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DETERMINING SKIN TEMPERATURE DIFFERENCES BETWEEN THREE COLD COMPRESSION MODALITIES

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DETERMINING SKIN TEMPERATURE DIFFERENCES BETWEEN THREE COLD COMPRESSION MODALITIES

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Determining Skin Temperature Differences Between Three Cold Compression Modalities

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Background: Cold and compression are common therapeutic interventions used in the treatment of acute musculoskeletal injuries. Cryotherapy uses extreme cold to decrease cell metabolism and pain following injury. Compression works to decrease overall blood flow and control edema. The benefit of combining cold and compression is to increase the rate and depth of the temperature drop, while utilizing the effects of both modalities. *Purpose:* The objective of this study was to determine if a crushed ice pack was as effective as newer cold compression technology to decrease skin temperature. A crushed ice pack was compared to the PowerPlay and Game Ready, two competing cold compression devices. We hypothesized that each of the modalities would reach therapeutic temperatures, and the Game Ready would be the most effective at cooling skin temperatures due to the circulation of ice and water. *Participants:* Ten (7 female, 3 male) healthy, recreationally active students (Age: 22 $\pm$ 1.3yrs; Height: 66 $\pm$ 4.2 in; Weight: 167 $\pm$ 34.3lbs) participated in the study. A repeated measures design was utilized; each participant completed each of the three trials, ice pack, PowerPlay, and Game Ready in a randomized order. Skin temperatures over the sinus tarsi were recorded before and after each trial by the Ryobi infrared laser thermometer. Skin temperature differences were examined before and after a 20-minute treatment of each modality. *Results:* There was a statistical significance between trials and skin temperature (p =0.000). Specifically, post hoc testing revealed ice pack cooled skin temperature significantly more than PowerPlay (p=0.001), as well as Game Ready more than PowerPlay (p=0.021). Ice pack and Game Ready cooled skin temperature similarly (p= .506). *Conclusion:* We found that each of the modalities reached therapeutic temperatures necessary to slow cell metabolism and provide analgesic effects. However, our results indicate that an ice pack and ace bandage and Game Ready were more effective at producing cooler skin temperatures when compared to the PowerPlay.

Introduction

Cryotherapy is the therapeutic use of extreme cold, commonly used in the management and rehabilitation of musculoskeletal injuries in sport.[1] The purpose of cryotherapy is to inhibit the body's inflammatory response and decrease pain by producing cold, burning, aching, and numbness sensations to modulate pain.[1,2,3] Cryotherapy has been shown to be one of the most effective treatments of musculoskeletal injuries in the acute and subacute stages.[3,4] When combined with compression, cryotherapy is an important factor in reducing blood flow and pumping edema away from the injury site.[1] The combination of cold and compression increases the rate and depth of the temperature drop.[1] In the past few decades, new modality techniques began using cryotherapy in addition to dynamic compression which not only improves local metabolism and soft tissue exchange, but prevents necrosis of the skin.[3]

There are a variety of cryotherapy techniques used and many have different thermodynamic properties, resulting in different cooling effects. The cooling efficacy depends on factors such as the duration of treatment, location of treatment, the added use of compression, and mode of cryotherapy.[5,6] Traditional cryotherapy techniques include crushed ice packs, frozen gel packs, ice massage, and cold-water immersion.[2] Ice packs and ice massage undergo a physical state of change from solid to liquid, whereas gel packs and cold-water immersion techniques do not have this benefit. Ice packs, ice massage, and gel packs dissipate heat through conduction, while cold-water immersion cools via convection.[5] Crushed ice packs go through a phase change and is often combined with the added benefit of compression making them extremely effective at cooling tissue temperatures.

The combination of ice and static compression has been shown to increase the magnitude of skin temperature cooling.[5,7] Because of these effects, newer cryotherapy devices were marketed to provide continuous cooling with added compression. Instead of static compression, these devices offer dynamic compression, meaning they inflate and deflate between various pressures.[7] These devices are thought to be even more effective than traditional forms of cryotherapy, mentioned earlier. Crushed ice packs were chosen in this study because they have been shown to be the most effective at cooling skin temperatures through conduction, are cost effective, and can be secured with an ace bandage for added compression. Crushed ice packs were then compared against newer cold compression devices, the Game Ready and PowerPlay.

