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THE EFFECTS OF GALVANIC CURRENT AND ICE ON MUSCLE TEMPERATURE

A Thesis
Presented to
The Faculty of the Department of Human Performance
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Masters of Arts

by
Sally J. Grutzner
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ABSTRACT

THE EFFECTS OF GALVANIC STIMULATION AND ICE ON MUSCLE TEMPERATURE

By Sally J. Grutzner

Muscle temperature was measured in 20 subjects, 10 males and 10 females, 25.1 $\pm$ 2.3 years of age, with no muscle strains in their gastrocnemius muscles, in response to 15 minute treatments of ice, and the treatment of ice with positive polarity galvanic stimulation (PPGS) and 105 minutes of rest. Two-way ANOVAs revealed no significant difference ($p > .05$) in muscle temperature between treatments. Significant difference ($p < .05$) existed for each treatment across time. Subjects were divided into two groups based on gender. Two-way ANOVAs revealed no significant difference ($p > .05$) between groups for the ice treatment. Significant difference ($p < .05$) between groups existed for ice with PPGS. T - tests conducted over seven 15 minute time intervals revealed no significance ($p > .007$). Two-way ANCOVA ($p > .05$) covaring for skinfold thickness, eliminated the gender difference in muscle temperature following the treatment of ice with PPGS.

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CHAPTER I

THE PROBLEM

Introduction

Physical activity places great load on individuals' musculoskeletal systems, potentially leading to an injury. Injuries are very common. Traditional treatment of acute injury today is rest, ice, compression, and elevation, usually referred to as RICE (Knight, 1995). This protocol reduces the risk of further trauma and provides the best healing environment, by decreasing the swelling and metabolism to the injury site. However, why is it beneficial to reduce metabolism and swelling to the injured area? After the initial trauma, additional cell death and damage to tissues can occur due to secondary hypoxia (Lachman & Jenner, 1994). The additional tissue damage can result in higher oncotic and capillary filtration pressure creating a greater sensation of pain. Ice application has been shown to reduce the amount of secondary damage by lowering the cellular metabolism. As a result of decreased cellular death, there is less swelling and pressure in the traumatized area (Knight). Cells are able to survive longer since their need for oxygen has been reduced, potentially reducing the time of healing and returning the individual to physical activity.

An additional benefit of cryotherapy is the analgesic effect. Ice numbs the area of application and can help break the pain-spasm-pain cycle (Knight, 1995). A recent trend involves combining interferential electrical stimulation with the ice application to treat pain and joint sprains by "activating the spinal gate, inhibiting the transmission of noxious impulses" (Starkey, 1993, p.157). Another common form of treating acute injuries with electrical stimulation involves the combination of cryotherapy with galvanic stimulation (Michlovitz, Smith, & Watkins, 1988). Galvanic current is a high volt direct current and can have either a positive or negative pole. A negative pole produces vasoconstriction and sedates a nerve while a positive pole promotes vasodilation and stimulates a nerve (Harris, 1994). Very little conclusive research is available to support the use of galvanic stimulation in conjunction with cryotherapy (Mendel & Fish, 1993).

This study was designed to examine the treatment of galvanic stimulation and ice on muscle temperature. Ice in conjunction with galvanic stimulation with a positive polarity theoretically should produce vasoconstriction. Vasoconstriction decreases the cell permeability and metabolism which can lessen secondary hypoxia (Knight, 1995; Harris, 1994). This study was designed to examine if there is a difference in muscle temperature between the treatments of ice in conjunction with galvanic current and ice alone. Staodyn's EMS+2 Neuromuscular Electrical Stimulator, Staodyn Inc (Longmont, CO) is a portable pulsed galvanic stimulator which is designed to decrease edema, promote wound healing, and be a nerve stimulator. The EMS+2 was the galvanic stimulator used in this study.

Significance of Study

Traditionally, acute injuries have been treated with rest, ice, compression, and elevation. This protocol has been effective in providing the proper healing environment in acute joint sprains and muscle injuries (Starkey, 1993). The ability to further enhance the healing process resulting from acute injury would not only facilitate a quicker return to activity, but lessen the total amount of trauma.

There are many therapeutic modalities on the market today. Anecdotal evidence on the benefits of galvanic stimulation and its ability to accelerate the healing process has been justification for its use. However, there is little experimental research available supporting their effectiveness (Mendel & Fish, 1993).

This study was designed to determine if ice in conjunction with galvanic current has a greater effect than ice alone. The study was designed to determine if galvanic stimulation and cryotherapy are effective in reducing muscle temperature. This investigation intended to challenge the traditional approach of rest, ice, compression, and elevation. In addition, the results might have encouraged future study of galvanic current and its effects on blood flow and tissue healing.

Statement of Purpose

This study was designed to assess the effects of ice in conjunction with positive polarity galvanic stimulation and ice alone on muscle temperature among healthy male and female adults.

Delimitations

While designing this study, certain delimitations were accepted.

1. The sample group was delimited to college aged males and females participating on a volunteer basis. Thus, this population was not selected by random sampling.

2. The subjects were delimited to healthy individuals as defined by the American College of Sports Medicine. Human research employing invasive techniques mandated that informed consent was secured from all subjects who volunteered to undergo explicit testing.

3. The tests were performed in the same room to ensure the same environmental conditions for all subjects. The availability of technical resources to the researcher and testing equipment allowed for sophisticated data collection in a controlled environment.

4. Subjects were delimited to those individuals with healthy uninjured leg muscles. Previous muscle damage could have possibly compromised muscle tissue temperature.

5. Galvanic stimulation was the only electrical stimulation therapy used in this study.

6. The need for invasive intramuscular analysis did discourage potential subjects; therefore, the study sample was small.

Limitations

The limitations of this study reflected the effects of the delimitations on collection, interpretation of the data, and the availability to expand the scope of inference beyond the sample population. The following limitations were accepted in this study. Generalizations made from the results were compromised by the following limitations.

1. Healthy college age subjects were tested based on their availability and to reduce the potential incidence of secondary injury.

2. Results could not be generalized beyond the test group.

3. Baseline tissue temperatures did vary between subjects. Attempts were made by the investigator to maintain consistency in all tests throughout the evaluation period.

4. Selection criteria were limited by the memory and honesty of subjects on their health history form. A medical physician was available to ensure that all precautions were adhered to during the testing session.

5. Results of this study could not be applied to interferential, faradic, or other forms of electrical therapy. Other electrical therapeutic modalities may demonstrate significant differences in results.

6. The number of subjects constrained the power of testing for statistical significance. Results could not be inferred beyond the study sample.

Assumptions

The following assumptions were made for the study:

1. Changes in muscle temperature did reflect changes in vasoconstriction and cell metabolism.

2. The skinfold measurement was the best way to measure the amount of cutaneous and adipose tissue covering the gastrocnemius muscle. Tissue and fat amounts differed between individuals. Therefore, the tip of the temperature probe was two centimeters below the site of application, five centimeters lateral to the medial side. If the depth was inadequately measured, the study results may have been confounded.

3. Subjects truthfully answered their health history questionnaire in all categories to adequately assess their health.

4. The EMS+2 was consistent with all therapeutic galvanic current units available on the market today in terms of conductibility, frequency, and intensity.

Null Hypotheses

No significant difference will result in muscle temperature between the treatment of ice and the treatment of ice in conjunction with positive polarity galvanic current among healthy male and female adults. There will be no significant change in temperature across time for the treatment of ice alone or ice with positive polarity galvanic stimulation. No significant interaction will occur between the treatments of ice alone and ice with positive polarity galvanic stimulation. No significant difference will result between genders and their muscle temperature response to the treatments of ice alone and ice with positive polarity galvanic current.

Definition of Terms

Anode - the positive pole of an electrical circuit (Starkey, 1993).

Cathode - the negative pole of an electrical circuit (Starkey, 1993).

Cell metabolism - the combination of all the cell's chemical processes (Campbell, 1990).

Cell permeability - the ability of fluids or substances to pass in solution (Taber, 1993).

Direct current (DC) - the continuous flow of electrons in a single direction (Starkey, 1993).

Hyperaemia - an unusually excess of blood in any region of the body (Costello, 1991).

Secondary hypoxia - death of cells due to a deprivation of oxygen (Starkey, 1993).

Vasoconstriction - a decrease in blood vessels diameter (Starkey, 1993).

CHAPTER II

REVIEW OF LITERATURE

Introduction

Musculoskeletal injuries are a common part of physical activity. Individuals and health professionals are looking for ways to help facilitate the healing process. Rest, ice, compression, and elevation (RICE) is traditionally the most effective way of treating acute injuries (Knight, 1995). Galvanic stimulation is being used in addition to the RICE protocol, but there is little experimental research available to support its use for acute injuries (Mendel & Fish, 1993). This investigation focused on the effect of ice in conjunction with galvanic stimulation on muscle temperature. The review of literature was divided into: a) the acute inflammatory process, b) treatment of acute injury with cold, c) the effectiveness of galvanic stimulation, and d) the summary.

The Acute Inflammation Process

Taber's Medical Cyclopedia defines inflammation as the "tissue reaction to injury" (Taber, 1989, p. 912). Acute inflammation can be the result of damage to tissues due to trauma, infections, or other damaging substances such as extreme heat or cold, or chemicals. Arterioles constrict during the first few minutes following the trauma. Histamine, serotonin, and bradykinin follow and cause vasodilation of the arterioles and venules resulting in hyperaemia (Lachman & Jenner, 1994; Wilkerson, 1985). During the hyperaemia phase, capillary walls become permeable to fluid and large molecules. This vascular permeability is maximal within 10-30 minutes after trauma (Baumert, 1995). In addition, a protein-rich inflammatory fluid which contains fibrinogen flows into the traumatized area, placing pressure on the tissue, and resulting in visible swelling. Leukocytes are pulled toward the area to clean up debris in the traumatized area. Blood flow through the dilated capillaries slows due to the white blood cells sticking to the walls. After 24-48 hours, the traumatized blood vessels have been closed with platelets and fibrin, while the extravascular spaces are expanded to the maximum (Lachman & Jenner).

