17.

is kept in an expansion barrel at a temperature of -196°C has been heated.

Group 3 patients were treated for 10 minutes with ligno-paraffin (paraligno), a mixture of pure paraffin and ground birchwood, which is maintained at 50°C in a Fangooven FW 5070G (Enraf Nonius, Delft, The Netherlands). The mean application temperature was 47°C . The paraligno was wrapped completely around the knee and covered with two blankets.

Patients in group 4 received placebo short wave diathermy for 15 minutes. A Curapuls 419 apparatus (Enraf Nonius) was used. Electrodes (13 cm in diameter) were placed at the medial and lateral aspects of the knee. The machine was turned on, but with no effective output.

Measurement procedures. A technique previously used in a study of healthy subjects (7) was used to measure intraarticular and skin surface temperature. Patients were acclimatized in the test room for at least 30 minutes before the physiotherapy and temperature recordings were begun. Their knees were exposed to the ambient temperature during the whole test procedure. The average temperature in the room was 21.5°C (SD 0.7°C). There were no statistically significant differences among treatment groups in the mean temperatures of the room (as measured with an Exacon S01 probe; Exacon Scientific Instruments, represented by Polystan Benelux, Almere-Haven, The Netherlands) for the intervals during which they were measured (21.3°C , 21.7°C , 21.6°C , and 21.2°C for groups 1, 2, 3, and 4, respectively). The measurement procedure was performed twice with each patient, with 14 days between the 2 sessions.

The percentage of body fat was calculated after measuring skinfolds over the left triceps and biceps brachia, under the angle of the left scapula, and directly over the left iliac crest (8). We also measured the skinfold over the patella of the treated knee. These data were obtained because of a possible correlation between body fat mass and the insulation of deeper tissues from changes in superficial temperature.

Before every measurement, inflammatory activity was investigated by ^{99m}technetium pertechnetate-pertechnetate perfusion scan (9). ^{99m}Tc-pertechnetate (111 MBq) was injected intravenously and measurements were obtained after 20 minutes, using a parallel collimator. The ^{99m}Tc-pertechnetate perfusion index was calculated as the ratio of the total counts in a region of interest, drawn around the joint under study, to the total counts in a background region, drawn over a normal perfused area of the same extremity.

Statistical analysis. Comparisons within and between groups were analyzed by Wilcoxon signed rank test and Mann-Whitney U test, respectively. *P* values less than 0.05 were considered significant. Spearman's rank order was applied in the correlation studies.

RESULTS

Thirty-nine inpatients were included in the study. There were no significant differences among treatment groups with respect to their clinical data, which are summarized in Table 1. The mean \pm SD

Table 2. Skin surface temperatures in the 4 treatment groups*

Treatment (n)	Baseline temperature	Minimum/maximum temperature†	Temperature after 3 hours	Change, minimum/maximum versus baseline	Difference from change produced by comparable procedure‡
Ice chips (20)	32.2 ± 0.5	16.0 ± 1.0§	31.1 ± 0.8¶	-16.2 ± 0.7	
Nitrogen (19)	32.6 ± 0.4	9.8 ± 1.4§	32.0 ± 0.6¶	-22.8 ± 1.2	6.5§
Paraligno (19)	32.5 ± 0.5	40.0 ± 0.3§	32.3 ± 0.5	7.5 ± 0.5	
Placebo short wave (15)	31.7 ± 0.5	32.4 ± 0.4	31.6 ± 0.5	0.6 ± 0.2	

* Values are the mean ± SEM degrees celsius; n values refer to the number of applications.

† Minimum refers to results with cold treatment; maximum refers to results with heat treatment.

‡ Nitrogen compared with ice chips.

§ $P \leq 0.001$.

¶ $P \leq 0.05$.

thickness of soft tissue over the knee did not differ significantly among the 4 groups, with the exception of the skinfold thicknesses of groups 3 (paraligno) (7.2 ± 2.1 mm) and 4 (placebo) (9.5 ± 4.0 mm) ($P \leq 0.05$). ^{99m}Tc -pertechnetate perfusion indexes were increased in all patients, indicating inflammatory activity in the knee joints (Table 1); in a noninflamed joint, the index would be ~ 1 .

The results of the temperature measurements are summarized in Tables 2 and 3 and Figures 1 and 2. Surface measurement data and intraarticular measurement data were incomplete in 5 cases and 7 cases, respectively, owing to internal damage to the wire, and were excluded from the statistical analyses. With cold treatment, surface temperature as well as intraarticular temperature decreased significantly. Heat treatment with paraligno increased surface temperature as well as intraarticular temperature significantly. Pla-

cebo treatment produced no significant temperature changes. A significant correlation was found between the maximal changes in surface temperature and the maximal changes in intraarticular temperature (Spearman's $\rho = 0.75$).