Statement of the Problem

Current research is inconclusive as to which cold therapy technique is the most beneficial for acute injuries. What is known is immediate application of cold decreases the metabolic rate and reduces secondary metabolic injury.[1,8] Though research is limited, it is assumed that greater cooling effects lead to greater metabolic suppression.[1,5] This statement suggests the modalities that create lower temperatures are the most effective.[5] Though it is not the target tissue for cooling, skin is the first layer to be cooled.[6] To produce local analgesia, skin temperature is cooled to 56.5-degrees Fahrenheit.[8] Skin temperature is an effective way in measuring the efficacy of cooling modalities as it transfers the cooling deeper in the tissues below.[6,9] With these concepts in mind, in this study we aimed to determine which cold compression device created the largest temperature changes. We also aimed to discover if the cost-effective, traditional means of cryotherapy, an ice pack, was as effective as the more expensive, technologically advanced cryotherapy devices.

Significance of the Study

The use of cryotherapy has become an increasingly popular modality technique.[3] In this study, the PowerPlay and Game Ready devices were compared against a crushed ice pack secured with an ace bandage for compression. As the popularity of cold compression therapy devices continue, we hoped to discover which device was the most effective when cooling skin temperatures. Several studies examined the efficacy of ice packs, ice massage, and cold-water immersion on cooling tissue temperatures. However, these traditional forms of cryotherapy have not been compared to newer cold compression devices. We determined if traditional ice packs produced the same skin temperature changes as these devices.

Purpose of the Study

The purpose of this study was to determine which cold compression modality produced the greatest change in skin temperature following a 20-minute treatment. We assumed the modality that created the greatest temperature difference was most effective at cooling skin temperatures.[5] The three treatments compared in this study included the PowerPlay, Game Ready, and a crushed ice pack secured with an ace wrap. Each treatment has the benefit of combining cold and compression therapy. The clinical relevance of this study aimed to help clinicians make an educated decision regarding the most cost-effective means to achieve therapeutic skin temperatures to facilitate the healing process. We hypothesized, because of the added circulation, the Game Ready would create a greater temperature difference as compared to the other two techniques.

REVIEW OF LITERATURE

Overview

Immediate care following an injury is an important part in healing. The use of cryotherapy and compression are a part of the RICE prescription, which stands for rest, ice, compression, and elevation.[10] These principles are continuously used by clinicians due to their cost-effectiveness and ease of accessibility. Throughout this review, these principles are explained and how they can reduce the risk of further damage following an injury.

Tissue Response to Injury

When an injury occurs in the body, anatomical, physiological, pathological, and psychological changes occur.[10] When caring for and rehabilitating an injury, these bodily changes need to be considered. The first response after an injury is inflammation. After an injury, ultrastructural changes begin to occur, which includes the breakdown of the cell membrane.[11] The cell's contents spill out often creating injury to healthy tissue. Chemical mediators such as histamine, bradykinin, and cytokines are released once injury occurs.[10] These mediators act to regulate the inflammatory response and begin cleaning up cellular debris. An increase in blood flow occurs following the release of these chemical mediators transporting leukocytes to the injury site. Leukocytes function to "wall off" the injury so that healthy tissue in the surrounding area is not damaged further.[10] Phagocytes are then activated to clean up cellular debris in the injured area.[11]

Metabolic changes also occur during the inflammatory response. After the primary injury, the body's response to the dying cells can also result in secondary injury to viable cells surrounding the area.[10] Secondary injury results from either enzymatic action or metabolic deficiency. During primary injury, the body releases enzymes to digest wastes and cellular debris; however, they often break down live cells which is known as secondary enzymatic injury. Secondary metabolic injury, however, occurs due to a lack of blood to the injured area, resulting in ischemia.[10] Ischemia can occur due to hypoxia, inadequate delivery of fuels, or an inadequate removal of wastes. If these metabolic deficiencies are severe enough, healthy cells die, resulting in the amount of damaged tissue to increase.[10] With proper care, such as applying ice and compression immediately following injury, secondary metabolic injury is slowed down[10,11]