As the body is responding to the traumatized tissue, the surrounding cells are deprived of the necessary oxygen to continue with cell metabolism. Aerobic metabolism no longer occurs and anaerobic metabolism takes over resulting in a state of hypoxia (Knight, 1995). Normal activity of the cell begins to slow and sodium is no longer pumped out of the cell by the sodium pump. Water leaks into the cell to decrease the high concentration of sodium. The cell starts to swell and can eventually burst, adding to the amount of damage. Applying ice as soon as possible to the traumatized area, slows the metabolism of the uninjured cell and keeps the cell from going into a state of hypoxia, decreasing the amount of total tissue damage (Knight).

Inflammation is often the result of musculoskeletal injuries. The body allows extra fluid to be sent to the area to aid in healing. Excess fluid prevents normal blood flow from getting to the surrounding cells. As a result, uninjured cells often die due to secondary hypoxia. The greater the amount of tissue death, the longer it takes to heal. The extra fluid can also slow the rate of recovery for the athlete, by producing swelling which leads to pressure and pain (Lachman & Jenner, 1994). Therapeutic modalities are applied to help promote the best environment for healing (Knight, 1995).

Treatment of Acute Injury with Cold

One of the main goals for immediate care following a musculoskeletal injury is to limit the swelling. Reducing swelling helps speed the healing process by lowering the pressure in cellular environment. The best way to accomplish this is through the use of RICE (Baumert, 1995; Knight, 1995). Resting the area decreases the muscle's need for oxygenated blood. Cooling the area significantly reduces the oxygen consumption as described by McLean (1989) in a review of literature. Compression provides a physical barrier to prevent more swelling from entering the injured area. Once swelling has occurred, elevating the injured area above the heart aids in pulling the extravascular fluid toward the heart and away from the injured area. The components of RICE are designed to provide the best healing.

Ice is the main component for decreasing the total amount of damage. The application of ice slows cellular metabolism and decreases the amount of oxygen used by the uninjured cells surrounding the injured tissue (Baumert, 1995). Ice has an inhibitory effect on inflammation by decreasing the rate of chemical reactions in cells and by decreasing the need for enzymes, which can lower the amount of inflammatory substances that are released (Wilkerson, 1985).

Experimental research supports the use of cold for musculoskeletal injuries. Cote, Prentice, Hooker, and Shields (1988) examined the treatment of cold, heat and contrast bath during the third, fourth, and fifth days following ankle sprains. Thirty subjects were randomly assigned to one of the three treatment groups and treatments were given once daily for twenty minutes. Water displacement measurement was used to measure the change in edema and statistical significance was determined by a 3x3 two-way ANOVA for repeated measures. The results revealed a significant difference in treatment effects between cold and heat as well as between cold and contrast bath.

Cote et al. (1988) concluded that cold is the most favorable treatment for minimizing edema.

Merrick, Knight, Ingersoll, and Potteiger (1993) also conducted a study which supports the effectiveness of cold and its potential for slowing metabolism. They measured intramuscular temperature during the treatments of ice and compression at the skin surface, 1 cm below the fat layer, and 2 cm below the fat layer. Eleven subjects were given all four treatments of control, ice alone, compression alone, and ice with compression wrap for thirty minutes. Temperatures were measured every thirty seconds during five minutes prior to treatment, during the treatment, and twenty minutes after the treatment. Ice alone and ice with compression produced significant cooling effects at all three tissue depths. Again, ice has been shown to be effective in decreasing muscle temperature and potentially slowing metabolism of the surrounding tissues.

One of the newest products on the market to cool musculoskeletal regions is the Pro-Stim Edema Management System (TKO, Inc, Alameda, CA). The Pro-Stim system is different from the conventional treatment of ice with an Intelect High Voltage Stimulator because the electrodes are part of the pack and the compression wrap adheres to the pack (Holcomb, Mangus, & Tandy, 1996). Skin temperatures were taken every minute during the thirty minute treatment session. The results revealed that temperatures were significantly colder under the electrode with the Pro-Stim system than the conventional method.

The Effectiveness of Galvanic Stimulation

Treatment with galvanic current has been defined by academia and manufacturing companies in many different ways. As a result there is confusion about its the effectiveness. Experts agree that galvanic stimulation is a direct current (DC) that flows unidirectionally and contains polarity (Nelson & Currier, 1987; Starkey, 1993; Ralston, 1985). Staodyn states that their EMS+2 stimulator is a DC, galvanic stimulator in which polarity can be controlled through electrode pad placement.

However, some individuals in academia use the term high voltage pulsed galvanic stimulation (Voight, 1984; Newton, 1987). According to Starkey (1993) this term is an oxymoron since "pulsed" and "galvanic" are used to name the same type of current flow. Even though fluctuations in voltage can occur, the flow continues and remains in one direction. Flow above baseline is constantly occurring, but the level of intensity may vary which is referred to as pulsed. High voltage galvanic stimulation is a correct term. In addition, high voltage galvanic stimulation is not to be confused with low intensity. High voltage refers to the range of volts that the stimulation unit is using, while low intensity is the degree at which the current is set.

The book Clinical Electrotherapy by Nelson and Currier (1987) adds to the confusion by stating that "high voltage galvanic stimulation (HVGS)" is a misnomer since the current is interrupted to produce a series of pulses. Nelson and Currier theorized that high voltage pulsed galvanic stimulation is the best way to refer to DC pulses since the wave form may alter to improve injury recovery, for muscle re-education, or to reduce pain.

Although varying opinions exist on what to name galvanic current, the researchers all tend to use the same type of current in their studies. For the remainder of this study galvanic current will be referred to as unidirectional, continuous direct current, with an assigned polarity. During the literature review the name for galvanic current will be used as used by the researcher.

Galvanic stimulation can produce chemical changes that occur at the cellular and tissue levels. The type of polarity used can produce two different effects. A negative pole will increase circulation while the positive pole will decrease circulation (Newton & Karselis, 1983). Positive polarity current treatment is used for the first twenty-four hours following an injury to decrease circulation and the amount of exudate. With the use of negative polarity, there is an increase in blood flow and serous exudate, and thus a decrease in edema (Harris, 1994). Negative polarity can produce chemical changes that can be beneficial to edema reduction, nerve stimulation, and wound healing. The problem with some of the research available is that many investigators neglect to describe the type of polarity and intensity that was used.

Ralston (1985) sought to unite philosophies of HVGS and produce guidelines for treating injuries. The investigator supported the definition previously stated that HVGS is a continuous and unidirectional current. The majority of the protocols and recommendations come from HVGS manufacturers. The positive pole is recommended for acute pain set at a high frequency (approximately 100 pps) for fifteen to twenty minutes. The small electrode is placed over the injury site, while the larger should be viewed as more of a dispersive pad. Ralston also conducted a survey from Certified Athletic Trainers and Physical Therapists on the use of galvanic stimulation. The survey revealed that galvanic current is used to treat acute and chronic conditions, joint effusion, pain caused by injury, swelling, edema, muscle spasms, contusions, and other injuries. Eighty-two percent of the athletic trainers surveyed used some type of cold with the HVGS (Ralston). However, the investigator neglected to site any experimental research which demonstrated its effectiveness.

In 1993, Mendel and Fish investigated the history and new perspectives in edema control via electrical stimulation. The researchers took measurements of frog leg volume after uniformly injuring them and then assigning them to a treatment group. Treatment consisted of four, thirty minute cathodal high voltage treatments with thirty minutes rest between treatments and were monitored for twenty-four hours. The results revealed that treatments significantly slowed edema formation following the injury as compared to the control group. In addition, four treatments of anodal HVPG were done with 120 pps, and intensities 10% less than visible motor threshold. The results failed to curb edema formation. The difference between these two tests was that the intensity was not indicated for the cathodal treatment. The cathodal treatment could have produced muscle contractions which would have provided a muscle pump to remove the fluids. The authors recommended a protocol consisting of thirty minute treatments of cathodal HVPS at 120 pps every four hours.

In addition to the RICE protocol, some individuals are adding electrical stimulation to the treatment scenario. Michlovitz, Smith, and Watkins (1988) compared the modalities of ice in conjunction with high voltage pulsed stimulation (HVPS) with ice on the treatment of mild and moderate ankle sprains. The HVPS involved unidirectional and continuous current, which meets the criteria of galvanic current. Thirty subjects were evenly divided into three different treatment groups and treated within the first thirty hours following injury, once a day for three days. Group one received ice, group two received ice with a negative polarity treatment of 28 pps of HVPS, and group three had the same treatment as group two except for the frequency was set at 80 pps. All treatments had a duration of thirty minutes. Volumetric measurements were taken using a Lucite tank which measured water displacement. One way analysis of variance was used to determine significance of volume and range of motion. The results revealed that ice and HVPS at 28 and 80 pps had greater decreases in foot and ankle volumes, but the differences were not significant. Michlovitz et al. concluded that HVPS did not further enhance the effects of ice, compression and elevation. Their results were not significantly conclusive to support the use of negative polarity with acute ankle sprains. What about following manufacturers recommendations and treating the ankle sprain within the first 24 hours of injury with a positive polarity current?

Some concern existed about the possible chemical changes that might occur under the electrode which could increase the chance of skin irritation following prolonged treatments. Newton and Karselis (1983) explored this concern and theorized that positively charged ions would gather under the cathode and negatively charged ions would collect under the anode. The combination of these ions with moisture on the skin could potentially form a chemical reaction. Since HVPG units have a low current (1.5 mA), the amount of acid and base under the skin should be minimized. Forty subjects were used and randomly assigned to one of four groups. The three HVPG groups received thirty minutes of negative current from different HVPG units. Skin pH was measured immediately after the treatment under each electrode. This study determined that there was no statistically significant change in the skin pH as the result of positive or negative polarity galvanic stimulation (Newton &

Karselis). Therefore, HVPG should not produce skin irritations under the electrode.

