

Tissue Temperature Response to Hot and Cold Therapy in the Metacarpal Region of a Horse

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Ice water immersion resulted in the greatest changes in tissue temperature when compared to three other thermal treatment modalities. The temperature of warm water from a hose should be closely regulated to 40–45°C using a thermometer in the water stream. Tissue temperatures for both ice water immersion and warm water hose therapy stabilized after 10 min. Commercial hot and cold packs were convenient to use but had relatively lower changes in tissue temperatures than ice water immersion or warm water hose treatments. Author's address: Department of Veterinary Clinical Sciences, College of Veterinary Medicine, The Ohio State University, 601 Vernon L. Tharp Street, Columbus, OH 43210-1089. © 2000 AAEP.

Introduction

Thermal therapy, the application of heat and/or cold to a site of injury, is commonly recommended by veterinarians for treatment of equine musculoskeletal injuries. Thermal therapy may have benefits for both acute and chronic injuries. Application of cold therapy to a wound within the first 24–48 hr of injury results in decreases in pain, swelling, local blood flow, and activity of inflammatory mediators at the site of injury.^{1–3} Cold therapy of ankle sprains in humans initiated within 36 hr of injury resulted in decreased pain and return to full use 15 days earlier than controls.⁴ Also in human ankle sprains, cold treatment during the first 48 hr after injury resulted in return to full activity 5 days earlier than bandaged controls.⁵

Heat therapy commencing 72 hr after injury results in increased local blood flow, decreased sensation of pain and increased tissue extensibility.^{1–3} The effects of heat therapy result in increased local tissue metabolic rate that may increase

the rate of healing and facilitate stretching of local tissues.^{1–3}

Procedures for application of thermal therapy in humans have been specifically defined based on tissue temperatures that have demonstrable beneficial effects.^{1–4} In humans, optimal therapeutic tissue temperatures range from 15–19°C for cold therapy,^{1–3} and 40–45°C for heat therapy.^{1,3,6} There are no reports that document tissue temperatures achieved in horses during thermal therapy.

The objective of this study is to determine tissue temperature profiles in response to commonly used hot and cold physical therapy methods in horses.

Materials and Methods

A nine-year-old gelding had thermistor probes aseptically implanted subcutaneously and between the superficial and deep digital flexor tendons of the metacarpal region of one limb.^a A third thermistor was applied to the skin surface.^b Four different thermal therapy modalities (2 hot and 2 cold) were applied to each limb. Baseline temperature read-

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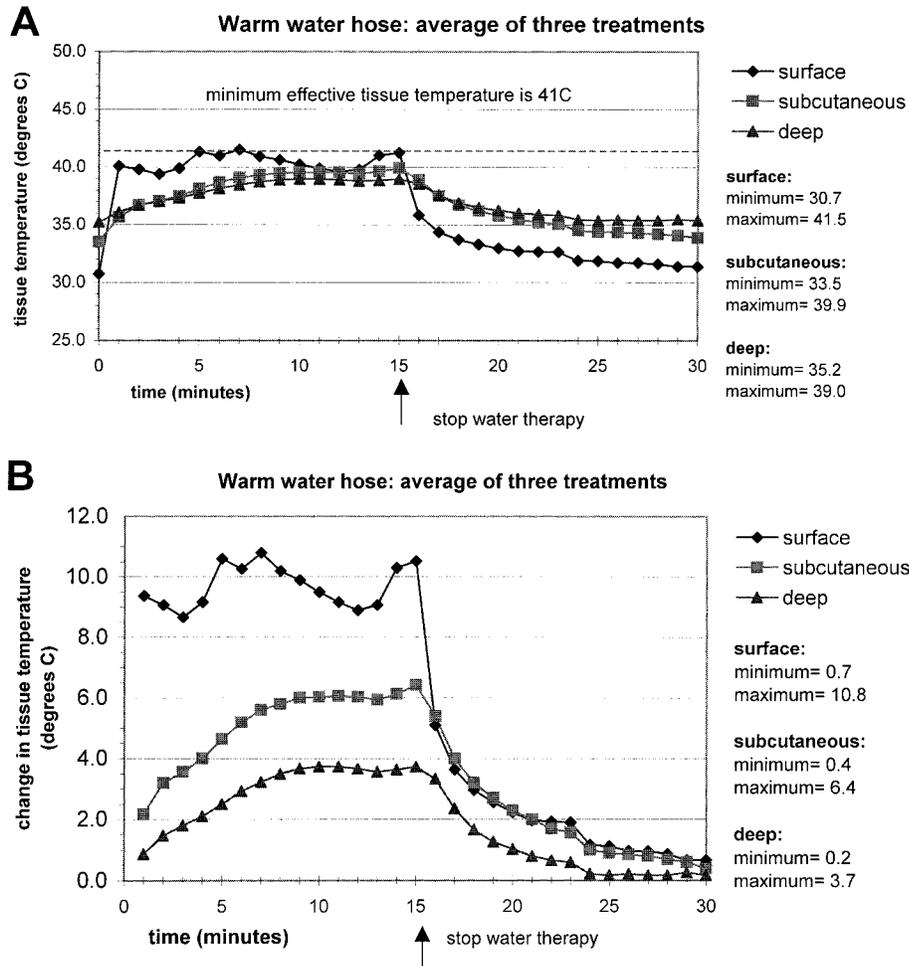