RICE in Injury Care

The acronym RICE represents the combined use of rest, ice, elevation, and compression to treat musculoskeletal injuries.[10,12] RICE principles aim to minimize the effects of swelling, pain, muscle spasm, neural inhibition, and secondary metabolic injury.[10] The goal of rest during the acute phase of injury is to not aggravate the damaged tissue any further. This means moving the injured limb within a protected range of motion.[10] The individual avoids activities that induce stress on the injured tissues which increases blood flow and interferes with the repair and healing processes.[12] Aggravation of the tissue may cause further damage, spasm, or pain. The patient is allowed four to five days of rest to limit aggravation of the injured tissues, therefore decreasing the risk of further injury. Ice, often known as cryotherapy, is most commonly used to treat swelling and minimize secondary metabolic injury.[10]

Cryotherapy decreases tissue temperature which reduces metabolic demands, induces vasoconstriction, and limits bleeding which all limits secondary injury, ultimately reducing pain.[12] The goal of compression is to control edema and stop hemorrhaging. Compression increases the pressure outside the capillaries, which helps control the formation of edema.[10,12] The final element to RICE, is elevation. Elevation helps to decrease the hydrostatic pressure of the capillaries, decreasing the force of the fluid out of the capillaries, aiding in controlling edema formation and bleeding.[10,12] Each element of RICE is important in protecting an injury from further damage.[12]

Cryotherapy

Cryotherapy is the most common choice of modality in treating musculoskeletal injuries. Cryotherapy is the therapeutic use of cold, which works to lower tissue temperatures by removing heat from the body.[6,10] The goal of cryotherapy is to minimize secondary injury by decreasing metabolism in the injured tissues. There are many ways to apply cryotherapy, and a variety of protocols exist. Evidence, however, is not clear as to which is best. Evidence suggests there is a direct relationship between tissue temperature and metabolism; as tissue temperatures drop, tissue metabolism also decreases.[10] Therefore, the greater the cooling and the quicker cryotherapy is applied, the more effective it becomes.[10]

Physiological Effects of Cold

Cold is not a physical substance like heat, rather is the absence of heat. When cooling the body, a heat transfer in the form of conduction occurs and there is an exchange of energy between two substances.[10] In this case, the exchange of heat occurs between two objects of uneven temperatures. The cryotherapy agent cools the skin through conduction. The heat from the body transfers to the cryotherapy agent, therefore cooling the skin. This allows the body to reach temperature equilibrium.[10] The rate at which temperature decreases is related to the rate of conduction and is dependent on a variety of factors including the rate of conduction, storage capacity of the modality, length of application, and the individual's characteristics.[10,13]

The rate of conduction depends on the temperature differential between the body and the cold modality. The larger the difference in temperature, heat conducts and reaches equilibrium faster.[10] During the application of a cold modality, the tissue gives up heat. In doing so, some of the heat lost is replaced by blood in the surrounding tissues. The modality device accepts this heat which also elevates its temperature to attempt to reach equilibrium. These two factors affect temperature change.[10]

The next variable influencing cooling is the heat storage capacity of the modality device.[8,10] Different cold modalities accept different amounts of heat before they begin to rewarm. The larger the surface area of the cold modality and the greater area that is in contact with the skin, increases the amount of heat it accepts.[6,8,10] The length of the application is also an important factor in the rate of conduction. The longer the application, more heat is removed from the body.[6,10]

It is also important to keep in mind individual patient variability in heat conduction.[10,13] This difference is largely attributed to adipose tissue between the skin and underlying muscles. The amount of adipose tissue varies due to sex, body region, and fitness levels.[10] Adipose is an insulator often interfering with the transfer of heat further into the muscle tissue below. Greater presence of adipose tissue means an increased treatment time to cool muscle tissue. [10,13]

Two other definitions that factor into choosing a cold modality are specific heat and phase change.[4,5,6,10] Specific heat is the amount of energy is takes to raise 1 kilogram of a substance 1-degree Celsius.[10] The larger the specific heat the more energy it removes. A phase change is the transition from one thermodynamic state to another. Phase change occurs when a solid converts to a liquid, without a change in temperature.[4,5,6,10] When ice changes to water, it requires a large amount of specific heat, thus maximizing cooling.[10] When choosing a cryotherapy technique, it is important to keep these factors in mind to produce the greatest effects of conduction from skin to muscle.