In addition to treating inflammation, galvanic current can be used for nerve stimulation and wound healing. Balogun, Onilari, Akeju, and Marzouk (1993) tested different pulse frequencies of high voltage electrical stimulation and its effect on augmentation of muscle strength. The study involved thirty subjects randomly assigned to three groups of ten subjects. Prior to the electrical stimulation, the legs of subjects were determined to have equal strength as measured by a cable tensiometer for knee extension. The right quadriceps femoris muscles were electrically stimulated with a high-voltage pulsed galvanic stimulator. The groups were assigned a pulse frequency of 20 pps, 45 pps, or 80 pps. The results revealed that the stimulator improved strength of normal innervated muscles, but the pulse frequencies did not have a significant difference in producing muscle strength. Although galvanic stimulation is used in an attempt to increase the augmentation of muscle strength, its effectiveness has been proven in accelerating wound healing (Balogun et al.).

Galvanic stimulation has been shown to decrease edema and accelerate the healing of wounds. Carley and Wainapel (1985) tested fifteen hospital patients with an negative pole low intensity direct current and fifteen patients served as controls by getting traditional wound care therapy of whirlpool cleansing. The galvanic stimulation treatment was given twice daily for two hours, five days a week. Data collection lasted for five weeks or until the ulcer was healed. Measurements of wound length, width, and depth were recorded with no knowledge of the type of treatment that was given. A nonparametric technique, Wilcoxon's rank sum test was used to compare the two treatment groups. The patients with the galvanic stimulation demonstrated a 1.5 to 2.5 times faster healing rate.

High-voltage galvanic stimulation has been used for wound healing. Brown, Gogia, Sinacore, and Menton (1995) conducted a study in which guinea pigs with full thickness incisions were treated with HVS for two weeks. Untreated and treated wounds were compared after two and four weeks. Peak force to failure averages of the eighteen subjects were highly variable, so the hypothesis that HVS increased wound strength could not be accepted. Histology examination results on wound closures were higher on the treated subjects at two and four weeks. This study suggests that HVS has the potential for accelerating wound healing, but more studies need to be done.

Strong supporting research exists for the treatment of galvanic current for wound therapy (Mendel & Fish, 1993). However there continues to be a shortage of experimental research on the therapeutic effects for acute musculoskeletal injuries. Further experimental research needs to be done with explicit details on polarity, strength of current, and objectives to support its use (Mendel & Fish).

Summary

Unfortunately musculoskeletal injuries are a part of human movement. Injuries can prevent individuals from participating while the body is responding to the trauma (Lachman & Jenner, 1994). As the inflammation process begins, surrounding uninjured tissue can be destroyed if the inflammation is not kept under control. The application of ice immediately following injury can decrease the amount of secondary tissue death from occurring by slowing the metabolism of the surrounding cells. Ice combined with compression, elevation, and rest is currently the most effective way of treating acute inflammation (Knight, 1995). Galvanic stimulation is currently being used to help treat a variety of conditions from wound care to musculoskeletal injuries (Michlovitz, Smith & Watkins, 1988; Ralston, 1985). However, there is little research to support its effectiveness in reducing inflammation and edema (Mendel & Fish, 1993). This experiment was designed to determine if galvanic stimulation and ice can significantly decrease muscle temperature more than ice alone. This potentially would aid in slowing metabolism and saving surrounding tissue. Decreasing the amount of inflammation can also optimize the healing environment (Knight). Providing the best healing environment can ultimately help the individual return to participation faster.

CHAPTER III

PROCEDURES

Introduction

The main objective of this study was to determine the effects of ice alone and ice in conjunction with galvanic stimulation on gastrocnemius muscle temperature among male and females between the ages of twenty-one to thirty-one years. This chapter contains a detailed description of the procedures of the study. The procedures are divided into: a) the setting, b) source of the data, c) instrumentation, d) permission and consent, e) the testing procedure, f) and the treatment of data.

Setting

The testing was performed during one session at the Student Health Services at San Jose State University, San Jose, California. One S was tested per day over an eight week period. The environmental room temperatures were taken during the study. If the temperatures were below eighteen degrees Celsius or greater than twenty-four degrees Celsius, the results of that particular test were discarded to control for possible environmental changes that might have compromised study results.

Source of the Data

Volunteers from the Human Performance Department at San Jose State University were recruited for the research study. Ten female and ten male subjects between twenty-one and thirty-one years of age volunteered for this investigation. The volunteers were required to sign the informed written consent (Appendix A) and complete a health questionnaire (Appendix B) designed to evaluate health status and medical history. A physician evaluated the health questionnaire to determine the subjects health status. Any indication that the volunteer might have injured a part of their calf muscle in the past month would disqualify them from participation. Only healthy subjects were used to maintain internal validity of the study. Volunteers with Raynaund's phenomenon, allergies to Cephalosporins, penicillin or cold were excluded from the study for their own safety. The volunteers cleared for participation were given the treatment of ice on the left leg and the treatment of ice with galvanic stimulation on the right leg. Identical protocols and instrumentation for all subjects were used in an attempt to control any confounding variables.

Instrumentation

A ball point pen and a tape measure were used to determine and mark the point of greatest girth around the lower legs. A Fisher's engineer and carpenter's square (#285, with mitre square, spirit level, 45° level, plumb level, height guage, marking guage, straight edge, steel rule, and scriber) was used to determine the height of the calf at the point of greatest girth and the horizontal plane two centimeters down from the highest point bilaterally on the gastrocnemius. The carpenter's square was also used as a level guide for the insertion of the temperature probe. A 27-gauge needle was used by a physician to inject 1 cc of 1% Xylocaine from Astra (Westborough, MA) subcutaneously into the identified site for the probe. A needle microprobe (MT-23/5) from Physitemp Instruments Inc. (Clifton, NJ) was inserted into the lateral side of the gastrocnemius to measure muscle temperature. The monitor connected to the probe was a Thermalert TH-8 Thermometer from Physitemp Instruments Inc. The temperature sensitivity range was -10° to 60° C and has an accuracy of 0.1° C plus or minus one digit. Calibrated Lange skin calipers from Lafayette Instruments (Lafayette, IN) were used to measure the skinfolds of the tissue and adipose tissue of the medial gastrocnemius muscle.

Permission and Consent

Permission to conduct the study was granted by the Human Research Review Board at San Jose State University. Once the volunteers had completed their health questionnaire, the physician determined if they were cleared for participation in the study. Exclusions from the study included individuals who reported allergies to Cephalosporins, penicillin, or cold, any history of problems from cold, such as frostbite, those individuals with Raynaund's Phenomenon, or a fear of needles.

Testing Procedure

All subjects reported to the testing site prior to the initiation of treatment. They signed an informed consent form which included a thorough description of the experimental procedures before beginning the treatment (Appendix A). A licensed medical physician gave subjects a 500 mg dose of Cephalexin, to reduce the chance of a bacterial infection even though sterile techniques were used. The use of Cephalexin was used in a series of studies in which the same invasive technique was modeled. No infections developed following their testing procedures (Draper, Castel, & Castel, 1995; Draper, Schulthies, Sorcisto, & Hautala, 1995; Draper & Sunderland, 1993; Draper, Sunderland, Kirkendall, & Ricard, 1993; Myer, Draper, & Durrant, 1994; Rimington, Draper, Durrant, & Fellingham, 1994). After the experiment, the subjects were instructed to take two more doses, one every six hours to reduce the risk of infection (Draper et al., 1995; Draper & Sunderland; Draper et al., 1993; Myer et al.; Rimington et al.).

The room temperature was taken by a thermometer and if the room temperature was less than 18° C and greater than 23° C the test was not performed. The subjects were told , "should you have any pain or discomfort during the test notify the tester immediately" (Appendix C). The subjects were instructed to lay on their stomach on the testing table. While in a relaxed prone position, with their legs in neutral, the point of greatest girth was determined using a tape measure. A ball point pen marked an X where the center point of the greatest girth existed. These measurements were taken bilaterally. A carpenter's square (Fisher, England) was used to measure two centimeters down from the point of greatest girth. A line was drawn in the horizontal plane, parallel with the table, and level with the carpenter's square. A circular area approximately two centimeters in diameter around the horizontal line was shaven, scrubbed with a Betadine scrub, and swabbed with 70% isopropanol alcohol (Draper, Castel, & Castel, 1995). The medial side of the gastrocnemius muscle along the greatest girth was pinched by Lange calipers and then shaken gently to allow the muscle to fall away. This measurement was repeated until two identical measurement values were taken. This was performed bilaterally. The identical value divided by two was used in the descriptive statistical analysis and in the analysis of covariance (Draper & Sunderland, 1993).

The physician numbed the sterilized area by injecting one cubic centimeter of one percent Xylocaine into the subcutaneous area of the left and right gastrocnemius muscles (Draper, Schulthies, Sorcisto, & Hautala, 1995). The sterile temperature probes were removed from the Wavicide solution, swirled in sterile water for a minimum of ten seconds. The physician pierced the skin with a 21-guage needle before inserting the MT 23/5 temperature probe from Physitemp Instruments five centimeters into the skin, parallel to Fisher's carpenter square which had been adjusted to two centimeters down from the point of greatest girth (Myrer, Draper, & Durrant, 1994). This depth was chosen to ensure that the probe was going into the muscle, not just into the adipose tissue lay and to avoid the peroneal nerve. The probe was then connected to the Physitemp Instrument's Thermalert TH-8 Thermometer (Rimington, Draper, Durrant, & Fellingham, 1994). The subjects were asked if they were comfortable and their response was recorded.

Once the baseline temperature had been maintained for approximately three minutes, the treatment set-up began. The positive electrode pad for the galvanic current was placed on the X, the point of greatest girth. The negative electrode pad was placed 31 millimeters superior to the positive electrode pad on the hamstring. A plastic bag with one liter of crushed ice was placed over the positive electrode pad at the same time a one liter bag of crushed ice was being placed over the left leg. The intensity of the galvanic current was increased one increment at a time until the subjects felt a sensation. Intensity continued to be increased as long as the stimulation was comfortable for the subjects and did not produce a muscle contraction. Muscle temperature was recorded every minute during the fifteen minute treatment. Once the treatments were removed, muscle temperatures continued to be taken for 105 minutes of rest (Appendix D).

