Sensory Perception of the Foot and Ankle Following Therapeutic Applications of Heat and Cold

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ABSTRACT: Many athletes are treated with hot and cold modalities prior to therapeutic exercise, but the effects of these treatments on sensory perception are not clear. The purpose of this study was to examine the effects of hot and cold treatments on sensory perception. We recruited 21 volunteer subjects, who reported for testing on three separate occasions. One of three treatments was applied to the left ankle and foot each day for 20 minutes: cold immersion, hot immersion, or quiet sitting (control). Three variables were measured following treatment: topagnosis, two-point discrimination, and one-legged balance. We assigned treatments and the testing order according to a Greco Latin square. Data were analyzed using a multivariate analysis of variance (MANOVA). No significant differences were detected for the three dependent measures, suggesting that therapeutic applications of heat and cold do not affect sensory perception. These findings indicate that heat and cold applications can be used prior to therapeutic exercise programs without interfering with normal sensory perception as do other analgesic and anesthetic agents. For example, the hypalgesic effect of cold, which is essential to cryokinetics, can be realized without fear of altered sensory perception.

Many athletes are treated with hot and cold modalities prior to therapeutic exercise, but the effects of these treatments on sensory perception are not clear. If sensory perception is altered following therapeutic applications of heat or cold, it is possible that the athlete will reinforce neural pathways that are not sport specific and therefore counterproductive to progress in the rehabilitation program. The purpose of this study was to examine the effects of hot and cold treatments on sensory perception.

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Methods

Subjects

We obtained informed consent from 21 volunteer subjects who had no previous ankle injuries. We recruited them from the student body at Indiana State University in Terre Haute, Ind.

Protocol

Subjects reported to the Sports Injury Research Laboratory on three separate occasions. Each session commenced with application of the treatment: cold immersion, hot immersion, or quiet sitting (control). Hot and cold treatments involved immersing the right foot and ankle above the malleoli for 20 minutes per session. Water temperature upon immersion was 1°C for the cold treatment and 40°C for the hot treatment. We made no attempt to maintain water temperature throughout immersion. Our reasoning was that we wanted to simulate a clinical protocol.

Following treatment, we recorded three dependent measures: topagnosis, two-point discrimination, and postural balance. We made measurements on both the treated foot and the contralateral foot.

We measured topagnosis by blindfolding the subject, touching the sole of his or her foot with a marker, giving the subject a marker, and asking him or her to use the marker to point to the spot where he or she was touched (Fig 1). We used the distance between the marks as the measure for topagnosis.

Fig 1.—Topagnosis measurement

We determined two-point discrimination by using thirteen styrofoam blocks that were covered with athletic tape, with one or two thumbtack points protruding from the surface of the block through the tape. Five blocks had one tack and eight blocks had two tacks. The tacks of the two-point blocks were placed at 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0 cm apart. During testing, we pressed the block against the sole of the foot and asked the subject to determine if the block had one or two pins (Fig 2). The pins did not penetrate the skin. We attempted to apply

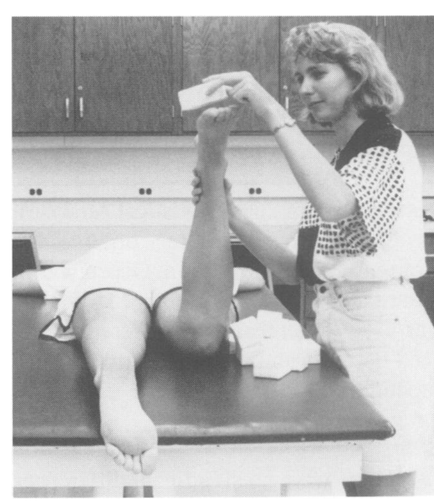

Fig 2.—Two-point discrimination measurement

uniform pressure throughout testing. A sensitivity score (S) was calculated to determine two-point discrimination: $S = (IC\ (1 - CC)^{1/2})/(CC\ (1 - IC))$; IC = incorrect responses, and CC = correct responses.

Postural balance was assessed using a one-legged balance test (stork stand). We instructed subjects to stand on one foot with their hands on their hips and the opposite foot tucked behind the knee of

