DABBING THE SKIN SURFACE DRY DURING ICE MASSAGE AUGMENTS RATE OF TEMPERATURE DROP

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ABSTRACT

Int J Exerc Sci 1(1) : 14-21, 2008. While ice massage (IM) is a rapid cooling technique used to facilitate therapeutic movements in the rehabilitation process, evidence of its efficacy over alternative therapeutic protocols is scarce. We determined whether dabbing the skin surface dry during a standard IM treatment would lead to greater rate of skin temperature reduction in comparison to without dabbing; and whether dabbing the skin would lead to an acute change in flexibility. Sixteen healthy volunteers received a "dabbing" and "non-dabbing" 7-minute IM treatment over the surface of each triceps surae muscle. Minute-by-minute temperature change in skin surface was evaluated using an infrared thermometer. Active (AROM) and passive (PROM) range of motion were evaluated via hand-held goniometer and passive stretch force was evaluated with an algometer. Dependent variables (reported as Mean ± SD) were tested with two-way analysis of variance with repeated measures. Skin temperature (°C) was reduced to with dabbing (5.8 ± 1.1) in comparison to without dabbing (6.8 ± 1.4), evoking significantly greater cooling at 1-min of ice massage (group X time interaction, $p<0.01$). However, after two minutes of IM, each method of application evoked similar surface temperatures. There was no significant difference in AROM, with dabbing (-0.63 ± 2.55°) in comparison to without dabbing (1.18 ± 2.90°), and no significant difference in passive-length tension relations ($p>0.05$) for either IM group. The dabbing protocol resulted in more rapid rate of temperature drop at 1-minute, however, both IM techniques are sufficient in cooling surface temperature after 2-minutes of IM. Further study is warranted to determine the clinical significance of the dabbing procedure.

KEY WORDS: Conduction, cryostretch, cryotherapy, evaporation

INTRODUCTION

Ice massage (IM), as opposed to other forms of cryotherapy, is administered when the clinician desires a rapid means of cooling a body part (10). IM is recognized for its ability to superficially anaesthetize an area (3), which in turn may promote soft tissue elongation, or cryostretching (4). Cryotherapy can suppress the myotatic reflex response during passive stretch (8). As such, cryotherapy enhances passive range of motion (PROM)(9), particularly in the patient recovering from orthopedic injury (14). Moreover, pre-cooling may raise a patient's tolerance to active contractions, as in cryokinetics, which may ultimately accelerate restoration of function (4).

According to the First Law of Thermodynamics, thermal energy is neither gained nor lost, but transferred through one of four mechanisms. These mechanisms include conduction, convection, evaporation, or radiation. For instance, rapid cooling of the skin with IM, or ice packs, is achieved by conduction of the ice directly with the skin (4). When more than one mechanism of heat transfer is utilized, the rate of temperature change to the treated body part may be accelerated (11).

In theory, excess water over the skin may blunt the contribution of evaporation: that is, a more rapid cooling of the skin is achieved with conductive and evaporative cooling. Alternatively, a warmer water gradient may be wiped away to enable better conductivity between the ice and the skin (6). Before contrasting theories may be examined, we sought to verify that dabbing accentuates the treatment effect of IM by measurement of minute-by-minute skin temperature during standard IM and IM performed with dabbing. Moreover, we evaluated if any differences in treatment affected PROM or active range of motion (AROM).

METHOD

Participants

Based on a priori power analysis, using an effect size of 1.0 from pilot data, and a 1-B of 0.80, we recruited a convenience sample of sixteen healthy adults (body mass = 70 ± 14 kg, height 167 ± 9 cm). Informed consent was obtained and our institutional committee for the protection of human subjects approved all procedures. Potential participants were excluded from this study if they reported a history of lower extremity injury, Raynaud's syndrome, or an active disease process affecting either lower limb.

Experimental Design

This prospective study was designed to evaluate change in skin temperature, ROM, and the passive length-tension relationship in response to two different IM interventions. The limb receiving the experimental treatment was counterbalanced such that half of the participants received the dabbing IM on the dominant limb and half received non-dabbing IM on the dominant limb (note: the leg that participants self-identified as the leg they would kick a ball the furthest distance was presumed as the dominant limb). Therefore, contralateral limbs received the opposite treatment. All data were collected within a single treatment session and performed by same individual, trained in equipment-use through supervised pilot testing.