Benefits of Cold

There are many benefits to the application of cryotherapy. Cryotherapy has effects on decreasing tissue temperatures which decreases pain and cellular metabolism.[1,10] When cryotherapy is applied, heat moves from the target tissue to the cold modality decreasing tissue temperature.[10] In order to achieve therapeutic effects skin temperatures need to reach 50-55°F.[2,6]

Cryotherapy is an extremely beneficial modality in treating pain. During the application of cold, the body transitions through a series of sensations.[2,14] It begins with a sensation of cold, stinging, burning, aching, and finally numbness.[2] It is unknown when these sensations take place, but it is generally thought to occur within 5-15 minutes of treatment.[14] This suggests that the analgesic effects of cold are caused by these skin sensations.[2] As temperature decreases, metabolism also decreases suggesting a direct relationship between the two.[12] With a decrease in metabolism, secondary metabolic injury is minimalized. As a result, the greater the cooling, and the quicker it is applied, the more effective it becomes.[12]

To produce the analgesic effects of cryotherapy, the application must be applied no shorter than 15 minutes.[14] Recommended treatment times range from 15-45 minutes, depending on the goal of rehabilitation. Following an injury, to reduce the effects of further damage (secondary metabolic injury), ice should be applied for 30-45 minutes every two hours.[10] In clinical practice, a commonly used treatment time is 20 minutes. Analgesic effects occur, however, after only 15 minutes. To improve the effectiveness of the cryotherapy treatment, compression is added.[14]

Compression

Compression is the application of an external force that alters capillary pressure subsequently improving lymphatic flow.[10] The primary rationale to apply compression following an injury is to create an external pressure gradient and reduce edema.[15] Compression following an injury works by increasing the pressure outside the capillaries and decreasing the pressure inside the capillaries which helps control edema. Compression is most beneficial once the edema begins to form and is beneficial for as long as the edema is present.[10,12] It is unknown when edema begins to form, so compression is generally applied immediately following an injury.

There are two types of compression which include constant and intermittent.[10,14] Constant pressure is commonly used during the immediate treatment of an injury to prevent edema. These treatment times are typically 15-30 minutes.[10] Intermittent compression is commonly used to remove edema once it has formed. This form of compression acts to stimulate the lymphatic system by a using a pumping effect to remove tissue debris.[10,12] These treatments are also recommended for 15-30 minutes. The pumping effect occurs when compression fluctuates between the highest pressure to no pressure.[15] To produce therapeutic effects with compression, pressures should not exceed diastolic blood pressure as to not occlude venous flow. Recommendations for the lower extremity include a pressure setting of 60-100 mmHg.[15] Increasing venous pressure between 35 and 55 mmHg increases venous flow by 175%. Therapeutic compression is an important aspect in controlling edema, but typically is not used alone.[6,10]

Use of Cold and Compression

There are many different types of cold compression devices. Cold compression devices force air, water, ice, or a combination throughout a sleeve or boot.[14] The sleeve is fitted around the joint so that when it inflates, pressure and cryotherapy is applied.[14] These devices offer either intermittent or static pressure setting throughout the treatment. The two devices used in this study were the PowerPlay and Game Ready. The PowerPlay is a convenient cold compression device which utilizes gel sleeves and intermittent, sequential compression for joint and muscle relief. The PowerPlay has three pressure settings ranging from 30 mmHg to 70 mmHg and offers intermittent or sequential compression.[16] Compression is applied distal to proximal to facilitate in edema reduction. The device weighs only one-pound, making it portable and convenient for the athlete or the clinician to use.

The Game Ready combines cold and compression by circulating ice water through a sleeve with intermittent, pneumatic compression. The three pressure settings include low, medium, and high, which range from no compression or 15 mmHg to 75 mmHg of pressure.[17] The change in pressure in the sleeve produces a pumping effect assisting with edema removal and decreases skin temperature.[3,12] Cryotherapy with the addition of dynamic compression works to enhance the analgesic effects of cold by producing lower temperatures and thus improves exchanges of oxygen and nutrients in the target tissue.[3] It has been shown that combining cryotherapy and dynamic compression decreases the risk of skin necrosis along with the other benefits of cold and compression as separate entities.[3]

Conclusion

Following a musculoskeletal injury, it is important to apply these concepts to help reduce the impact of secondary injury. Once an injury occurs, inflammation is necessary for the body to heal. It is important, however, to minimize the impacts of inflammation and the risk of further tissue damage.[10] The concept of RICE has been used by clinicians, as it is typically easily accessible. While the evidence suggests application of both cryotherapy and compression in combination enhances cooling, it is unclear at this time what device is most effective at lowering target tissue temperatures. Therefore, this study aimed to determine if the traditional ice pack with a secured ace bandage for compression was as effective as newer technology in cooling tissue temperature.

