Peripheral Blood Flow & Temperature Modulations after Common Cryotherapy Treatments.

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Introduction

In the sports medicine field, Certified Athletic Trainer's use an assortment of treatment modalities and techniques to aid athletes with acute and chronic musculoskeletal injuries. One of the most commonly used treatments is cryotherapy, or the application of cold as a therapeutic treatment. Cryotherapy lowers tissue temperatures by the withdrawal of heat energy from the body to achieve therapeutic effects.[1] Mattacola et al.[2] stated "the control of swelling and effusion in acute injuries must be accomplished with frequent application of external pressure, modalities such as cryotherapy, and active range of motion." Cryotherapy includes ice bags, instant and gel ice packs, ice immersion, cold whirlpool, theragesic agents, and ice massage. There are several different techniques in practice today, but by far the most commonly used technique by Certified Athletic Trainers is the RICE (Rest, Ice, Compression, Elevation) technique; and the often more convenient 'wrap and go' ice bag technique. RICE is simply placing and wrapping ice on the injury and elevating the extremity. It requires only an ice bag, wrap, and 15-20 minutes of the Athletic Trainers, and the athletes' time.

Since compression enhances intramuscular and surface cooling[3] and time is often of the essence, Athletic Trainers often apply ice bags "to go" using plastic wrap, allowing the athlete to leave the athletic training room while icing the injury. Although both techniques are expected to produce therapeutic effects, there is little research to compare temperature differences and physiological effects of the elevation and 'wrap and go' methods.

Cryotherapy is used for its cooling effects of both superficial and intramuscular tissues, a reduction in and has been shown to reduce inflammation, pain, and muscle spasm.[2] Inflammation causes pain, weakness, and limited range of motion. The cooling effects of cryotherapy lead to many different physiologic changes, including: vasoconstriction, decreased metabolism, spasm and edema formation, and pain sensation. Moreover, cryotherapy is considered to be the most beneficial treatment for rapidly reducing cellular metabolism.[2] The lasting effects of cold play a significant role in the healing process by limiting inflammation, which essentially allows the injury to have an optimal environment for healing. However, there is still much that we do not understand about the application of cryotherapy to acute and chronic injuries. For example, there is limited research to examine the role of elevation in vascular and temperature changes during cryotherapy.

Infrared thermography (DIRT) is a safe, non-invasive, non-contact method of collecting real time temperatures of tissues up to 2 inches in depth.[5] Infrared thermography averages the temperature of a specific region/treatment area as opposed to the spot specific measurement obtained with a thermocouple.[5] This allows for average regional temperatures of the superficial structures of the lateral ankle to be measured and compared.

More than 23,000 ankle sprains have been estimated to occur per day in the US, which equates to one sprain per 10,000 people daily.[3] The severity of ankle sprains may often be underestimated by athletes, and current treatment strategies for lateral ankle sprains may not be effective in preventing recurrent injuries or residual symptoms.[4] Cryotherapy has been shown reduce many of the adverse conditions related to the

inflammatory or reactive phase of an acute injury associated with this common injury. However, little research has been completed comparing the superficial cooling methods of the superficial RICE method and the superficial 'wrap and go' method on the lateral ankle joint.

As athletic trainers, it is important to know the immediate and lasting effects of icing techniques in use so we can properly treat athletes, giving them the best, most effective option for treatment, and get them back to activity as quickly and safely as possible. Thus, the purpose of this study was to compare the effect of ice bag application without elevation, with elevation, and during sub-maximal movement (walking) on non-contact surface temperature in participants with healthy ankles. We hypothesized that the "wrap and go" technique will provide the therapeutic effects necessary for healing. However, the RICE method will produce more beneficial therapeutic effects that will last longer after the ice is removed, allowing for more decreased inflammation and healing time.

Methods

Study Design

A 2x3x2 repeated measures factorial experimental design covered this study. Independent variables were treatment with 2 levels (ice, no ice), position with 3 levels (no-elevation, elevation, and treadmill walking), and time with 2 levels (pre-test, post-test). The dependent variable was skin temperature.

Participants

Twelve (six males: $\bar{x} = 23.5$ years and six females: $\bar{x} = 21.5$ years) moderately active (activity 3-5 times per week for 30 minutes), healthy, college aged individuals with

no history of lower extremity injury in the past year volunteered for this study. A health questionnaire (medical PAR-Q) was used to determine the subject's activity level. Participants were not eligible if they had any cold hypersensitivity or known cold related allergy conditions that may increase normal discomfort. Each subject read and signed the informed consent approved by the University's institutional review board, which also approved this study.