Once the testing period was over the physician removed the probe. A gloved hand and sterile gauze was applied directly over the insertion hole to stop any bleeding that might have occurred. The area was swabbed with isopropanol alcohol. A sterile elastic bandage was placed over the injection site (Rimington, Draper, Durrant, & Fellingham, 1994). The subjects were asked how their calf muscle felt. The subjects were given verbal instructions as well as an instruction sheet containing directions for taking the antibiotics and persons to call if they had any problems or concerns (Appendix E). The tester made a follow-up phone call between twenty-four and thirty-six hours following the test. After the testing procedure, the temperature probe was immersed in Wavicide, a sterilizing solution for a minimum of ten hours in accordance with the manufacturer's specifications (Rimington et al.).

Treatment of Data

The Statistical Package for Social Sciences for the mainframe was used for all analyses. Frequency of distribution for gender was determined. Mean, standard deviation, and range calculations were used for demographic information gathered from the health questionnaire, plus skinfold measurements and room temperature measurements taken prior to the study.

The dependent variables in this study were muscle temperature measurements during and following the two treatments of ice alone and ice in conjunction with galvanic current. The independent variables in the study were the treatments ice alone and ice in conjunction with positive polarity galvanic current. The amount of time for muscle temperature to begin to increase following each treatment as well as demographic information was compared descriptively to maintain statistical power. Time intervals in which muscle temperatures were compared included baseline, 15, 30, 45, 60, 75, and 90 minutes, but not at intervals 105 and 120 due to lack of enough data as a result of subject withdrawal to maintain statistical power. Two-way analyses of variance were used to determine if the difference in muscle temperatures between the two treatments and across time were statistically significant. Two one way analyses of variance were performed with Tukey post hoc follow-up tests could be performed. Statistical significance was set at an alpha level of $p<0.05$.

Secondary analysis placed subjects into groups based on gender. Differences in muscle temperature in response to the treatments and across time were analyzed using two two-way analyses of variance for gender. Two one-way analysis of varinace across time, t-tests, and follow-ups with Tukey post-hoc tests were performed. Three two-way analyses of covariance with covariates of skinfold thickness stimulation level, and skinfold thickness in combination with stimulation level to determine if significant differences existed between the gender groups.

Summary

The purpose of this study was to examine the differences in muscle temperature during and after the treatments of ice alone and ice in conjunction with galvanic stimulation. This research design used a strict protocol to reduce the risk of infection. The protocol has been used several times in other studies with no reports of complications (Draper, Castel, & Castel, 1995; Draper, Schulthies, Sorcisto, & Hautala, 1995; Draper & Sunderland, 1993; Draper, Sunderland, Kirkendall, & Ricard, 1993; Myer, Draper, & Durrant, 1994; Rimington, Draper, Durrant, & Fellingham, 1994). The subjects had baseline temperature readings and temperatures recorded every minute during the 120 minutes of testing. Statistical analysis included examination of data from all subjects and then divided the data into two groups based on gender. Two-way analyses of variance, one-way analysis of variance, Tukey post-hoc tests, and two-way analysis of covariance were the statistics used in this study.

CHAPTER IV

RESULTS

Introduction

The major objective of this investigation was to assess the effects of ice alone and ice in conjunction with positive polarity galvanic electrical stimulation on muscle temperature. This chapter describes the results of this investigation. The demographic information of the subjects were descriptively analyzed. These results describe the differences in age, activity level of the subjects, electrical stimulation intensity, skinfold measurements, treatment time, and muscle temperature changes.

The purpose of this study was to determine if there was a significant difference in muscle temperature between the treatment of ice alone and the treatment of ice in conjunction with galvanic electrical stimulation; to determine if both treatments were effective in reducing muscle temperature; and to determine if gender differences existed in muscle temperature in response to both treatments. A temperature probe was inserted five centimeters into the left and right lateral gastrocnemius muscles to measure the muscle temperatures during fifteen minutes of treatment followed by one hundred five minutes of rest.

Selected Subject and Treatment Data

Twenty healthy, college-aged subjects participated in this investigation to determine the effects of ice alone and ice in conjunction with galvanic electrical stimulation on muscle temperature. Ten males and ten females participated in the study having a mean age of 25.10 ($\pm$ 2.30) years and ranged between 21 and 31 years. The subjects reported exercising a minimum of thirty minutes per day an average of 3 (± 1.55) days a week. During the test, subjects were to have the electrical stimulation as high as possible without producing a muscle contraction. The average electrical stimulation level was 14.7 (± 5.1) mA ranging from 10.0 to 32.5 mA. Skinfold measurements were taken bilaterally on the medial side of the gastrocnemius muscle in line with the point of greatest girth. The average skinfold for the leg with ice alone treatment was 12.55 (± 5.66) millimeters and average skinfold for ice with galvanic stimulation was 12.55 (± 5.89) millimeters. Three millimeters to twenty-four millimeters was the range for skinfold measurements. Table 1 reports the descriptive characteristics of the subjects.

Table 1

Descriptive Characteristics of the Subjects

	n	M	SD	Range
Age (yr)	20	25.10	2.30	21.00-31.00
Exercise level (days/wk)	20	3.00	1.55	0.00- 5.00
Room Temperature (°C)	20	21.68	0.51	18.80-23.70
Ice Alone Skinfold (mm)	20	12.55	5.66	3.00-24.00
Ice & Stim Skinfold (mm)	20	12.55	5.89	3.00-25.00

Treatment

No tests were eliminated due to room temperature varying below 18° C or above 24° C. There were no negative responses from subjects once the temperature probes were in place. The average time for the muscle temperature to increase once the treatment had started was 33.75 (± 10.35) minutes for ice treatment and 35.41 (± 5.99) minutes for ice and galvanic stimulation. The baseline temperature reading for the ice alone treatment averaged 35.01° C (± .85° C) and ranged from 33.60° C to 36.40° C. After the ice treatment and 105 minutes of rest, the average ending temperature was 31.46° C (± 1.20° C) and ranged from 29.20° C to 33.10°C. There were three missing data points for temperature at minute 105 and 120 due to S withdrawal. Therefore statistical analysis could not be performed at those time periods for the twenty subjects. For the treatment of ice and galvanic stimulation, the baseline temperature was 34.82° C (± 87° C) and ranged from 33.30° C to 36.0° C. Following the test, the muscle temperature for the ice and electrical stimulation treatment averaged 31.61° C (± 1.08° C) and ranged from 29.8° C to 33.3° C. Table 2 reports the descriptive characteristics of the treatments.

Table 2

Descriptive Characteristics of the Treatments

	M	SD	Range
Stimulation intensity (mA)	14.70	5.10	10.0 - 32.5
Ice Time to increase (min)	33.75	10.35	20.0 - 64.0
Ice & Stim Time to inc (min)	36.41	5.99	22.0 - 47.0
Ice Baseline T (°C)	35.01	0.85	33.6 - 36.4
Ice & Stim Baseline T (°C)	34.82	0.87	33.3 - 36.0
Ice Ending T (°C)	31.46	1.01	29.2 - 33.1
Ice & Stim Ending T (°C)	31.61	1.08	29.8 - 33.3

Statistical Analyses

Primary Statistical Analysis

This study was conducted to determine if significant differences existed between muscle temperatures following the treatment of ice alone and ice with galvanic electrical stimulation for all twenty subjects, males and females. In addition, this study was designed to determine if ice alone and ice with galvanic stimulation are effective treatments for reducing muscle temperature. The independent variables were type of treatment, subjects, and time. The dependent variable was muscle temperature. The modified Bonferroni test was used for the statistical analyses (Keppel, 1982). A repeated measures two-way analysis of variance was performed to determine differences in muscle temperature between treatments. An alpha level of .05 was selected for all analyses (Thomas & Nelson, 1996). The main effect between the treatments was not significant, $F(1,19) = .92$, $p > .05$ but the main effect for muscle temperature across seven time periods was significant, $F(6,114) = 140.82$, $p < .0005$. Therefore, two repeated measures one-way analyses of variance, one for the ice treatment $F(6,114) = 94.02$, $p < .0005$ and one for the ice with galvanic stimulation $F(6,114) = 130.57$, $p < .0005$ were performed. To find where significant differences existed, Tukey's post hoc analyses were conducted demonstrating a critical mean difference of .437 for the ice alone treatment and .329 for the ice with galvanic stimulation treatment. Significant differences were detected between minutes 0-15, 0-30, 0-45, 0-60, 0-75, 0-90, 15-30, 15-45, 15-60, 15-75, 15-90, 30-60, 30-75, 30-90, 45-75, 45-90 for the ice alone treatment. The ice with galvanic stimulation had significant differences between minutes 0-15, 0-30, 0-45, 0-60, 0-75, 0-90, 15-30, 15-45, 15-