Fig. 1. Warm water hose, average of three treatments. Mean tissue temperature (A) and change in tissue temperature (B). Minimum and maximum values for surface, subcutaneous, and deep thermistors are included.

ings from the three thermistor probes were recorded using an electronic digital thermometer^c prior to treatment, and at 60-sec intervals during and after treatment.

Surgical Procedure

The horse was sedated with detomidine and butorphanol, the left fore limb was prepared for aseptic surgery, and regional anesthesia was administered in a ring block below the carpus using mepivacaine. Two thermistors were aseptically implanted at the same proximal-distal level equidistant from the carpometacarpal and metacarpophalangeal joints: (1) a superficial thermistor was implanted subcutaneously between the lateral and common digital extensor tendons, and (2) a deep thermistor was implanted between the superficial and deep digital flexor tendons. The horse was administered sulfadiazine-trimethoprim (15 mg/kg PO q 12 h) and phenylbutazone (2.2 mg/kg PO q 12 h) beginning the day before surgery and continuing until the third day following implant removal.

Treatment Procedure

Before each treatment the surface thermistor was attached to the skin of the dorsal metacarpus using waterproof tape at the same proximal-distal level as the implanted thermistors. Baseline temperatures were recorded for each probe before treatment was started. Hot water hose treatments were administered for 15 min and the other treatments were administered for 30 min. Temperatures were recorded at 60-sec intervals for each probe during treatment for a total of 30 min for hot water hose treatments and 40 min for the other treatment modalities.

The thermal therapy methods evaluated were: 1) ice water in a therapy boot—8 lbs. of ice mixed with 3 gal of cold water with no agitation during treatment; 2) hot water from a hose—temperature regulated to 42–45°C using surface thermistor readings; 3) commercial hot pack^d; and 4) commercial cold pack.^e The hot and cold pack treatments each used 2 packs activated according to the manufactur-