METHODS

Design

A repeated measures design was used to conduct this study. Each participant received three treatments in a randomized order: crushed ice pack with compression, PowerPlay, and Game Ready. Participants were placed in numerical order as they volunteered to participate in the study and treatments were randomized using randomizer.org. Participants completed three trials over a course of three different days to test the skin temperature cooling effects of each treatment modality. There was at least 48 hours between each treatment.

Participants

Ten (7 female, 3 male) healthy college-aged students from The University of Montana were recruited to participate in this study. The participants were informed of the study and written consent was obtained. The study underwent review by the University of Montana International Review Board, and the study was approved. Inclusion criteria for students participating included being healthy, recreationally active, and between the ages of 18 and 35 (Age: 22 ± 1.3yrs; Height: 66 ± 4.2 in; Weight: 167 ± 34.3lbs). Recreationally active was defined as participating in aerobic exercise at least two days per week. To qualify, the participants had no known cold allergies or sensitivity to cold, no vascular diseases, no compromised circulation, skin anesthesia, open wounds, or infections, and no lower extremity injuries within the last month. Prior to the first treatment each participant's height and weight was measured and age recorded. An incentive prize for participating was included – the opportunity to win a $50 gift card to the University of Montana Bookstore or Amazon (two were awarded).

Instruments

Crushed Ice Pack

Ice packs were made using Mueller 10 x 18-in, 1-mil polyethylene bags. The bags were filled with 1000 ml of crushed ice and all excess air was removed from the bag before tying with a knot. The same researcher made the ice packs each time to ensure each treatment was similar. The ice-packs were secured to the skin with a single 4-in Ace bandage to produce the added benefits of compression. The treatment was 20 minutes, which is a clinically relevant amount of time for ice packs to be applied.[14]

PowerPlay

The PowerPlay (PowerPlay, Tulsa) was utilized as one of the cold compression devices in this study. The PowerPlay combines gel ice pack wraps, specific to different body parts, and compression to aid in the recovery process.[16] In this study, the ankle wrap was used. The PowerPlay has three pressure settings which allow for intermittent and sequential compression.[16] For this study, the pressure setting was set at 70 mmHg and the treatment time was 20 minutes.[6] For the safety of the participants, a cotton sleeve was placed between the gel pack and the skin to prevent cold burns.

Game Ready

Game Ready (CoolSystems, Inc, Concord) is a cold compression therapy machine which uses active pneumatic compression and adjustable temperatures to aid in the recovery process.[17] Game Ready uses body part specific wraps which circulate a mixture of ice and water. The device has three pressure settings which mimic natural muscle contraction while cooling the tissues.[17] The highest setting was used in the study which reaches 75 mmHg. The temperature was set at the lowest available setting and the treatment time was 20 minutes.

Ryobi RP4030 Infrared Thermometer

The Ryobi RP4030 Infrared Thermometer (Ryobi, Chicago) is a 6.8 inch, 1.5-pound thermometer.[18] The Ryobi was utilized to assess skin temperature prior to and following the 20-minute application of the three modality devices. The Ryobi has a maximum temperature reading of 626°F and a minimum reading of -58°F. The infrared thermometer laser sighting accurately measures skin temperature when shot within a one to twelve-inch radius at a 90-degree angle.[18] For this study, the laser was pointed at a 90-degree angle to the sinus tarsi, approximately 3-4 inches from the skin. Three measurements were taken before, and three were taken following the 20-minute treatment of each therapy device and average was recorded.