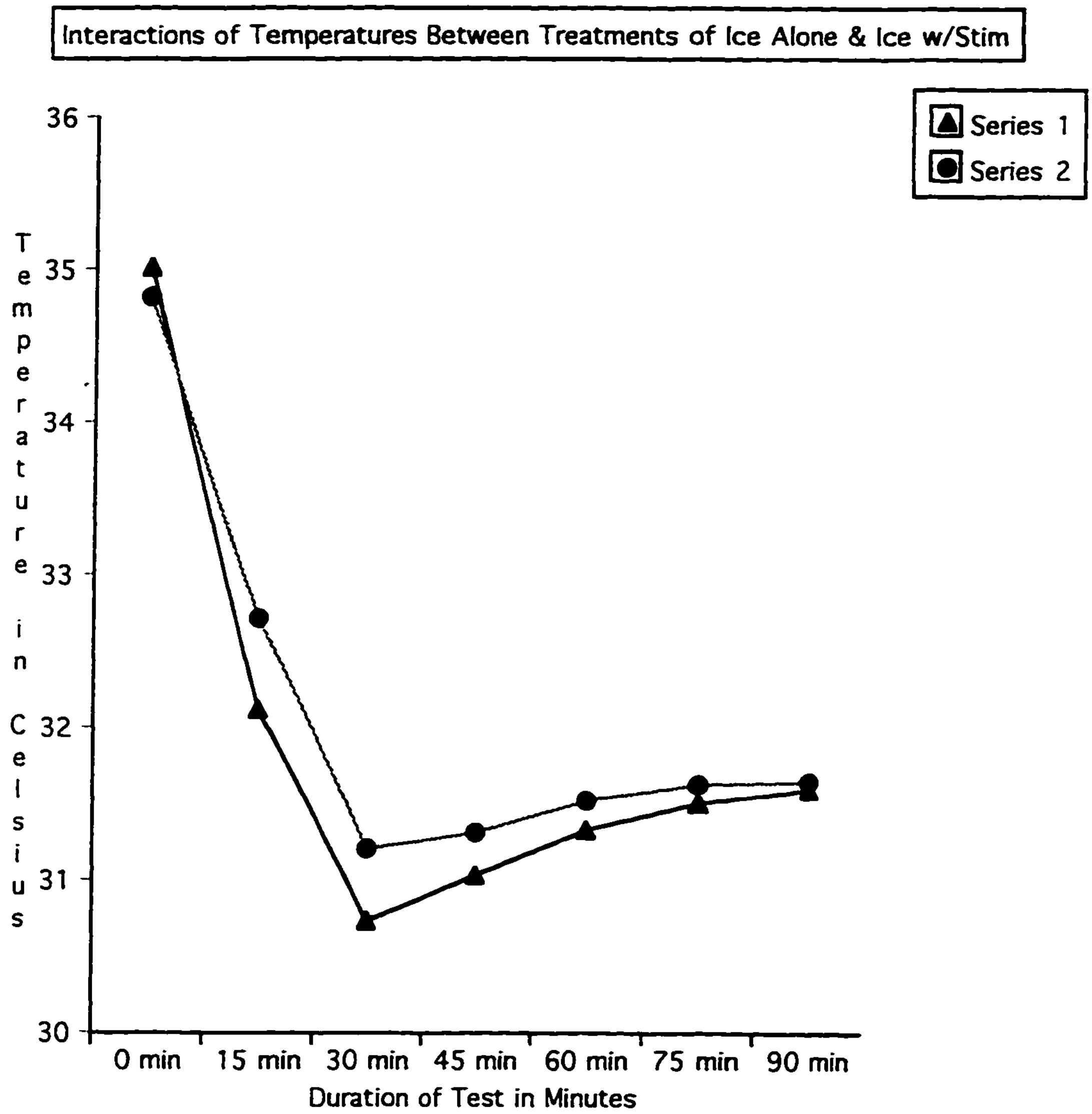
60, 15-75, 15-90, 30-75, 30-90, 45-90, 75-90. There was a significant interaction between the treatment of ice alone and the treatment of ice in conjunction with galvanic stimulation over time, $\underline{F}(6,114) = 4.16$, $\underline{p} = .001$. This interaction is graphed in Figure 1. The treatment of ice alone had a slightly higher baseline temperature and then had a greater decreasing slope than ice with galvanic electrical stimulation. The temperature paths crossed within the first three minutes. Both treatments dipped at the thirty minute mark, then slowly began to rise, and eventually reached equal temperatures at minute 105.

One of the null hypotheses stated that no significant difference would result in muscle temperature between the treatments of ice and the treatment of ice in conjunction with galvanic current among healthy male and female adults. The results failed to reject this null hypothesis. Also, the null hypothesis stated that no significant changes in muscle temperature following either of the treatments of ice alone or ice with galvanic stimulation. There were significant changes in muscle temperature for each of these treatments and thus the null hypothesis was rejected. It was also hypothesized that no interaction would occur between the treatment of ice alone and ice in conjunction with galvanic stimulation. This hypothesis was rejected since a significant interaction occurred and is demonstrated in Figure 1.

Secondary Statistical Analysis

Primary statistical analysis found that there were no significant differences between the treatments and both treatments were effective in significantly reducing muscle temperature. The secondary analysis was performed to determine if there were gender differences in muscle temperature within the treatments and if the treatments were effective in reducing muscle temperature. A two-way analysis of variance of the ice alone

Figure 1

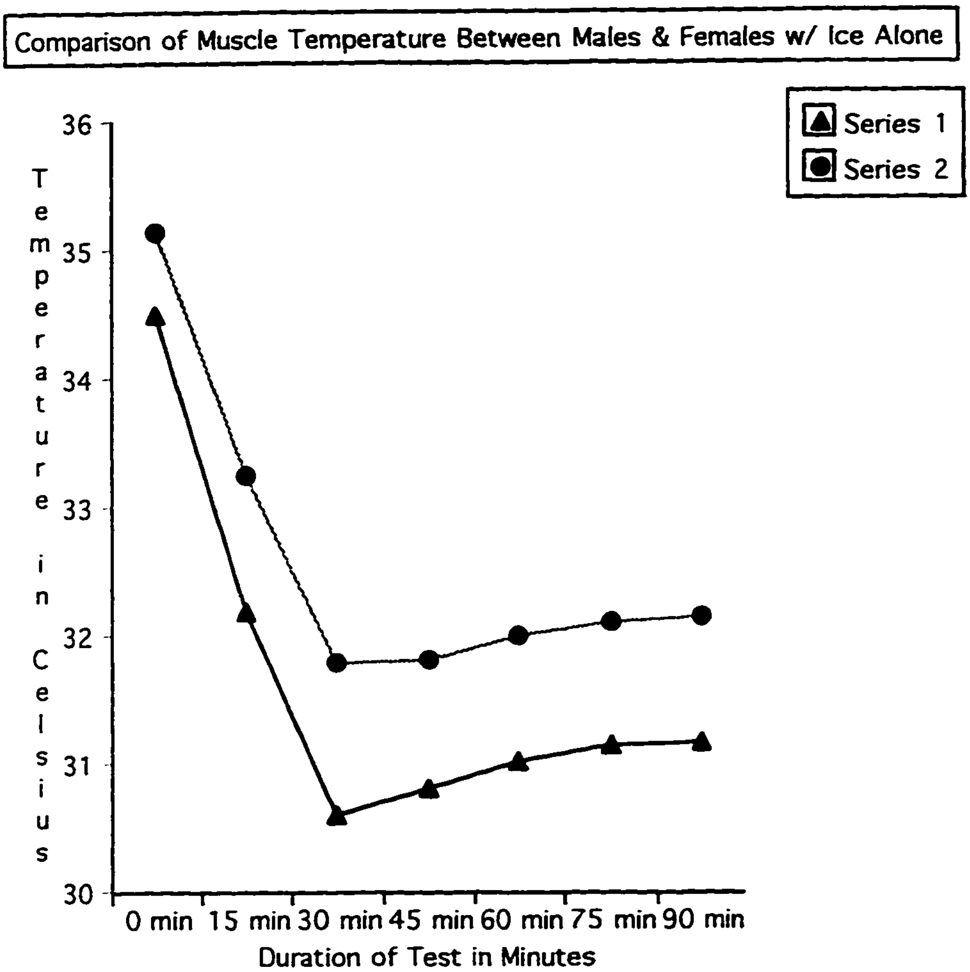


Note: Series 1 is Ice Alone
Series 2 is Ice w/ Galvanic Stimulation

significant $F(1,18) = 3.80$, $p > .05$. The main effect for change in muscle temperature was significant across time $F(6,108) = 103.23$, $p < .0005$. Therefore two one-way analysis of variance were performed, one for the females and one for the males. The main effect on muscle temperature across time was significant $F(6,54) = 80.44$, $p < .0005$ for females with the treatment of ice alone and also for the males $F(6,54) = 44.10$, $p < .0005$. Tukey's post hoc follow-up was conducted to identify where the differences existed. The critical mean value for the females was .612 and differences existed between minutes 0-15, 0-30, 0-45, 0-60, 0-75, 0-90, 15-30, 15-45, 15-60, 15-75, 15-90. For the males, Tukey's critical mean difference was 1.061 and this differences occurred at minutes 0-15, 0-30, 0-45, 0-60, 0-75, 0-90, 15-30, 15-45, 30-75, 30-90 for the ice alone treatment. A significant interaction of gender existed in muscle temperature across time for the ice treatment (Figure 2). The males' muscle temperature was lower than the females' while they both followed similar rates of decrease. The females' temperature plateaued between thirty and forty-five minutes before the tissue began to rewarm while the males' temperature began rewarm immediately following its lowest recorded temperature.

Another two-way analysis of variance was conducted to compare gender differences for the treatment of ice with galvanic stimulation. The main effect between males and females was significant $F(6,108) = 127.39$, $p < .0005$. Seven independent t-tests were performed to compare the muscle temperatures of the males and females at seven time periods to see where the differences existed. The significance level was adjusted ($0.05/7 = .007$) for multiple t-tests (Thomas & Nelson, 1996). There were no significant differences at the individual time periods with the alpha level adjusted for

Figure 2



Note: Series 1 is Males
Series 2 is Females

multiple t-tests (Table 3). The main effect for muscle temperature across time for ice with galvanic stimulation was significant $F(6,108) = 103.23$, $p < .0005$. Two one-way analysis of variance were performed, one for the males $F(6,54) = 46.91$, $p < .0005$ and one for the females $F(6,54) = 115.95$, $p < .0005$, both were significant. In addition to muscle temperature, electrical stimulation intensity was compared between males ($M = 1.66$, $sd = \pm 0.63$) and females ($M = 1.28$, $sd = \pm 0.27$) and was found not to be significantly different $t(18) = 1.72$, $p > .05$. There was also a difference between males ($M = 4.80$, $sd = \pm$ 2.73) and females ($M = 7.25$, $sd = \pm 2.73$) in skinfolds on the leg with the ice and galvanic stimulation, however the difference was not significant $t(18) = -2.54$, $p > .05$. The difference between males ($M = 4.90$, $sd = \pm 2.66$) and females ($M =$ 7.65, $sd = \pm 2.36$) in skinfolds on the leg with ice alone treatment was not significant $t(18) = -2.44$, $p > .05$.