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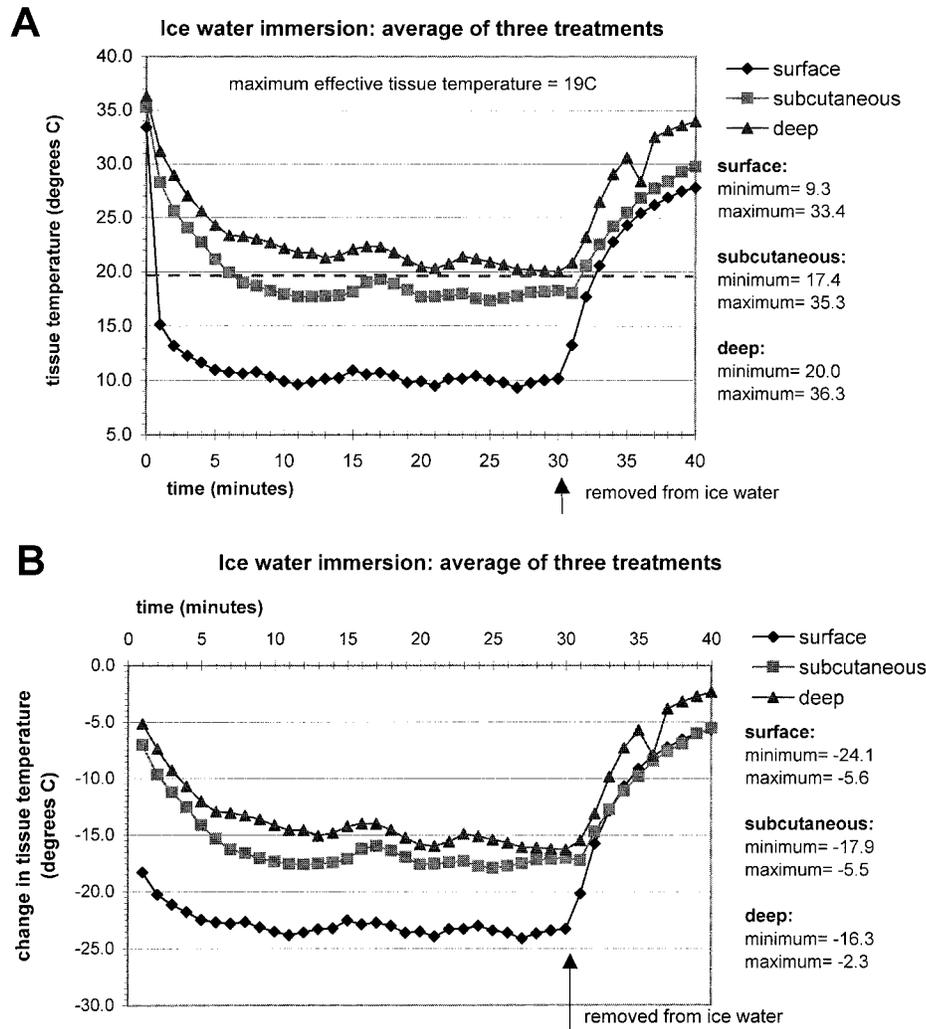


Fig. 2. Ice water immersion, average of three treatments. Mean tissue temperature (A) and change in tissue temperature (B). Minimum and maximum values for surface, subcutaneous, and deep thermistors are included.

er's instructions. The packs were held on the limb using a neoprene wrap with a terry cloth lining provided by the manufacturer^{d,e} which was soaked in water and wrung out before the packs were placed. Each treatment was repeated three times on different days. Following the completion of all treatments the implanted thermistors were removed.

Data Analysis

The data was expressed as mean \pm SD for tissue temperatures recorded for each thermistor at each recording time. Data was combined to create x-y scatter graphs to represent the thermal profile of the tissues for each treatment method. For each treatment modality one graph was made of actual tissue temperature, another was made of changes in tissue temperature compared to baseline. The graphs were used to determine if the treatment modalities achieved the optimal therapeutic tissue temperatures as determined for humans. Friedman's re-

peated measures analysis of variance on ranks was used to determine if differences were present between surface, subcutaneous and deep temperature readings for each of the treatment modalities. Significant differences were isolated using Tukey's test. Significance was set at $p < 0.05$.