Procedures

Each of the participants received each of three cold therapy treatments on separate days in a randomized order. Each cold therapy modality was placed around the ankle and temperature was recorded before and after a 20-minute treatment. The ankle was chosen because it is a common site for injury and does not contain a significant amount of adipose tissue, which allows for better conduction of the cold. [5,6,13,19] There were three trials which consist of 20-minute treatments of the crushed ice-pack, PowerPlay, and Game Ready. Temperature was recorded over the anterior talofibular ligament (ATFL) in the sinus tarsi. Recordings were taken at a 90-degree angle prior to and following each of the three treatments. To simulate a rest, ice, compression, and elevation (RICE) condition, the participants were supine, ankle flexed, and leg elevated to a 45-degree angle.

Data Analysis

Descriptive statistics were calculated for each subject's age, height, weight, and temperature measurements. A 2X3 repeated measures (time x condition) ANOVA was used to evaluate significance where alpha was set *a priori* at 0.05.

Results

A 2X3 repeated measures ANOVA revealed statistical significance between trials and skin temperature (p =0.000). Specifically, post hoc testing revealed ice pack cooled skin temperature significantly more than PowerPlay (p=0.001), as well as Game Ready more than PowerPlay (p=0.021). Ice pack and Game Ready cooled skin temperature similarly (p= .506). The results are illustrated in Figure 1.

Discussion

The purpose of this study was to identify which cold compression device was more effective at cooling the skin, over the anterior talofibular ligament (ATFL) of the ankle. These cryotherapy techniques included the use of the traditional cryotherapy technique of an ice pack secured with an ace bandage compared to two cold compression therapy devices, the PowerPlay and the Game Ready. We found that each of the modalities reached therapeutic temperatures necessary to slow cell metabolism and provide analgesic effects. These effects occur when skin temperature reaches between 50-55°F.[2,6,13] Our results indicated that all three devices used in this study reached therapeutic temperatures to produce analgesia, and the crushed ice pack and Game ready were more effective than the Power Play in cooling skin temperature. Cryotherapy techniques, elected treatment time, and type of compression selected may all influence the outcome of cooling.

Although research is limited, current evidence suggests colder is better.[19] To produce analgesic affects, the skin only needs to be cooled to 50-55 °F.[2,6,13] When comparing our outcomes with current research, Love et al[2] reported similar outcomes regarding skin temperature cooling.[2] In their study, skin temperatures reached 60.3 °F for ice bags, 43.7 °F for ice massage, and 57.9 °F for cold whirlpool post-treatment.[2] Our results for the ice pack and Game Ready reached similar temperature levels to ice massage, and all three of the treatments from our study reached colder temperatures than the cold whirlpool and ice pack cryotherapy treatments reported by Love et al.[2] Although the results coincide with reducing tissue temperatures to optimal cooling levels, we found that whilst optimal analgesic effects are achievable it is difficult to ascertain whether cooler skin temperatures have a more meaningful effect metabolically. The major shortcoming is that standards set for optimal cooling are assumed but not definitive.[4]

Variables that Influence Effectiveness

There are many variables to consider when making a clinical decision to applying cryotherapy techniques. Clinicians want to know which method is going to be the most effective at cooling skin temperatures. For immediate care, according to Knight and Draper,[10] ice should be applied for 30-45 minutes every 2 hours. With these guidelines, the goal is to cool tissue temperature to reduce the risk of secondary metabolic injury. If a patient is being active following the treatment, then cryotherapy should be applied every hour. Treatment duration is also dependent on individual variability. Every patient is unique, and each treatment should be individualized to provide an effective treatment. It is important to think about the treatment site and the amount of adipose tissue present in the area. Otte et al[20] found that larger amounts of adipose tissue require longer treatment times. For every 10mm of adipose tissue, the time increases by at least 10 minutes.[20] If skinfold thickness cannot be measured, the following principles can be taken into consideration. Females typically have higher skinfold thickness than males, recreationally active individuals have more adipose tissue than Division I athletes, and the treatment area such as the ankle has less adipose tissue than the thigh.[20]

In this study, we used three cold compression treatments to determine skin temperature differences. We chose skin temperature because it is a non-invasive technique to determine the effectiveness of the treatment. The treatment was performed on the ankle and skin temperature was recorded over the sinus tarsi. The ankle is a common place for musculoskeletal injury and the amount of adipose tissue is low for better conduction of cold.[5,6]