Instrumentation

A Thermal Image Processor (TIP) (Computerized Thermal Imaging, Inc., Ogden, UT, USA) (Figure 1) with an infrared camera was used to capture and analyze images, utilizing advanced image analysis software, TIPMED. An Xpress compact scale (XRW 11-1221; Mettler-Toledo, Inc., Worthington, OH, USA) (Figure 2) was utilized to accurately weigh each ice bag. Cramer heavy duty ice bags (Cramer Products, Inc., Gardner, KS, USA) (Figure 3) were used during each ice bag session, and Cramer Flexi-Wrap (4"; Cramer Products, Inc., Gardner, KS, USA) (Figure 4) was used to wrap on each ice bag to the ankle. Pads for elevating the leg off of the table to eliminate surface contact and for the elevated condition were constructed in the laboratory (Figure 5) using 20" 2x4 with 4" foam padding covered with cloth, the elevation device was constructed with 2x4's, with a width of 20" and a height of 20" with 4" foam padding covered with cloth.

Procedures

A total of 13 images (Figure 6) were collected for each participant. Each image taken was of the right lateral ankle from the knee down. Data collection took place over 5 days, within a 2 week time period at the same time of day to eliminate diurnal variations.

Before each session the participants equilibrated to the temperature and humidity of the laboratory for 15 minutes, sitting in a chair with their feet flat on a carpet on the floor. Each session lasted about 45 minutes to 1 hour.

Day One:

- Equilibration for 15 minutes (seated in chair with feet on rug)
- Baseline image taken of the lateral aspect of the right lower leg and ankle, from the knee to the foot
- Subject positioned supine on the treatment table with right leg non-elevated (small pad) with no ice for 15 minutes (Figure 7)
- Thermal image taken immediately following treatment
- Subject sat for 15 minutes (seated in chair with feet on rug)
- Thermal image taken
- Subject positioned supine on the treatment table with the right leg elevated to 20 inches with no ice for 15 minutes (Figure 8)
- Thermal image taken immediately following treatment
- Subject sat for 15 minutes (seated in chair with feet on rug)
- Thermal image taken

Day Two:

- Equilibration for 15 minutes (seated in chair with feet on rug)
- Thermal image taken pre-treatment
- Subject walked on treadmill (2.0 mph at 0% grade) for 15 minutes with no ice (Figure 9)
- Thermal image taken
- Subject sat for 15 minutes (seated in chair with feet on rug)
- Thermal image taken

Day Three:

- Equilibration for 15 minutes (seated in chair with feet on rug)
- Thermal image taken pre-treatment
- Subject positioned supine non-elevated (small pad) with a 1 kg ice bag wrapped on the lateral aspect of the right ankle for 15 minutes (Figure 10)
- Thermal image taken
- Subject sat for 15 minutes (seated in chair with feet on rug)
- Thermal image taken

Day Four:

- Equilibration for 15 minutes (seated in chair with feet on rug)
- Thermal image taken pre-treatment

- Subject positioned supine elevated to 20 inches with a 1 kg ice bag wrapped on the lateral aspect of right ankle for 15 minutes (Figure 11)
- Thermal image taken
- Subject sat for 15 minutes (seated in chair with feet on rug)
- Thermal image taken

Day Five:

- Equilibration for 15 minutes (seated in chair with feet on rug)
- Thermal image taken pre-treatment
- Subject walked on the treadmill (2.0 mph at 0% grade) with an l kg ice bag wrapped to the lateral aspect of the right ankle for 15 minutes (Figure 12)
- Thermal image taken
- Subject sat for 15 minutes (seated in chair with feet on rug)
- Thermal image taken

Statistical Analysis

All data was inserted into a custom Excel spread sheet (Version 2007). An analysis of Variance (ANOVA) with follow up t-tests was completed using the Statistical Package for the Social Sciences (SPSS version 16). The alpha level was set *a priori* at $p = 0.05$.

<u>Results</u>

The descriptive statistics, 95% confidence intervals and effect sizes are located in Tables 1-2. The analysis indicated a significant interaction between treatment and time [$F(2,10) = 0.923$, $p < 0.0001$] and position and time [$F(2,10) = 0.923$, $p < 0.003$], with no interaction between treatment and position [$F(2,10) = 0.923$, $p = 0.429$]. Follow-up analysis revealed that position did not have a significant effect during the no ice condition [$F(2,10) = 1.02$, $p = .0394$]. However, position did have a within-subjects effect with ice treatment ($p = 0.026$); with a strong trend towards a significant difference between the no-elevation position and the treadmill walking position ($p = 0.056$). The biggest difference with ice treatment was between the treadmill walking and the no-elevation

condition. But interestingly, there did not seem to be a difference between the no-elevation and the elevated condition as we expected. The treadmill walking seems to produce a quicker return to baseline (warm-up) than the elevated position ($p = 0.02$), but these differences were not found when comparing no-elevation to the elevated ($p = 0.34$) or, interestingly, the treadmill walking to no-elevation ($p = 0.26$).