A two-way analysis of covariance was performed on the data to determine the effects of skinfold measurements on the muscle temperature for the ice alone treatment. When the ice alone treatment was covaryed for the skinfold $F(1,17) = 1.29$, $p > .05$, the results were not significant which was consistent with the findings from the two-way analysis of variance $F(1,18) =$ treatment was conducted. The main effect between males and females was not 3.80, $p > .05$. A two-way analysis of covariance was also performed covarying for the skinfold of the ice in conjunction with galvanic stimulation treatment to determine if gender differences existed. The two-way analysis of variance for gender across time with the ice in conjunction with galvanic stimulation treatment was significant $F(6,108) = 127.39$, $p < .0005$, but when skinfold was covaried, significant gender differences were eliminated $F(1,17) = 4.18$, $p > .05$.

In addition, a two-way analysis of covariance was perform to covary for stimulation level which also eliminated significant gender differences $F(1,17) = 4.19$, $p > .05$. Another two-way analysis of covariance was performed and stimulation level as well as skinfold measurements were covaried $F(1,16) = 3.49$, $p > .05$ and found that no significant differences existed between the genders.

The null hypothesis stated that no significant difference would exist between genders in muscle temperature in response to the treatment of ice alone or the treatment of ice with galvanic stimulation. The results failed to reject the null hypothesis for the treatment of ice alone. No significant difference in muscle temperature occurred between genders for the ice alone treatment. A significant interaction did occur between gender for the treatment of ice alone. The results are displayed in Figure 2. These results reject the null hypothesis which stated that there would be no significant interaction between the genders in response to the treatment of ice alone. This null hypothesis was upheld for the treatment of ice in conjunction with galvanic stimulation. Significant differences did occur in muscle temperature between genders in response to the treatment of ice in conjunction with galvanic stimulation. As a result, the null hypothesis was rejected for the differences in muscle temperature between genders in response to the treatment of ice with galvanic stimulation.

Summary

The first portion of this chapter described the demographic information of the subjects. Descriptive and interferential statistics were presented. The purpose of this study was to examine if there were significant differences in muscle temperature following the treatments of ice alone compared with ice in

Table 3

T-tests Comparing Muscle Temperature Between Males and Females at Various Time Intervals

Temperature	#	M	sd	SEE	t Value	df	2-tail Prob
Baseline							
M	10	34.50	1.02	.323			
F	10	35.14	.59	.187	1.71	18	.104
15 minutes							
M	10	32.19	1.58	.501			
F	10	33.26	.97	.310	1.82	18	.086
30 minutes							
M	10	30.61	1.36	.430			
F	10	31.80	.91	.290	2.29	18	.034
45 minutes							
M	10	30.82	1.25	.397			
F	10	31.81	.86	.275	2.05	18	.050
60 minutes							
M	10	31.03	1.21	.384			
F	10	32.01	.85	.269	2.09	18	.051
75 minutes							
M	10	31.15	1.14	.362			
F	10	32.10	.88	.279	2.08	18	.052
90 minutes							
M	10	31.17	1.16	.368			
F	10	32.14	.87	.277	2.10	18	.050

Notes: M = male subjects, F = female subjects. *$p < .007$.

muscle temperature following the treatments of ice alone compared with ice in conjunction with positive polarity galvanic electrical stimulation. There were no significant differences between muscle temperatures in response to the treatments of ice alone compared with ice in conjunction with galvanic electrical stimulation. There were significant effects in temperature within each treatment over time. Figure 1 demonstrated the trend of the muscle temperatures in response to the treatments. There was a significant interaction that occurred between the treatments at minute 105 of the test. After that point the treatment effect is over. These results retain the null hypothesis that stated there would be no significant differences in muscle temperature between the treatments of ice alone and ice in conjunction with galvanic electrical stimulation.

Once differences between treatments for all subjects were compared, differences between genders were evaluated using two-way analyses of variance. For ice alone, there were no significant differences between males and females. Both groups demonstrated significant changes in muscle temperature across time. Tukey's post hoc analysis were performed to see where differences existed. There was a significant interaction of gender by time that was plotted in Figure 2. When evaluating the differences between gender for the ice with galvanic stimulation, there was a significant difference. Independent t-tests were performed to determine where differences existed. There was also a significant change in muscle temperature across time. Two one-way analyses of variance were performed with Tukey's post hoc follow-up tests to see where differences existed. For the treatment of ice with galvanic stimulation there was no significant interaction for gender by muscle temperature.

To determine which factors might have contributed to gender differences within the treatments, two-way analyses of covariance were performed. First skinfold covariates were used which eliminated significant gender differences for the ice with galvanic stimulation and did not affect the results from the ice alone treatment. Stimulation level, and stimulation level combined with skinfold thickness covariates also eliminated significant gender differences for the ice with galvanic stimulation.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

Cold is a modality used to decrease muscle temperature and slow the muscle metabolism in the area of application. This reduces the amount of secondary injury due to hypoxia (Lachmann & Jenner, 1994). Galvanic stimulation in conjunction with ice has also been used to initiate vasoconstriction in the area of application and potentially further decrease muscle temperature (Harris, 1995). The purpose of this study was to determine if there was a difference in the reduction of muscle temperature between the treatments of ice alone and ice in conjunction with galvanic stimulation and if both treatments were effective in significantly reducing muscle temperature.

Twenty subjects participated in this study having no history of allergies to cold nor Cephalexin, no reports of trauma to the gastrocnemius muscle, no reports of having Raynaund's phenomenon nor skin infections. Measurements were taken to determine the point of largest girth on the gastrocnemius muscle and the point of insertion while the subjects remained in a prone position on a table for the testing procedure. The area of temperature probe insertion was shaven, scrubbed with Betadine, and swabbed with isopropanol alcohol to sterilize the area. A physician anesthetized the area and then inserted the temperature probes aligned with a level carpenter's square, into the point of insertion. All subjects completed fifteen minutes of both treatments, one on each leg, followed by a minimum of ninety minutes of no treatment without movement of the legs. One leg received ice alone treatment while the other leg received the treatment of galvanic stimulation and ice. The first portion of this chapter discusses the descriptive data, followed by discussion of primary and secondary statistical analysis of the data collected. Practical applications, a summary of the results, conclusions and recommendations are given at the end of the chapter.

Discussion of Descriptive Data and Treatment

The average baseline temperatures for both treatments (35.0 ± .85° C and 34.8 ± .87° C) for this study were similar to Draper and Sunderland (1993) average baseline temperature (35.4 ± 1.2° C). The difference between the studies was in the depth of the temperature probe; this study used a depth of two centimeters and Draper and Sunderland (1993) used three centimeters. Slightly lower baseline temperature found in this study can be attributed to the difference in depth of the temperature. Differences in depth were attributed to the type of modality used, since ultrasound has a greater depth of penetration, its effectiveness was measured at a deeper level (Draper & Sunderland). This study used a lesser depth to demonstrate the effects of the treatment more rapidly (Starkey, 1993). Waylonis (1967) found that as the depth of the temperature probe increases, the muscle temperature also increases which can explain why this study had lower baseline temperatures. In addition some variation could be attributed to individual differences in core temperature.

During the testing period, muscle temperature continued to decrease after the treatments had been removed. Temperatures decreased and stabilized for an average of 18.75 ± 10.35 minutes after ice alone treatment and 21.41 ± 5.99 minutes after ice with galvanic stimulation treatment before the temperature began to rise. This finding was consistent with the Swenson, Sward, and Karlsson's (1996) report which stated that unlike skin and subcutaneous temperatures, intramuscular temperature continue to fall even after the cold treatment has been removed.

By the end of the testing period, muscle temperature still had not rewarmed to baseline temperature readings. For the ice alone treatment, ending temperature was an average of 3.55° C below baseline and an average of 3.21° C below baseline for the ice with galvanic stimulation treatment at the end of treatment. This observation is consistent with results from Knight (1995), Knight, Bryan, and Halvorsen (1981), and Wolf (1971) which found that the body parts did not return to baseline temperatures even after two hours. Knight reports that the lack of activity of a body part and the exposure to an unnatural environment are the main factors which contribute to the lack of rewarming in the studies previously mentioned. These factors are consistent with this study since subjects had to lay still on a table for almost two and a half hours.

In the research, contralateral limb temperatures have been measured as a control to compare with rewarming rates. In a review of literature by Swenson, Sward, and Karlsson's (1996) and Wolf's (1971), found that local cooling had a contralateral effect after a cooling treatment to the ipsilateral side. Since this study evaluated muscle temperatures in both legs in response to two treatments, the contralateral effect would be occurring to both legs simultaneously. However, if this phenomenon exists, the potential effects would be happening bilaterally, and would be reflected in both results. Therefore a significant difference would not exist.

Discussion of Primary Statistical Analysis

The subjects used in this investigation were between twenty-one and thirty-one years of age and exercised an average of three days a week. For this population there was no significant difference between the treatments of ice alone and ice with galvanic stimulation. Currently there is no research that supports or contradicts the lack of significant difference in muscle temperature between these treatments. There were significant changes in muscle temperature throughout specific time intervals for both ice alone and ice in conjunction with galvanic stimulation. These observations support Holcomb, Mangus, and Tandy (1996) study that determined that cryotherapy decreases tissue temperature which can slow metabolism and reduce the amount of secondary hypoxic injury. The significant decrease in tissue temperatures slows blood flow to the site by increasing blood viscosity and producing vasoconstriction. Trends in temperature change from ice application follow the similar patterns to a study by Merrick, Knight, Ingersoll, and Potteiger (1993) which examined intramuscular temperature in response to ice and compression wraps. Since there has been no studies of intramuscular temperature in response to the treatment of ice with positive polarity galvanic stimulation, no comparisons of results can be made.

Positive polarity current decreases blood flow and prevents edema from forming and suppresses inflammation (Harris, 1995). These results demonstrate that positive polarity galvanic stimulation and ice significantly reduce muscle temperature. However this technique was not shown to significantly reduce muscle temperature more than ice alone. The effects of the positive polarity galvanic stimulation was not great enough to significantly affect the effects of ice on muscle temperature.