Intramuscular temperature is the target tissue, however skin temperature is an appropriate measure as it transfers the cooling deeper into the underlying tissues.[6,9] We chose a 20-minute treatment time for each device, because it typically takes only 5-15 minutes to create analgesia.[14]

Compression Techniques

There are a variety of ways to apply compression when using cryotherapy to maximize its effectiveness. These techniques enhance the cooling effect of cryotherapy.[10] Some form of compression is more effective than not using compression altogether.[10] The PowerPlay uses intermittent or sequential compression, which acts as a milking effect working distal to proximal.[16] The Game Ready utilizes pneumatic compression, which circulates from full pressure to no pressure.[17] In this study, we found that static compression from the ice pack and Ace bandage was more effective at cooling skin temperatures than the Game Ready and PowerPlay. These results support Hawkins et al's findings,[21] which demonstrated that an ice pack with static compression was more effective at cooling skin temperatures than Game Ready with pneumatic compression on the medium setting. In our study, the Game Ready was set on the highest pressure, and similar results were found. Static compression is shown in both studies to be more effective at cooling skin temperatures than intermittent compression. The intermittent compression is primarily used for mimicking muscle contractions, not improving cooling.[21]

Recommendations

Modalities that utilize cold and compression produce much lower skin surface temperatures.[1] It is important to note, although the ice pack and Game ready were more effective cooling the skin temperatures than the PowerPlay, all three treatments produced an analgesic effect. The reproduction of the analgesic effect suggests both modalities induce a local hypothermic effect along with compression, which causes vasoconstriction and lowers microcirculation.[11] This cold induced vasoconstriction reduces extravasation of blood into surrounding tissues, local inflammation and edema production. Adding in the compression aspect, reduction in blood flow and swelling are achieved by facilitating translocation of edema away from the site of injury toward proximal non-compressed tissues.[22] Pushing this edema and swelling away from the injury site allows for the lymphatic system to reabsorb the plasma and plasma proteins more efficiently. The results show that both the PowerPlay and Game Ready devices do facilitate injury healing and support patient recovery.

Cooling efficacy is dependent on the anatomical location, duration of the treatment, the use of compression, and the mode used. These factors should be taken into consideration as a clinician to choose the correct treatment for athletes following an injury. In this study, each cryotherapy mode reached optimal cooling of at least 50-55°F after a 20-minute treatment. Each of the modalities would be beneficial to apply following an acute injury to decrease secondary metabolic injury, but a traditional crushed ice pack secured with an Ace bandage displayed the most cooling and may be the most cost-effective treatment.

Limitations

One limitation of this study includes using young, healthy subjects with no current ankle injury. The results could differ in those patients who are injured and present with edema and pain. The study also focused on skin temperatures rather than intramuscular temperature which was not obtained in this study due to laboratory constraints. These factors should be taken into consideration when developing future research.

Future Considerations and Recommendations

Cold compression devices have become an increasingly popular tool for athletic trainers for use following acute musculoskeletal injuries. While these devices are often expensive, during this study we aimed to determine if a traditional ice pack with an ace bandage would be as, or more, effective at cooling skin temperatures as the newer cold compression devices, Game Ready and PowerPlay. We found that after a 20-minute treatment, the ice pack was as effective as Game Ready and more effective than the PowerPlay at cooling skin temperatures.