Results

The horse tolerated the surgical procedure and the implants without complications. Tissue-response to warm water hose treatment is documented in Figures 1A and 1B. Subcutaneous and deep tissue temperatures never exceeded the therapeutic threshold of 41°C. Skin surface temperatures were raised up to 10°C above baseline during treatment and rapidly declined to near baseline at 30 min. Subcutaneous and deep tissue temperatures increased over the first 9 min of treatment and were stable from 9 to 15 min. Absolute tissue temperatures did not significantly differ by thermistor

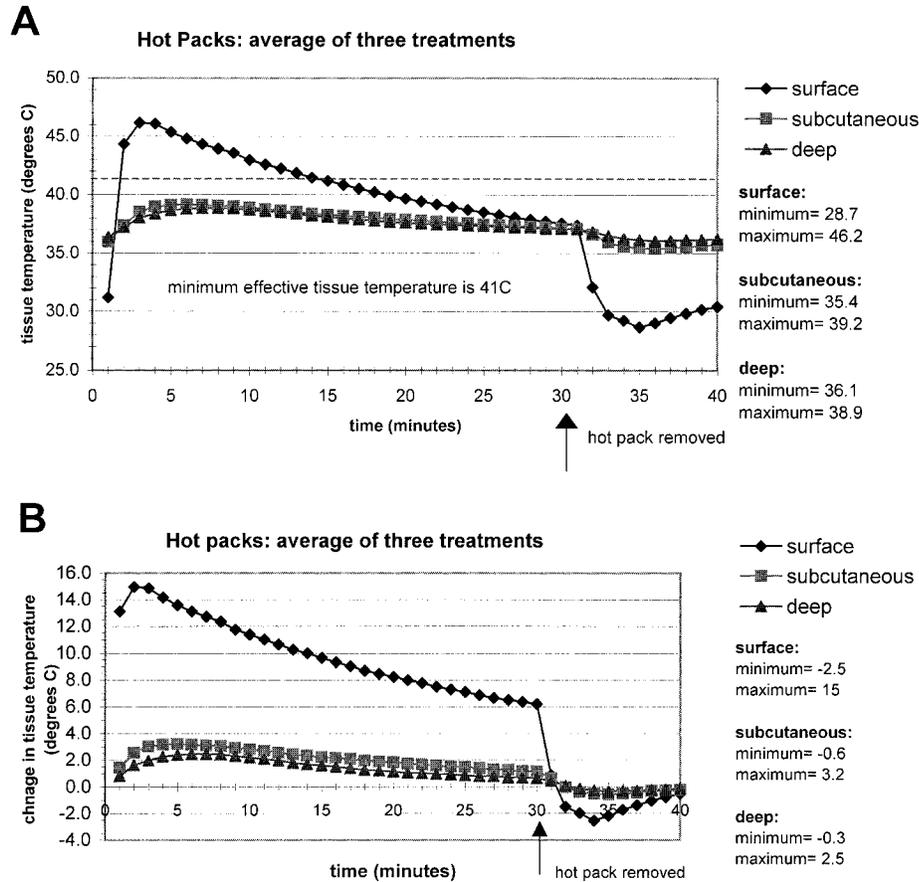


Fig. 3. Hot packs, average of three treatments. Mean tissue temperature (A) and change in tissue temperature (B). Minimum and maximum values for surface, subcutaneous, and deep thermistors are included.

location ($p = 0.95$). The maximum increase in subcutaneous and deep tissue temperatures was 6.4°C and 3.7°C , respectively. Changes in tissue temperature were significantly different by thermistor location ($p < 0.001$). As expected, the surface readings changed the most followed by subcutaneous temperatures, with deep temperatures changing the least ($p \leq 0.05$).

Tissue response to ice water treatment is summarized in Figures 2A and 2B. Tissue temperatures rapidly decreased during the first 5 min of therapy and stabilized during minutes 8 through 30. Surface and subcutaneous tissue temperatures were below the therapeutic threshold of 19°C for study minutes 1–32 and 7–30, respectively. Deep tissue temperature never measured below the 19°C therapeutic threshold. Absolute tissue temperatures significantly differed by thermistor location ($p = 0.004$). Surface temperatures were significantly cooler than subcutaneous and deep tissue readings ($p < 0.05$). All tissues were 5 to 17°C colder than baseline during treatments. Changes in tissue temperature stabilized after approximately 10 min of treatment.