Instruments/Equipment

An infrared thermometer (Radio Shack, USA, Model # 22-325) was used to measure skin temperature before, during (every 1-minute), and 1-minute after each IM intervention. The intraclass correlation coefficient of the thermometer has been found to be 0.999 with standard error of measurement of 0.136° F (17). AROM at the ankle joint was evaluated using a hand-held standard long-arm plastic goniometer. Goniometric measurements of joints in the lower extremity have been found to have an intrarater standard error of estimate 0.8° and reliability of 0.89 (2). A hand-held dynamometer (Hoogan Systems, Salt Lake City, UT) was used to measure the force to stretch the ankle into a position of dorsiflexion. Measurements were taken before and subsequent to each IM intervention. Towels were used for dabbing.

Protocol

Participants were instructed to refrain from heavy exercise 2-hours prior to testing. Each participant was placed in prone position in a thermo-neutral laboratory (approximate temperature = 21°C, rh = 35%). The prone position optimally exposes the triceps surae skin surface and helps maintain the knee in an extended position while the ankle is dorsiflexed passively. An area equal to the size of a United States dollar bill (15.6 x 6.6 cm) was marked with pen on each surface of the triceps surae at a distance halfway between the lateral malleolus and fibular head. A standard goniometer was then taped to the participant's lower leg in a standardized position for measuring ankle range of motion in the sagittal plane (16) (Figure 1).

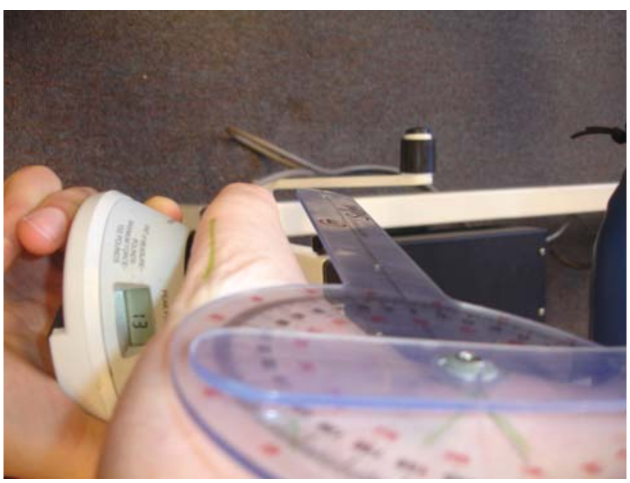

Figure 1. Passive muscle length-tension measurement using goniometer and dynamometer.

One-time baseline measurements included initial skin temperature, AROM, PROM, and amount of force into maximal passive stretch. Skin temperature was measured by pointing an infrared thermometer at a 90° angle to the skin surface, which took ~1-2 seconds to record. AROM into dorsiflexion was measured with a goniometer by asking the participant to "Please bring your toes up towards your nose, as far as you can, by moving only at the ankle." The ankle was put back in the neutral position, at 90° by having the participant relax, and taken passively into maximal dorsiflexion using a hand-held dynamometer at the head of the 3rd metatarsal to measure the force required to obtain the greatest degree of dorsiflexion. Figure 1 illustrates PROM joint angle and force measurements being taken. To ensure that only force into maximal dorsiflexion and not beyond was measured, dorsiflexion was backed off by one degree and that force was measured as baseline. Then two more force measurements were taken by letting off by 2° increments to establish a passive muscle length-tension relationship.

Both IM conditions used a standard 3 oz paper cup torn to expose a cylindrical ice cube (Figure 2) and all cups were filled with frozen water to the same level. The dabbing IM procedure consisted of continuous circular motions with periodic drying of excess water with a towel approximately every 10-15 seconds (Figure 2). For the contralateral limb receiving the control treatment, excess water was allowed to build on the skin surface; however, it was necessary to dry the skin each minute for recording the skin, and not water, surface temperature.

Immediately following each IM treatment, post-treatment measurements were taken. AROM, PROM, and force measurements were performed in the same manner as in baseline measurement and were performed

Figure 2. The dabbing procedure.

by the same person. The amount of torque at the ankle joint was determined by the product of the force and the distance measured between the ankle joint to the head of the 3rd metatarsal, where the force transducer was depressed. The participant was then instructed to rest for 8 minutes before beginning the second IM treatment to the contralateral limb.