In 6 of 19 measurements in the ice chip-treated group and in 6 of 17 measurements in the group treated with nitrogen, there was an initial increase in the intraarticular temperature. The increase varied from 0.1°C to 0.3°C and lasted up to 3 minutes. It was always followed by a significant decrease in temperature (Figure 3). In the group treated with paraligno, there was an initial dip in intraarticular temperature in 2 cases. The decrease was 0.2°C in 1 case and 0.3°C in the other, and neither lasted more than 3 minutes.

To take into account the possibility that intraarticular temperature changes might be influenced by the amount of body fat present, we calculated the

Table 3. Intraarticular temperatures in the 4 treatment groups*

Treatment (n)	Baseline temperature	Minimum/maximum temperature†	Temperature after 3 hours	Change, minimum/maximum versus baseline	Difference from change produced by comparable procedure‡
Ice chips (19)	35.5 ± 0.4	29.1 ± 1.1§	33.8 ± 0.9¶	-6.4 ± 0.7	
Nitrogen (17)	35.8 ± 0.4	32.5 ± 0.8§	34.6 ± 0.7#	-3.3 ± 0.4	3.1#
Paraligno (20)	35.6 ± 0.4	37.3 ± 0.2§	35.4 ± 0.4	1.7 ± 0.3	
Placebo short wave (15)	35.4 ± 0.3	35.7 ± 0.3	34.7 ± 0.5	0.2 ± 0.1	

* Values are the mean ± SEM degrees celsius; n values refer to the number of applications.

† Minimum refers to results with cold treatment; maximum refers to results with heat treatment.

‡ Nitrogen compared with ice chips.

§ $P \leq 0.001$.

¶ $P \leq 0.05$.

$P \leq 0.01$.

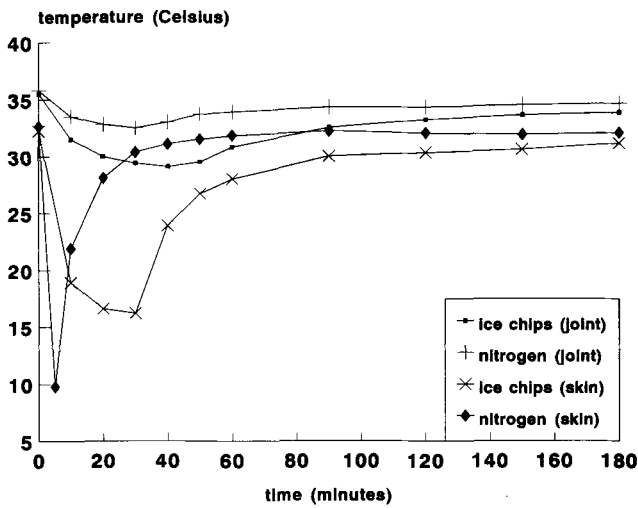


Figure 1. Mean skin and intraarticular temperature during and after treatment with ice chips (30 minutes) and nitrogen (6.5 minutes).

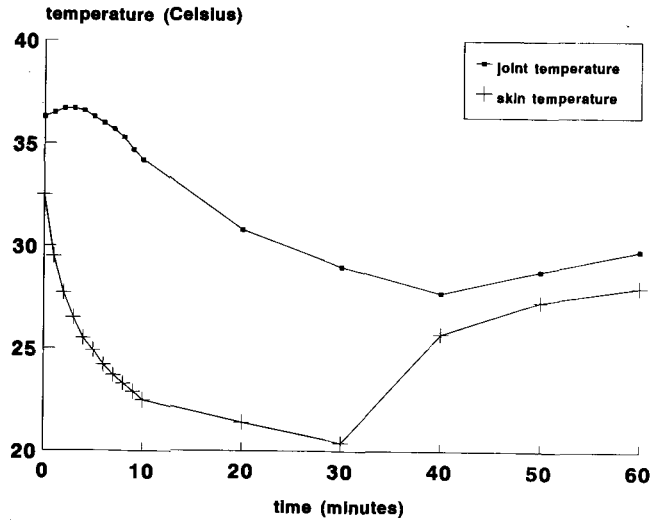


Figure 3. Example of "reflex phenomenon" in a female patient treated with ice chips.

correlations of body fat percentage and skinfold thickness with intraarticular temperature changes. No significant associations were found.