Tissue response to hot and cold packs are summarized in Figures 3 and 4. Subcutaneous and

deep temperatures during hot pack treatments never exceeded the therapeutic threshold of 41°C and resulted in maximum temperature changes of 3.2°C and 2.5°C , respectively. Absolute tissue temperatures significantly differed by thermistor location ($p = 0.004$). Surface temperatures were significantly warmer than subcutaneous and deep tissue readings ($p < 0.05$). Changes in tissue temperature were significantly different by thermistor location ($p < 0.001$) with surface temperatures increasing significantly more than subcutaneous or deep tissues ($p < 0.05$). None of the tissue temperatures measured below the therapeutic threshold of 19°C during cold pack treatments. Subcutaneous and deep tissue temperatures decreased a maximum of 3.1 and 2.5°C below baseline, respectively. Absolute tissue temperatures significantly differed by thermistor location ($p = 0.004$) with surface temperatures significantly warmer than subcutaneous and deep tissue readings ($p < 0.05$). Changes in tissue temperature were significantly different by thermistor location ($p < 0.001$) with surface temperatures decreasing significantly more than subcutaneous or deep tissues ($p < 0.05$).

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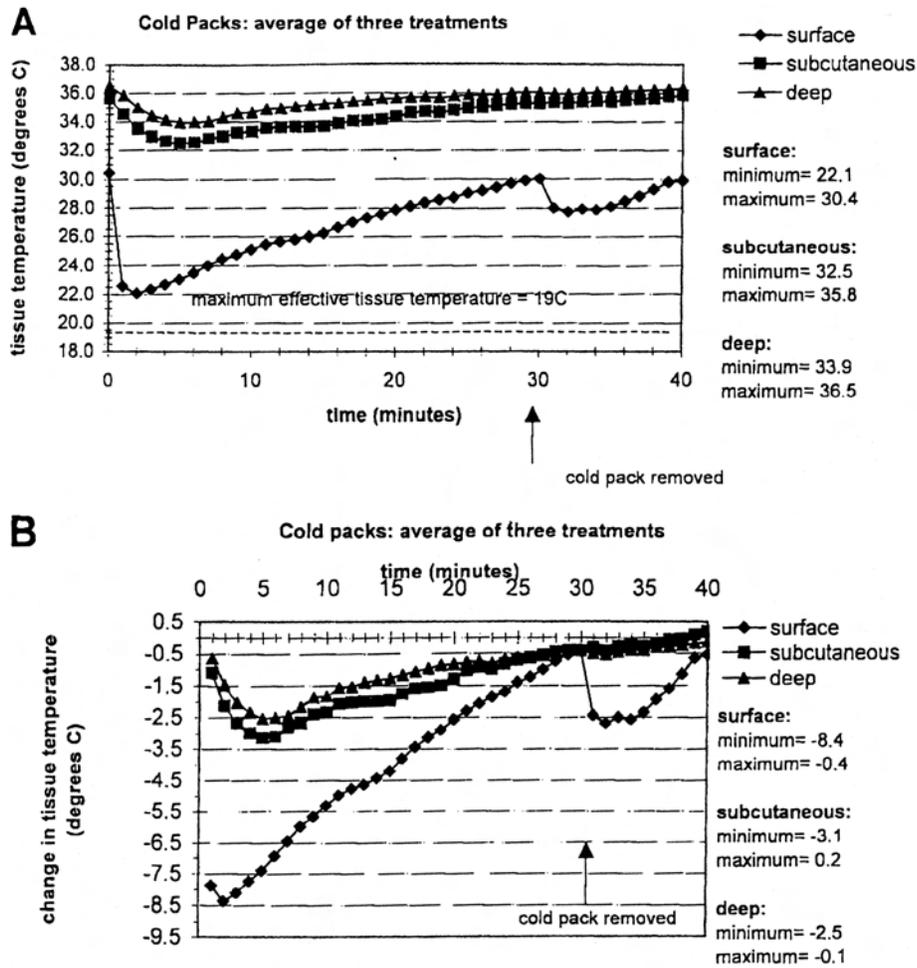


Fig. 4. Cold packs, average of three treatments. Mean tissue temperature (A) and change in tissue temperature (B). Minimum and maximum values for surface, subcutaneous, and deep thermistors are included.