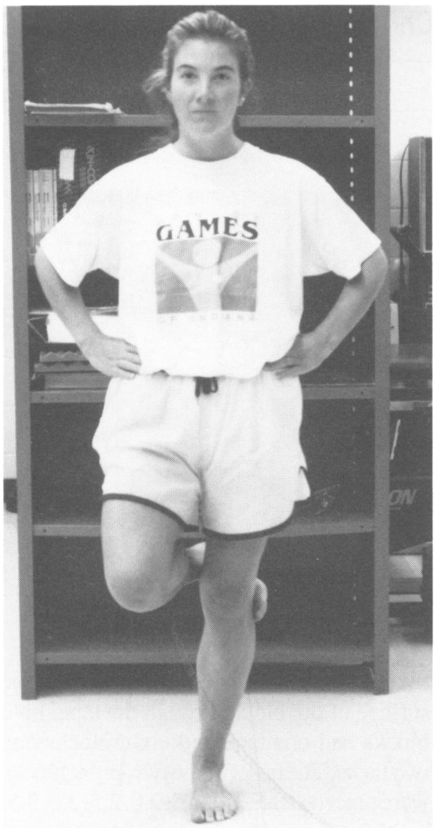

Fig 3.—Balance measurement

the supporting leg (Fig 3). The time the subject maintained this posture was used as the measure of balance. The test was considered complete if the subjects: (1) lifted their toes or heel off the ground, (2) moved their arms away from their sides, or (3) moved their unsupporting heel away from the knee of the supporting leg.

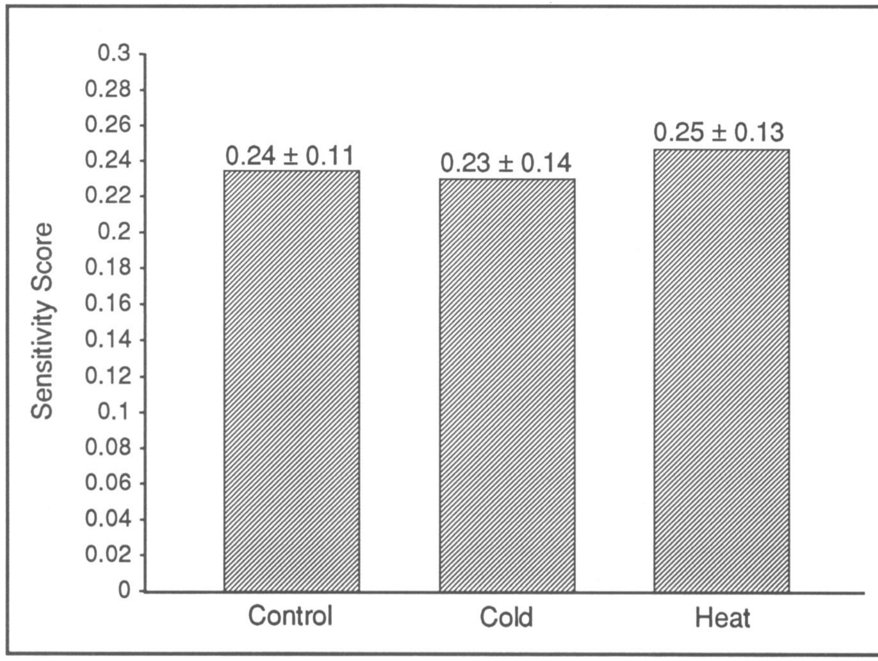

Fig 4.—Two-point discrimination sensitivity scores for cooling, heating, and no treatment

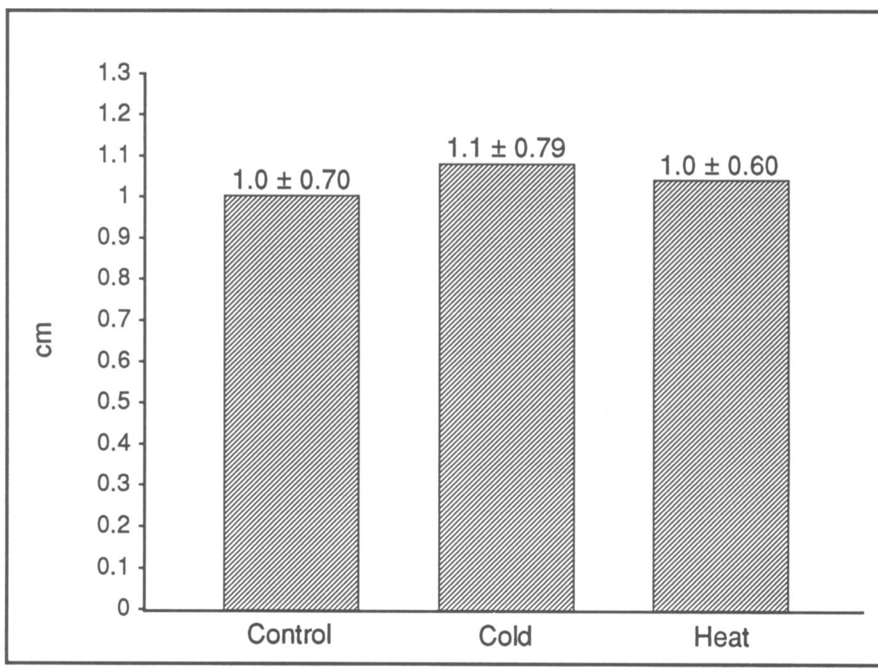

Fig 5.—Topagnosis distance scores for cooling, heating, and no treatment

Research Design and Statistical Analyses

The treatment and test orders were arranged according to a Greco Latin square. A repeated measures MANOVA was used to determine if differences existed between linear combinations of the dependent measures.