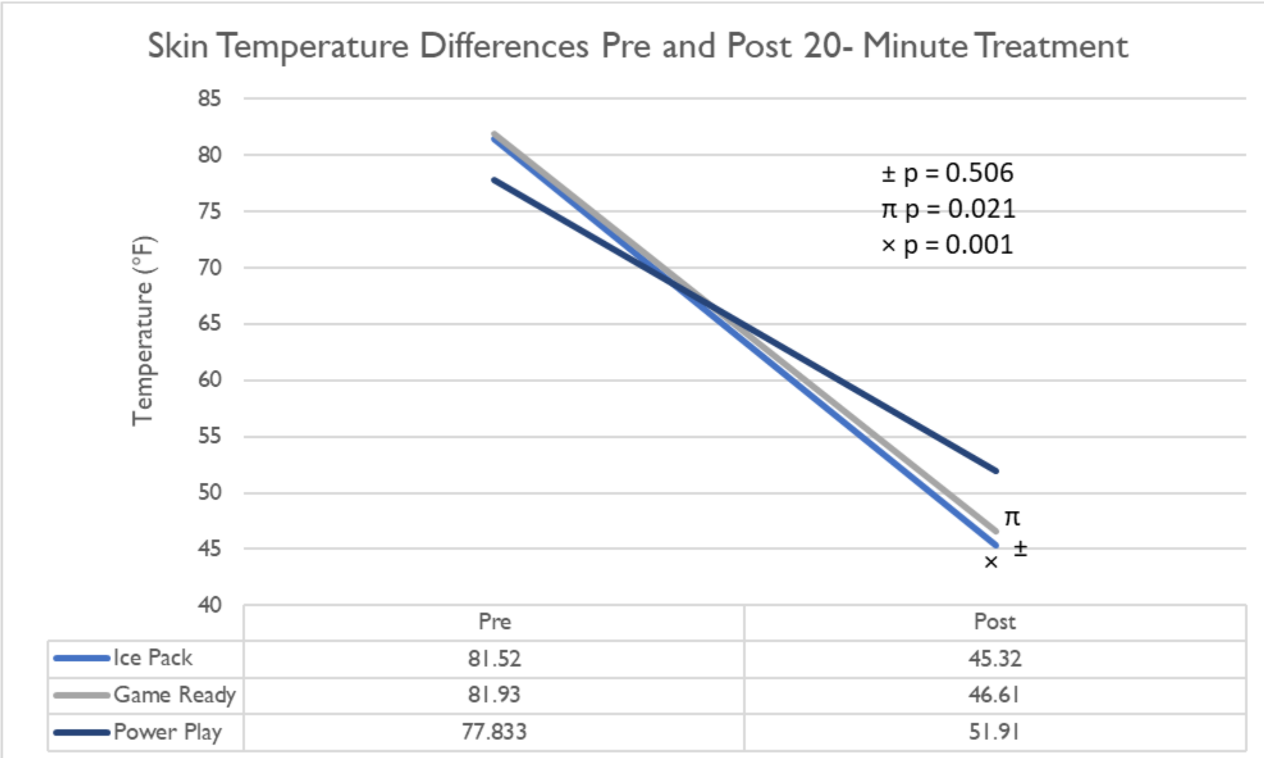
Currently, it is unknown whether there is a target tissue temperature that optimizes healing after a musculoskeletal injury.[6] In this study, we found a significant difference in the ice pack and Game Ready's pre-and-post temperature values. However, it is unknown whether important physiological changes occurred because of the significant difference in temperature. It is known that the use of cold compression therapy improves clinical outcomes, however, in the future more research should be conducted to determine at which temperature, cryotherapy is the most beneficial. It would also be beneficial to look at intramuscular tissue temperatures as that is the target tissue of cryotherapy techniques.

In the clinical setting, cryotherapy modalities, such as an ice pack, PowerPlay and Game Ready, are often administered for 20 minutes. In our study, we found that the PowerPlay showed greater differences in skin temperature over 20 minutes. In future studies, it would be beneficial to discover how the temperature changes throughout the treatment and at which point each device reaches therapeutic temperatures.

CONCLUSION

Throughout our research, we found that different cold compression therapy devices do produce different skin temperature effects on the body. All three of the cold compression therapy devices reached analgesic affects, by dropping the skin temperature below 50°F. However, the ice pack and Game Ready produced cooler skin temperature differences than the PowerPlay. We found our results displayed statistical significance when it came to skin temperature differences pre-and-post with the Game Ready and ice pack. Research is limited whether colder temperatures produce better effects on the treatment of acute musculoskeletal injuries. Based on the idea of colder is better, our results showed that Game Ready and ice packs were the most effective. This knowledge can help clinicians choose the most effective cold compression device with patients who suffered an acute musculoskeletal injury.

Figure 1. Skin Temperature Differences Pre and Post 20-minute Treatment.



± *p= 0.506* | Ice pack and Game Ready cooled skin temperature similarly.

π p= 0.021 | Game Ready cooled skin temperature significantly more than PowerPlay.

× *p= 0.001* | Ice pack cooled skin temperature significantly more than PowerPlay.

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