DISCUSSION

On the basis of their classic studies, Hollander and Horvath proposed that in patients with degenerative joint disease and RA, the intraarticular temperature decreases when hot packs are applied to the surface of a joint. Conversely, they suggested that

intraarticular temperature increases upon the application of cold packs, as a result of what they referred to as a "reflex phenomenon" (1,2). According to their model, which is still mentioned in textbooks on physiotherapy (10), surface heating decreases intraarticular temperature by shunting the flow of blood to the dilated superficial vessels and away from the inflamed synovial tissue. The use of cold was believed to increase intraarticular temperature, apparently reversing the postulated shunt mechanism (11).

Acceptance of the model of Hollander and Horvath had consequences for treatment policy. The activity of cartilage-degrading enzymes in RA and OA patients is enhanced at higher intraarticular temperatures (12). The application of superficial heat was therefore advised as a countermeasure (13).

The present study clearly shows that superficial heat (paraligno) increases intraarticular temperature and that superficial cold (ice chips and nitrogen cold air) decreases it. These findings are at odds with those of Hollander and Horvath. In their series of 11 patients treated with heat or cold over a 4-minute period, they found a small change in intraarticular temperature within the first 2 minutes. We propose that what they described as "reflex phenomenon" corresponds to the dips and rises initiating overall increases and decreases, respectively, that we observed in a minority of cases (Figure 3). In all of our patients, the actual changes in intraarticular temperature were clearly related to the changes in the surface temperature caused by physiotherapy. This is supported by the

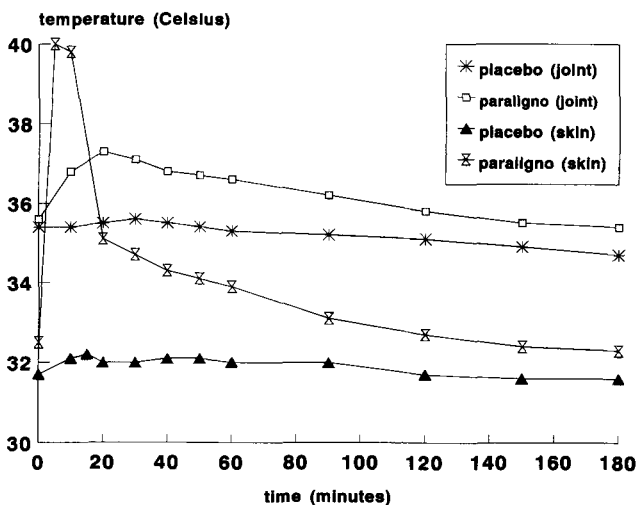


Figure 2. Mean skin and intraarticular temperature during and after treatment with paraligno (10 minutes) and placebo short wave (15 minutes).

significant Spearman's rank order correlation coefficient of 0.75 between surface and intraarticular temperature changes.

A survey of the current English-, German-, and French-language literature on thermotherapy and arthritis revealed only a few small studies performed more recently than those of Hollander and Horvath. Spiegel et al measured intraarticular temperature in patellofemoral joints of 5 RA patients before and during 1 hour of magnetrode treatment (14). Absorbed power (100–200W) was applied with waves of 13–56 MHz. Mean joint temperature increased from 36.6°C (SD 0.8°C) at the beginning to 42.0°C (SD 0.9°C) by the end of treatment. Weinberger et al studied the effects of a 30-minute application of 42°C hot packs on the intraarticular temperature of the knee in 1 OA patient and 4 RA patients (15). They found a significant increase of mean intraarticular temperature, from 35.2°C (SD 1.5°C) to 36.4°C (SD 1.0°C). The differences in the amount of temperature increase in the study by Spiegel et al are due to the duration and intensity of the magnetrode treatment. The results of the study by Weinberger et al are comparable with our findings. In neither study was the "cooling reflex" as described by Hollander and Horvath observed. Different cold and heat applications have varying effects on joint and skin temperature in healthy subjects and patients with arthritis (7,16). The temperature returns to initial values more quickly in arthritis patients than in healthy subjects (7).

Our results provide further evidence for the conclusion that in patients with arthritis, intraarticular temperature is increased by superficial heat and reduced by superficial cold. This has clear consequences with regard to treatment policy, if a goal of treatment is to modulate the activity of cartilage-degrading enzymes. The clinical consequences of these temperature changes with respect to intraarticular chemistry are yet to be determined. Our observations provide a basis for further research into the effects of physical therapy in arthritis.

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