Results

There were no significant differences (Wilk's Lambda (6,86) = 0.95, p = .89) between the three therapeutic treatments for two-point discrimination (Fig 4), topagnosis (Fig 5), or balance (Fig 6).

Discussion

Sensation can be divided into three categories: superficial, deep, and combined. Superficial sensation involves touch, pain, temperature, and two-point discrimination. Deep sensation is concerned with muscle and joint position sense (proprioception), deep muscle pain, and vibration sense. Stereognosis (the recognition and naming of familiar objects in the hand) and topagnosis involve both superficial and deep sensory mechanisms (2). We evaluated each sensory mechanism in our study: two-point discrimination, representing superficial sensation; proprioception, representing deep sensation; and topagnosis, representing combined sensory mechanisms.

Because superficial and deep sensations were not affected by cold or hot immersion, use of the term anesthesia as an effect of hot or cold modalities is inappropriate. There is an exception, of course. Pain, which can be a superficial or deep sensation, or both, is

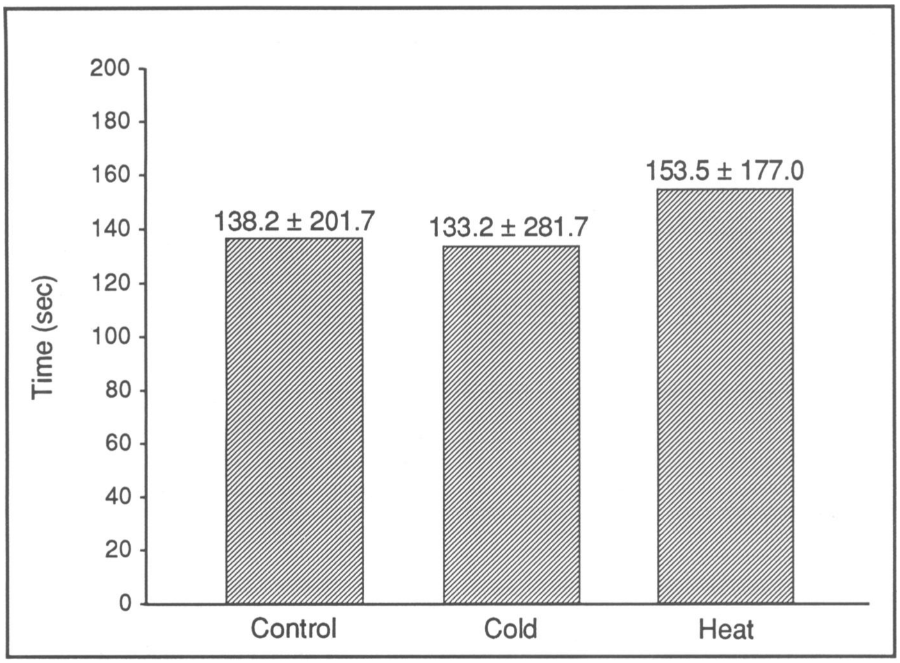

Fig 6.—Balance scores for cooling, heating, and no treatment

influenced by hot and cold modalities. This decrease in pain has been called analgesia, although the term hypalgesia is probably a more appropriate term (5).

Our findings are consistent with those of LaRiviere & Osternig (6), who found no difference in ankle joint position sense with cooling. Their protocol differed from ours in that we used 1°C ice immersion and they used ice immersion at approximately 4°C. Also, their measure of sensory perception was different than ours. They used open kinetic chain joint position sense, while we used closed kinetic chain proprioception (balance).

Cooling may affect proprioception in the same fashion as local anesthetics, which do not alter proprioception (1,3,6). Since the entire leg was not cooled or heated, it is possible that at least a portion of the proprioceptive mechanisms controlling posture were not affected. The source of proprioceptive input for posture maintenance may arise from afferent inputs from mechanoreceptors in the ankles or the soles of the feet, spindles in the leg muscles, or possibly some other source. This question has not been conclusively resolved (4). Certainly, a portion of proprioceptive afferent signals were exposed to cooling or heating.

While cooling or heating the body part does not affect two-point discrimination, heating or cooling the caliper probes does increase two-point discrimination acuity on the forearm and palm which are at normal skin temperatures (7). Altering probe temperatures appears to be unrelated to local cooling of an extremity. Only cold and touch receptors at the point of contact by the two-point discrimination probe are stimulated, while cooling the entire body part stimulates numerous cold receptors over the surface area cooled and the touch receptors are only stimulated under the two-point discrimination probes.

We conclude that the therapeutic applications of heat and cold used in this study do not affect sensory perception. Therefore, heat and cold applications to the foot and ankle can be used prior to therapeutic exercise programs without interfering with normal sensory perception as do other analgesic and anesthetic agents. For example, the hypalgesic effect of cold, which is essential to cryokinetics, can be realized without fear of altered sensory perception.

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