Statistical Analysis
Descriptive statistics on all outcome measures were reported as Mean ± SD. Normality was assessed with Kolmogorov-Smirnov tests and homogeneity of variance was assessed using Levene's test. Two-way analysis of variance (ANOVA) with repeated measures was used to test for differences between time and intervention. Main effects for time were examined with univariate ANOVA with repeated measures and Tukey's HSD post hoc test. Interaction was examined with multiple *t*-tests with Holm's sequential Boniferroni approach. Significance was accepted at 0.05.

RESULTS

Lower skin temperatures (°C) at 1-min were evoked from the dabbing condition (5.8 ± 1.1) in comparison to the non-dabbing

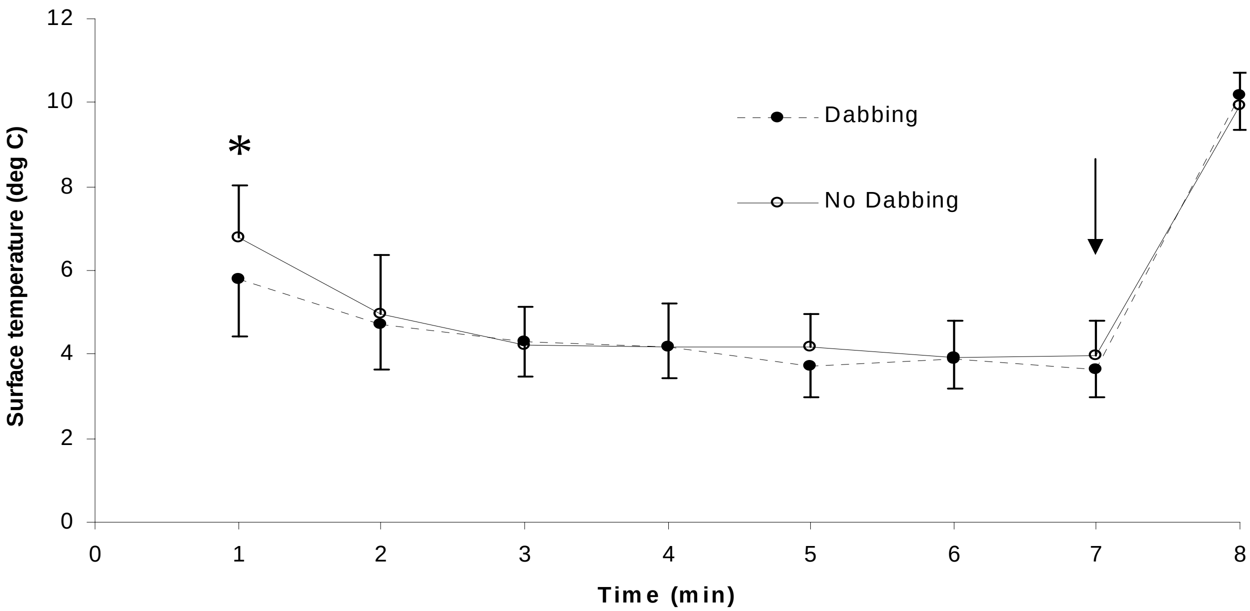

Figure 3. Baseline and min-by-min surface temperature for ice massage with dabbing and without dabbing (Mean ± SD). * Significant difference ($p < 0.01$) between dabbing and no dabbing. Arrow denotes end of ice massage intervention. Similar baseline skin temperatures (°C) were observed for the dabbing (31.06 ± 1.24) and no dabbing (30.73 ± 1.36) conditions ($p > 0.05$)(data not shown).

condition (6.8 ± 1.4) (group x time interaction, $p < 0.01$). However, after two minutes of IM, each method of application evoked the same surface temperature (~5°C). A graph representing minute-by-minute temperature is presented in Figure 3.

ANOVA for AROM revealed no main effects for either pre-post differences ($F_{1,15}$ = 0.38, p = .56) or for the dabbing vs. no dabbing intervention ($F_{1,15}$ = 0.01, p = .97). There was also no significant interaction ($F_{1,15}$ = 3.17, p = 0.10) (Figure 4). Thus, neither 7-min IM treatment affected AROM.