Discussion

Of the hot and cold therapy modalities evaluated in this study, only ice water immersion reached therapeutic tissue temperature levels as defined for humans. Ice water immersion resulted in skin and subcutaneous tissue temperatures, but not deep tissue temperatures, that exceeded the therapeutic threshold of 19°C.¹⁻³ These measures of therapeutic efficacy infer that the treatment methods evaluated may not be successful. As expected, surface temperatures always changed more than either subcutaneous or deep tissue temperatures.

Other methods of evaluation of these hot and cold modalities may have revealed substantial tissue effects. A major effect of heat or cold therapy is to modify enzyme action and tissue metabolism. Metabolic rates, cell activity and enzyme reactions change 2- to 3-fold for every 10°C change in tissue temperature.¹ Changes in tissue temperature compared to baseline for many of the treatment modalities in this study approached or exceeded 10°C. Maximum changes in tissue temperatures

during ice water immersion ranged from 16 to 24°C for all tissues measured. Tissue temperature changes due to warm water hose therapy ranged from 3.7 to 10.8°C. It would be expected that these changes in tissue temperature would modify the metabolic processes in the target tissues.

As was expected, these treatment modalities effected less change in tissue temperatures in the deep sites (between the deep and superficial digital flexor tendons) compared to subcutaneous and surface sites. Generally these methods, which are classified as superficial thermal modalities, can be expected to have beneficial effects at tissue depths less than 1.5-2 cm.¹⁻³ Horse limbs have an advantage over human limbs as there is no deep subcutaneous fat layer in horses which may insulate deeper tissues.

Practical aspects of thermal therapy using these modalities were also evident. Warm water from the hose was difficult to maintain at a uniform temperature. When surface temperatures reached or exceeded 45°C the horse reacted by stomping the

limb—a painful response. Based on these findings, the temperature of warm water therapy from a hose must be closely monitored using a thermometer and adjusted to maintain a narrow temperature range (40–45°C). Subcutaneous and deep tissue temperatures reached a plateau below the optimum therapeutic threshold of 41°C in 10 min. Thermal therapy is most effective when optimal temperatures are maintained for 10 to 20 min.^{2,3} Based on this information, warm water therapy should be continued for 20 to 30 min. Ice water immersion resulted in the most extensive changes in tissue temperatures and, like warm water therapy, tissue temperatures stabilized in approximately 10 min.

The commercial hot and cold packs were very convenient to use, but resulted in the most minimal changes in tissue temperatures measured in this study. These packs are activated by squeezing, placed in a neoprene/terry cloth wrap, and attached to the limb. The wrap likely provided excessive insulation of the limb from the cold packs. Since this study was completed the manufacturer has recommended applying the cold packs directly to the skin. The hot packs require a wrap to protect the limb, as after activation they reach temperatures of approximately 50°C^d which could injure the skin if applied directly.

Summary

Ice water immersion resulted in the greatest changes in tissue temperature when compared to the three other treatment modalities. The temperature of warm water from a hose should be closely

regulated to 40–45°C using a thermometer in the water stream. Tissue temperatures for both ice water immersion and warm water hose therapy stabilized after 10 min. Commercial hot and cold packs were convenient to use but had relatively lower changes in tissue temperatures than ice water immersion or warm water hose treatments.

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^aYSI 409A, Cole-Parmer Instrument Co., 625 East Bunker Court, Vernon Hills, IL 60061.

^bYSI 409B, Cole-Parmer Instrument Co., 625 East Bunker Court, Vernon Hills, IL 60061.

^cDigital Thermistor Thermometer Model 8502-10, Cole-Parmer Instrument Co., 625 East Bunker Court, Vernon Hills, IL 60061.

^dInstant Hot Therapy Pack, Tempra Technologies, 6140 15th Street East, Bradenton, FL 34203.

^eInstant Cold Pack, Tempra Technologies, 6140 15th Street East, Bradenton, FL 34203.