The muscle temperature trends for both treatments follow the same trend of decreasing, increasing, and then plateauing. The average muscle temperature for both treatments becomes the same at minute one hundred five. Ice with galvanic stimulation did not get as cold as the ice alone. This observation is similar to findings from Holcomb, Mangus, and Tandy (1996). The authors concluded that the electrode pad, which was directly over the center of the temperature probe, provided some insulation from the cold which accounts for the difference in decrease in temperature between the ice alone with ice in conjunction with galvanic stimulation. This statement holds true for this study and can be a reason for the difference in muscle temperature for the ice with galvanic stimulation.

Discussion of Secondary Statistical Analysis

For secondary analysis, the S population was divided based on gender and then the changes in muscle temperatures following the treatments were compared. For the ice alone treatment, there was no significant difference between males and females. There were significant changes in muscle temperature across time for the male group and also for the female group which was consistent with observations in the primary statistical analysis. Figure 1 in Chapter IV demonstrated the trend in muscle temperature during the test. The males had a lower baseline temperature and then decreased to a greater degree when compared to the females, but the difference was not significant. The temperature begins to rise for both males and females at about minute forty. At no point during the test were the males and females at the same temperature for the ice alone treatment. These results are not surprising since there are no significant gender differences in the composition of cutaneous, subcutaneous, and skeletal muscle tissue (Costill, Daniels, Evans, Fink, Krahenbuhl, & Saltin, 1976) which could significantly alter the effect of ice treatment.

For the ice with galvanic stimulation, two-way analysis of variance demonstrated a significant differences between the males and females. However when adjusting for multiple _t_-tests, there was no specific time at which the temperatures differed significantly. As a result of adjusting the alpha level for multiple _t_-tests, there was a risk of making a Type I error. If the alpha level were to remain at $p < .05$, risking a Type II error, significant differences would be evident at minute forty-five and minute ninety (Thomas & Nelson, 1996). A significant change in muscle temperature across time was evident for males and females which is consistent with results from gender analysis for the ice alone treatment and from primary statistical analysis. There was a non-significant interaction for gender by time.

Further statistical analysis was performed to determine if skinfold thickness could account for the significant gender differences in muscle temperature in response to the treatment of ice with galvanic stimulation. When covarying for skinfold thickness, the two-way analysis of covariance eliminated the gender differences. When comparing skinfold thicknesses of male and female subjects, males had a smaller skinfold than females. This suggests that adipose tissue was the underlying reason for the observed gender differences between the ice with galvanic stimulation. The greater skinfold thickness in the females decreases the effectiveness of ice and galvanic stimulation in reducing muscle temperature when compared with the males. From these observations, one can conclude that adipose tissue reduces the effectiveness of positive polarity galvanic stimulation. In addition skinfold thickness combined with stimulation level and stimulation levels alone were covaried for and also eliminated the gender difference for treatment of ice with galvanic stimulation.

When a two-way analysis of covariance was performed on the ice alone treatment, the skinfold thickness did not affect the results from the two-way analysis of variance. This observation conflicts with statements by Knight (1995) which said that adipose tissue insulate deeper tissues and lessens the effects of the cold application. The adipose tissue covering the gastrocnemius muscle must not have been enough to provide insulation.

Practical Application

Ice alone and ice in conjunction with positive polarity galvanic stimulation are two treatments used following acute injury. Theoretically, these treatments are used to decrease the muscle tissue, which slows the inflammation process, and decreases the amount of secondary hypoxia (Knight, 1995; Ralston, 1985). The purpose of this study was to determine if this theory can be supported. The results of this study demonstrated that both treatments of ice alone and ice in conjunction with positive polarity galvanic stimulation are effective in significantly reducing muscle temperature. Both of these treatments can be used following an acute injury if the goal is to decrease muscle temperature. Since both treatments are effective, which one should be used? These results did not demonstrate that one treatment was significantly better than the other in reducing muscle temperature. However the results did reveal that ice alone initially reduces muscle temperature faster than ice in conjunction with galvanic stimulation.

A consideration when using ice with galvanic stimulation is the area to be treated. This study revealed that greater skinfold thicknesses decreased the effectiveness of the treatment of ice with galvanic stimulation in reducing muscle temperature. Therefore when applying the positive polarity galvanic stimulation to an area, the amount of adipose tissue covering the muscle should be considered and the intensity adjusted to create the same results as with a leaner area.

Summary

The purpose of this study was to determine if there were significant differences in changes in muscle temperature between the treatments of ice alone and ice in conjunction with galvanic stimulation. There was no significant difference between the two treatments. Both treatments were effective in significantly reducing muscle temperature from the baseline temperature reading. When comparing genders, there was no significant difference in muscle temperature for the ice alone treatment. However there were significant differences in muscle temperature for the ice in conjunction with galvanic stimulation. The significant differences can be primarily attributed to differences in skinfold thicknesses between the male and female groups.

Conclusions

The following conclusions were established based on the study results.

1. No significant differences existed in muscle temperature in response to the treatments of ice alone and ice in conjunction with positive polarity galvanic stimulation.

2. Ice alone initially decreases muscle temperature faster than ice in conjunction with positive polarity galvanic stimulation.

3. Ice alone and ice in conjunction with galvanic stimulation is effective in reducing muscle temperature.

4. There is an inverse relationship between skinfold thickness and the effectiveness of galvanic stimulation. The greater the skinfold, the less

effective the treatment of positive polarity galvanic stimulation in reducing muscle temperature.

Recommendations

The following recommendations are based on the realization that this study could have been conducted differently.

1. When using galvanic stimulation, areas with greater amounts of adipose tissue may need greater intensity levels for the stimulation to be effective.

2. When treating an acute injury, ice alone and ice with galvanic stimulation are both effective in reducing muscle temperature, however ice alone reduces the temperature to a greater degree than ice with positive polarity galvanic stimulation.

3. Future studies should examine positive polarity galvanic stimulation alone and its effectiveness in reducing muscle temperature. Also, other types of stimulation including negative polarity galvanic stimulation, interferential, and faradic electrical stimulation should be examined.

4. Future investigations should include randomization of treatments including a control treatment to compare treatment results.

5. Altering the intensity of galvanic stimulation as well as the time of treatment should be examined to determine the best intensity and duration for reducing muscle temperature.

6. Different depths of the temperature probe could be compared to evaluate the time it takes for deeper tissues to be affected by the modality. In addition temperature probe could be inserted at a distance that accounted for differences in skinfold thickness.

7. Future research should include the effectiveness of galvanic stimulation on altering blood flow.

REFERENCES

Balogun, J. A., Onilari, O. O., Akeju, O. A., & Marzouk, D. K. (1993). High voltage electrical stimulation in the augmentation of muscle strength: Effects of pulse frequency. Archives of Physical Medicine and Rehabilitation, 74, 910-915.

Baumert Jr., P. W. (1995). Acute inflammation after injury. Postgraduate Medicine, 97, 35-42.

Brown, M. Gogia, P. P., Sinacore, D. R., & Menton, D. N. (1995). High-voltage galvanic stimulation wound healing in guinea pigs: Longer-term effects. Archives of Physical Medicine and Rehabilitation, 76, 1134-1137.

Campbell, N. A. (1990). Biology (2nd ed.). Redwood City, CA: The Benjamin/Cummings Publishing Company.

Carley, P. J., & Wainapel, S. F. (1985). Electrotherapy for acceleration of wound healing: Low intensity direct current. Archives of Physical Medicine and Rehabilitation, 66, 443-446.

Costello, R. B. (Ed.). (1991). Random house webster's college dictionary. New York, NY: Random House.

Costill, D., Daniels, J., Evans, W., Fink, W., Krahenbuhl, G., & Saltin, B. (1976). Skeletal muscle enzymes and fiber composition in male and female track athletes. Journal of Applied Physiology, 40, 149-154.

Cote, D. J., Prentice, W. E., Hooker, D. N., & Shields, E. W. (1988). Comparison of three treatment procedures for minimizing ankle sprain swelling. Physical Therapy, 68, 1072-1076.

Draper, D. O., Castel, J. C., & Castel, D. (1995). Rate of temperature increase in human muscle during 1 MHz and 3 MHz continuous ultrasound. Journal of Orthopaedics and Sports Physical Therapy, 22, 142-150.

Draper, D. O., Schulthies, S., Sorvisto, P., & Hautala, A. (1995). Temperature changes in deep muscles of human during ice and ultrasound Therapies: An in vivo study. Journal of Orthopaedic and Sport Physical, 21, 153-157.

Draper, D. O., & Sunderland, S. (1993). Examination of the law of Grotthus-Draper: Does ultrasound penetrate subcutaneous fat in humans? Journal of Athletic Training, 28, 246-250.

Draper, D. O., Sunderland, S., Kirkendall, D. T., & Ricard, M. (1993). A comparison of temperature rise in human calf muscles following applications of underwater and topical gel ultrasound. Journal of Orthopaedic And Sport Physical Therapy, 17, 247-251.

Harris, F. (1994). Efficacy of SPORTX galvanic therapy. Literature survey on DC microcurrent and pulsed galvanic stimulation. Unpublished manuscript.

Holcomb, W. R., Mangus, B. C., & Tandy, R. (1996). The effect of icing with the Pro-Stim edema management system on cutaneous cooling. Journal of Athletic Training, 31, 126-129.

Keppel, G. (1982). Design and analysis: A researcher's handbook (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Knight, K .L. (1995). Cryotherapy in sport injury management. Champaign, IL: Human Kinetics.

Knight, K. L., Bryan, K. S., & Halvorsen, J. M. (1981). Circulatory changes in the forearm in 1, 5, 10, and 15°C water. International Journal of Sports Medicine, 4, 281.

Lachman, S., & Jenner, J. R. (1994). Soft tissue injuries in sport. Boston, MA: Blackwell Scientific Publications.

McLean, D. A. (1989). The use of cold and superficial heat in the treatment of soft tissue injuries. British Journal of Sports Medicine, 23, 53-54.