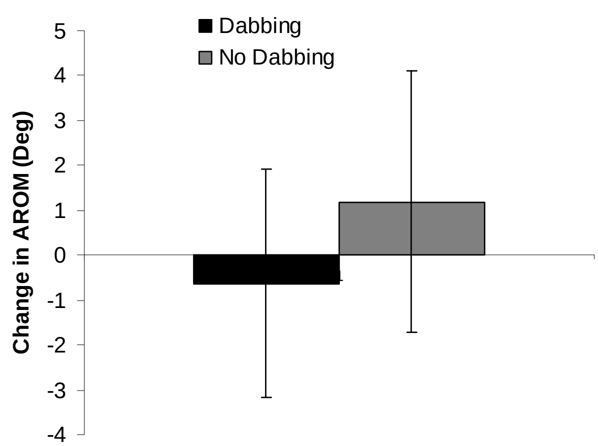

Figure 4. Change in active range of motion (AROM) in response to 7-min of ice massage with dabbing and without dabbing dry (Mean ± SD).

Passive torque was evaluated relative to each of three passive ankle dorsiflexion angles for standard and dabbed IM conditions (Figure 5). ANOVA of passive torque at the largest observed angle of dorsiflexion revealed no main effects for either pre-post differences ($F_{1,15}$ = 0.17, p = 0.68) or for the dabbing vs. no dabbing intervention ($F_{1,15}$ = 2.54, 0.13). There was

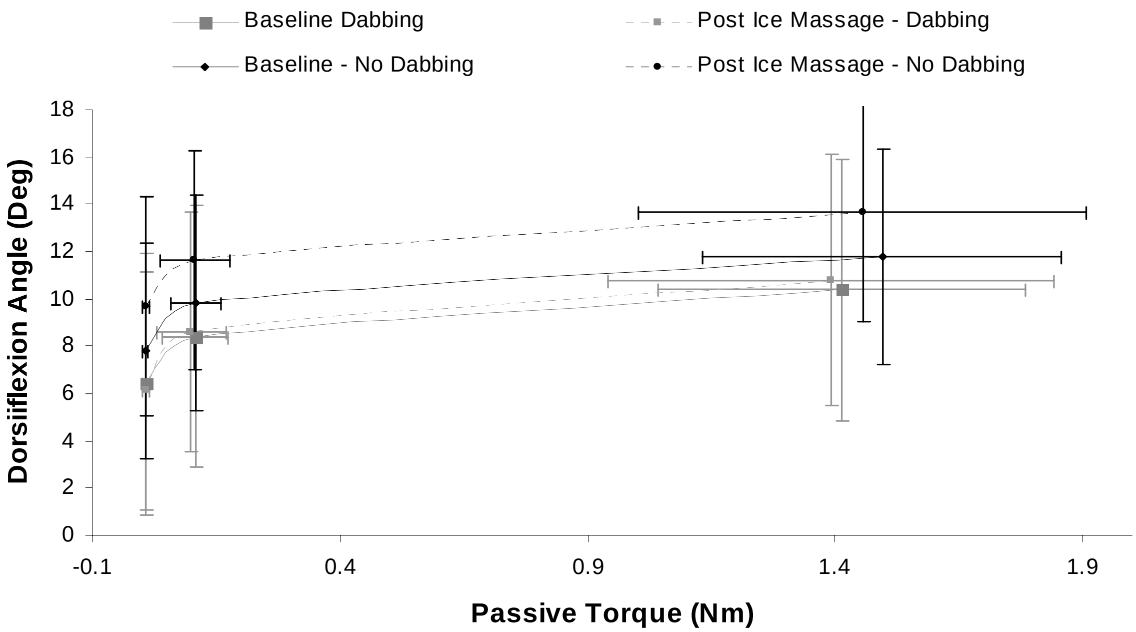

Figure 5. Passive muscle length-tension relations prior to and immediately following 7-min ice massage with dabbing and without dabbing dry (Mean ± SD).

also no significant interaction ($F_{1,15}$ = 0.01, p = 0.95). Similarly, ANOVA of passive ankle dorsiflexion angle, corresponding with these forces, revealed no main effects for either pre-post differences ($F_{1,15}$ = 3.41, p = 0.09) or for the dabbing vs. no dabbing intervention ($F_{1,15}$ = 1.09, p = 0.31). There was also no significant interaction ($F_{1,15}$ = 0.96, p = 0.34). Data at the other two angle-torque positions appearing in Figure 5 were not significantly ($p > 0.05$) affected.