Discussion

Cryotherapy treatment protocols suggest that icing be done in conjunction with ankle elevation. However, especially in the sports medicine area, often the ice bag is wrapped on the injured ankle so that athletes can hurry to their next activity. Does this wrap and go method interfere with the cryotherapy treatment outcomes? This study was designed to investigate the differences between the RICE and 'wrap and go' methods.

Non-contact surface temperature measures (DIRT) revealed that immediately following 15 minutes of ice bag application, the treadmill walking condition showed cooler superficial temperatures than the no-elevation condition ($p = 0.056$) (Table 1). The means indicate a difference in non-contact surface temperatures of about 2°C. When using DIRT, a temperature change of more than 1°C is considered clinically significant. It is worthy of mention that this finding was not expected, as our hypothesis predicted the treadmill walking temperatures would be higher than the other conditions. This may be due to the ice bag being in constant motion with the lateral ankle. Much like the effects of an ice massage treatment, this treatment may be more intense and cool the superficial surface more rapidly. Ice massage treatments only last for approximately 10 minutes because the specificity of location, motion, compression, and ice creates a more intense effect than other types of cryotherapy treatments. Its lowest temperatures are reached in

17.9 minutes while an ice bag reached its lowest temperatures in 28.2 minutes.[6] When the individual is lying supine on the treatment table there is no movement/friction between the ice bag and the lateral ankle whereas while walking on the treadmill there is a constant friction between the ice bag and the extremity. There was no significant difference found between the no elevation and the elevated condition unlike we expected ($p = 0.285$).

The application of cryotherapy produces physiologic changes in the tissue.[7] Compression enhances the intramuscular and surface cooling of a cold modality; moreover there seems to be an interaction between the use of compression and the effectiveness of the ice in reducing tissue temperatures.[8] In order to generate the necessary compression ice bags are commonly applied using elastic or plastic wrap[2] in the same way that the 'wrap and go' ice bag is secured. In a study which compared treadmill walking and lying prone with no-elevation, no changes were found in intramuscular temperature during the ice plus walking treatment, despite superficial recordings that showed skin surface cooling. So, when exercising the muscle during the treatment the cooling effect of the cryotherapy on the muscle is negated by the heat produced by the muscle activity.[2] This suggests that when an individual is active during cryotherapy treatment the surface temperature is going to decrease but there is not going to be a lasting effect of the ice on the muscle. With the information from this study, we wanted to look further at the effects of the cryotherapy treatment on a distal extremity/specific joint where there the bones are mainly attached by ligaments and where there are not many big muscles. We knew there was going to be a change in the

superficial temperatures of the skin but we wanted to have a better understanding of the effects of cryotherapy and blood flow at a specific joint.

In the current study treadmill walking also produced higher temperatures 15 minutes after the cryotherapy was removed compared to the elevated position ($p = 0.02$), but these differences were not found when comparing the no-elevation to the elevated condition ($p = 0.34$) or the treadmill walking to the no-elevation condition ($p = 0.26$). Circulation plays an important role in determining tissue temperature of the treatment area. Thus, in the elevated condition a decrease in circulation may occur compared to the treadmill walking condition. There may also be an increase in skin blood flow immediately following local ice application. This is known as the Hunting Reflex or the Hunting Response, a physiological reflex action to protect the body from cold damage.[9] In the Hunting Response the ice first produces vasoconstriction, which helps reduce the flow of cold blood to the core to reduce core cooling, a reflex vasodilation then occurs which produces an increase in circulation bringing warm blood to the area creating a pulsed circulation effect.[9] If cold is continuously applied for fifteen to thirty minutes, an intermittent period of vasodilation occurs every four to six minutes.[10] This response has primarily been observed in the appendages like the ankle joint, foot, and toes. Superficial tissues can re-warm by drawing heat from the deeper tissues.[1] This could potentially reflect deeper tissue cooling, which takes place upon removal of the cryotherapy.

It was also determined that the time period following removal of the cold treatment should be considered an important part of the treatment session. The time following the removal of the cryotherapy can be considered critical to producing the benefits of the therapeutic modality. The purpose of cryotherapy is to achieve a lasting

thermal effect, wherein the surface area being treated will continue cooling deeper tissues after the cryotherapy has been removed. This study only looked at the effects in the lower extremity; further research is needed to test the effects in the upper extremity. Moreover, research also needs to be conducted to investigate the differences in the cooling effects between joints and muscles. As athletic trainers we want to provide an optimal environment for healing. In order to achieve this we must fully understand the physiological effects of the modalities we use and complete evidence based research to determine the optimum parameters which will enable us to create an optimal healing environment.

Conclusion

The 'wrap and go' ice bag on the lateral ankle while walking produced lower superficial temperatures changes during a 15 minute treatment, and re-warmed quicker than the no-elevation condition. There were no differences between icing while elevated or during the no-elevation condition. These results suggest that the 'wrap and go' technique of cryotherapy may be beneficial in decreasing surface temperature but tends to re-warm quicker. So, the tradition RICE method is more appropriate for effective cryotherapy treatments.