DISCUSSION

The therapeutic effects of cryotherapy have been documented for over 40 years (5). Numerous investigations have emerged regarding appropriate application times, optimal applications modes (i.e. wet ice, dry ice, whirlpool, etc.), desired temperatures, and physiologic responses linked to therapeutic effects (1,3,5,7-14,16,18,19). Ice massage is reportedly superior to other forms of cryotherapy in its ability to cool an area rapidly (1,10,19). Little, if any, detail has been provided with regard to IM technique and method of application. Indeed, the use of toweling during IM treatments has been described for purposes of cleanliness and patient privacy (4); however, no substantive benefit from periodically drying the skin surface in relation to accentuating cooling effects have been suggested previously.

To our knowledge, this is the first study to explore whether periodically dabbing the skin dry during IM treatment has any clinical benefits. Specifically, we evaluated whether dabbing the skin surface dry during IM treatment would be more effective in changing the rate of skin temperature reduction and whether or not this would translate to a better change in AROM or PROM. We observed the dabbing IM technique resulted in more rapid cooling of the skin temperature at 1-min of application (Figure 3), in comparison to normal IM technique. By 2-min, both techniques evoked similar skin temperatures. Neither technique acutely affected AROM, PROM, or passive torque.

There are two plausible mechanisms for why we observed more rapid cooling with the dabbing IM technique. Either multiple mechanisms of energy transfer were in operation or an improvement in conductivity occurred. Firstly, since water accumulates immediately following the application of ice to the skin's surface, evaporative cooling might be attenuated, more so, in the no dabbing vs. dabbing condition. Because skin temperature is rather independent of air temperature in dry conditions, evaporative cooling is almost affected primarily by skin wetness and relative humidity (12). Following each "dab" the water molecules had only a moment to evaporate from the skin's surface before the ice produced another layer of water. Perhaps ice massaging a larger area such as the entire length of the muscle, which is typical, may have produced better translation of the evaporative effects on temperature drop. Secondly, in the dabbing condition, a warmer gradient of water might have been wiped away causing improved conductivity of ice with the skin. Such a phenomenon has been theorized to occur during cold water immersion (6). That is, when the warmer temperature gradient is disrupted with movement underwater, there is a transient decrease in skin temperature.

The skin temperatures achieved following 7-min of IM in this study were similar to temperatures observed in previous research (10). Further, Mac Auley (10) based on a critical analysis of the literature asserted that 10 minutes of IM achieves optimum skin temperature, with little reduction in skin temperature thereafter. Our ability to achieve low skin temperatures so rapidly (i.e., ~5 °C by 2-min) may have been a function of the small surface area we used for the IM treatments. Indeed, there was not significant lowering of skin temperature between 2- and 7-min (Figure 3).

Temperature data at 1-min supports the hypothesis that dabbing in comparison to non-dabbing increases the rate of cooling. However, such temperature change neither affected AROM (Figure 4) nor passive muscle force-length characteristics (Figure 5) in either condition. In theory, cryotherapy may inhibit undesired stretch reflex activity during PROM maneuvers (10). We are unable to conclude whether our specific treatments failed to influence ROM because muscle temperature was not measured.

In future studies, the concept of dabbing during IM treatment could be used in specific patient populations, such as those with delayed onset muscle soreness and those with an acute musculoskeletal injury. Additionally, future studies might examine the effect of ice massaging the entire length of the muscle to determine if dabbing a greater area would have greater effect. Finally, we submit that the potential for the dabbing procedure to produce a quicker means to anaesthetize an area and augment another intervention, such as stretching or myofascial release techniques (i.e., "cryostretching"), is an area worthy of exploration.

Clinicians may use IM with dabbing to achieve rapid cooling. Additional treatment time with IM does not provide substantially more cooling of the skin and superficial tissues (e.g., nerve endings); however, if lower muscle temperatures are desired, than more time is required. In the present study, 7-min of IM did not acutely affect ROM or the muscle length-tension relationship in apparently health individuals. Conversely, it is possible that the effects of dabbing IM may promote faster relief of spasm or faster inhibition for stretching or myofascial release techniques and we suggest these as areas worthy of exploration.

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