Mendel, F. C., & Fish, D. R. (1993). New perspectives in edema control via electrical stimulation. Journal of Athletic Training, 28, 63-74.

Merrick, M. A., Knight, K. L., Ingersoll, C. D., & Potteiger, J. A. (1993). The effect of ice and compression wraps on intramuscular temperatures at various depths. Journal of Athletic Training, 28, 236-245.

Michlovitz, S., Smith, W., & Watkins, M. (1988). Ice and high voltage pulsed stimulation in treatment of acute lateral ankle sprains. The Journal of Orthopaedic and Sports Physical Therapy, 9, 301-304.

Myrer, J. W., Draper, D. O., & Durrant, E. (1994). Contrast therapy and intramuscular temperature in the human leg. Journal of Athletic Training, 29, 318-322.

Nelson, R. M., & Currier, D. P. (1987). Clinical electrotherapy. Los Altos, CA: Appleton & Lange.

Newton, R. (1987). High-voltage pulsed galvanic stimulation: theoretical bases and clinical application. In R.M. Nelson & D.P. Currier (Eds.), Clinical electrotherapy (pp.165-182). Los Altos, CA: Appleton, & Lange.

Newton, R. A., & Karselis, T. C. (1983). Skin pH following high voltage pulsed galvanic stimulation. Physical Therapy, 63, 1593-1596.

Ralston, D. J. (1984). High voltage galvanic stimulation: Can there be a "state of the art?" Athletic Training, 20, 291-293.

Rimington, S. J., Draper, D. O., Durrant, E., & Fellingham, G. (1994). Temperature changes during therapeutic ultrasound in the precooled human gastrocnemius muscle. Journal of Athletic Training, 29, 325-327.

Starkey, C. (1993). Therapeutic modalities for athletic trainers. Philadelphia, PA: F.A. Davis Co.

Swenson, C., Sward, L., & Karlsson, J. (1996). Cryotherapy in sports medicine. Scandinavian Journal of Medicine, Science, & Sports, 6, 193-200.

Taber, C. W. (1989). Taber's cyclopedia medical dictionary (16th ed.). Philadelphia, PA: F.A. Davis. Co.

Thomas, J. R. & Nelson, J. K. (1996). Research methods in physical activity (3rd ed.). Champaign, IL: Human Kinetics.

Waylonis, G. W. (1967). The physiological effects of ice massage. Archives of Physical Medicine and Rehabilitation, 48, 37-42.

APPENDICES

APPENDIX A

INFORMED CONSENT FORM

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

College of Applied Sciences and Arts • Department of Human Performance
One Washington Square • San José, California 95192-0054 • 408/924-3010 • FAX 408/924-3053

APPENDIX A

Informed Consent Form

You are invited to participate in a study investigating muscle temperature during the treatments of ice and ice in conjunction with galvanic stimulation. This study will involve males and females between the ages of twenty-one and thirty-one. We hope to learn more about the benefits of galvanic stimulation. The purpose of this study is to determine if galvanic stimulation in conjunction with ice has a greater decrease in muscle temperature than ice alone. The results obtained from this study may contribute to the type of treatment applied immediately following an injury.

If you decide to participate, testing will be conducted in one session. You will be asked to complete a brief health questionnaire and several preliminary measurements consisting of lower leg girth measurements, and a skinfold measurement on your legs. It is important that you do not strain or injury your lower legs prior to the test session.

Subject's Initials ________

Prior to testing you will be given an explicit description of the test procedures. A physician will give you 500 mg of Cephalexin, an antibiotic to reduce your risk of infection. A pre-surgical protocol will be followed in shaving, cleaning and disinfecting a small section on each of your gastrocnemius muscles. A physician will inject a small amount of anesthetic to the area prior to the insertion of the temperature probe. You will receive a treatment of ice alone on one calf and a treatment of ice in conjunction with galvanic stimulation on the other for fifteen minutes and then a resting period of 105 minutes will follow. The galvanic stimulation will feel like a buzz and you will be able to determine your own intensity. The physician will remove the temperature probe after the resting period. You will receive written instructions for your care following the test which will include directions for taking two more doses of 500 mg of Cephalexin.

Your participation in this study should take approximately two hours and fifteen minutes. During the study you might have some discomfort as the anesthetic is injected into your calf, during the application of ice, and after the testing procedure is over. A strict protocol of sterilization of instruments, disinfecting your skin, and the antibiotics will be used to reduce your risk of infection. Your participation will help to determine the effectiveness of this therapeutic treatment on muscle treatment If you have any doubts or questions about the procedure, you may ask for further explanation. Any question about your participation in this study will be answered by the researcher, Sally Grutzner, at (408)978-5917, or Dr. Jack Ransone at (408)924-3019, Department of Human Performance San Jose State University.

Subject's Initials________

Your participation in this study is completely voluntary. You may refuse to participate in this study and may withdraw at any time without prejudice to your relations with San Jose State University. You are free to decline to answer any specific question on the medical questionnaire. The data generated may be used for scientific purposes including publication and presentation at professional meetings. Your name will not be revealed. I appreciate your cooperation and participation.

I have read this form and I understand the test procedures that I will perform. I consent to participate in this project and I understand that I can withdraw any time. I have received a copy of this consent form for my files.

Signature:______________________________Date:_____________

Print Name:______________________________

Investigator's Signature:__________________Date:_____________

APPENDIX B

HEALTH QUESTIONNAIRE

APPENDIX B

Health Questionnaire

Please complete the following health questionnaire to the best of your ability. This information will be used in determining your eligibility to participate in this research study. All information will be kept confidential.

Age________Date______________Birthdate_______________

Height___________Weight___________M____F_____

How many days a week do you do at least thirty minutes of continuous exercise?_______________

What type of exercise do you do on a regular basis (run, walk, lift weights, swim, stairmaster)?

____

Mark X If Yes

1) Have you had a strain in your calf muscle in the last three months? ( )

If yes, which leg____

2) Have you had a "charlie horse" or cramp in your calf in the last three months? ( )

3) Have you ever used ice for an injury? ( )

4) Have you ever been "ice burned"? ( )

Health Questionnaire

5) Have you ever had an allergic reaction or any other reaction from using ice? ( )

6) Have you ever been told that you have Raynaund's phenomenon? ( )

7) Have you ever been frostbitten? ( )

8) Are you allergic to any medications? ( )

If yes, what____

9) Are you allergic to Penicillin or Cephalexin? ( )

10) Do you have any allergies? ( )

If yes, what____

11) Are you currently sick? ( )

12) Do you have any medical conditions or illnesses? ( )

If yes, please explain________________________________

13) Do you have any skin problems? ( )

If yes, please explain________________________________

14) Do you have any skin infections? ( )

15) Are you afraid of needles? ( )

Subject #______________

APPENDIX C

EXPERIMENTAL PROCEDURES

APPENDIX C

Experimental Procedures

1) Subject reads and signs the Informed Consent Form.

2) Health questionnaire completed.

3) Physician reviews questionnaire; rejects or accepts the volunteer.

4) The physician gives the subject 500 mg of Cephalexin.

5) The room temperature will be taken by a thermometer and recorded.

6) If the room temperature is less than 18° C or greater than 24° C, the test will not be performed.

7) The subject will be told "Should you have any pain or discomfort during the test notify the tester immediately".

8) The subject will be instructed to lay on their stomach on the testing table.

9) The subject's feet will hang off the end of the table and their legs will be placed in neutral for the measurements and the insertion of the probes.

10) The point of greatest girth was measured using a tape measure on the left and right legs.

11) The center of the gastrocnemius will be determined using the tape measure and marked with an X. This step will be repeated for both legs.

12) The carpenter's square was used to find the horizontal plane 2 cm below the point of greatest girth and a line was drawn using a ball point pen on both legs.

13) The medial side of the calf at the level of greatest girth will be pinched by the calipers and then shaken gently to allow the muscle to fall

away. This procedure will be repeated two more times. Repeat this step on the other leg.

14) A two centimeter patch on the gastrocnemius muscles will be shaven, scrubbed with a Betadine scrub, and swabbed with 70% isopropanol alcohol.

15) The physician will inject 1 cc of 1% Lidocaine into the center of the sterilized area, level with the carpenter's square. This step will be repeated on the other leg.

16) The physician will use a 21-guage needle to pierce the surface of the skin just prior to inserting the MT 23/5 (Physitemp Instruments) temperature probe into the site of the Lidocaine injection. This step will be performed bilaterally.

17) The subject will be asked if they are comfortable.

18) A baseline temperature will be maintained for approximately 3 minutes after the probes have been inserted.

19) 1 liter of crushed ice in a plastic bag will be applied to the center X of the left leg. The treatment of galvanic stimulation and the one liter ice bag will be given on the right leg. The positive electrode will be placed on the center of the gastrocnemius muscle. The negative electrode will be placed thirty-one millimeters directly above the positive electrode on the hamstring. The subject will be instructed to tell the tester when they feel a sensation under the electrode. The subject will be asked to tell the tester when the sensation under the electrode is tolerable, without causing pain or causing the muscle to contract. The subject should feel a strong, comfortable buzz.

20) Temperatures will be recorded every minute during the fifteen minute treatment.

21) After the treatment the electrodes and ice will be removed and the muscle temperature will continue to be recorded every minute for 120 minutes.

22) The physician will remove both temperature probes after the 120 minutes or when the subject signals that they want to stop the test.

23) A gloved hand and sterile gauze will be applied directly over the insertion holes to stop any bleeding that might occur.

24) The areas will be swabbed with 70% isopropanol alcohol.

25) An elastic bandage will be applied over the injection sites.

26) The subject will be asked how their calf muscle feels.

27) A list of instructions will be read to the subject and a written copy will be given to them.

28) Two more 500 mg doses of Cephalexin will be handed to the subject by the physician.

29) A follow-up phone call will be made between twenty-four and thirty-six hours following the testing procedure.

30) The temperature probe will be immersed in Wavicide for a minimum of ten hours in accordance with manufacturer's specifications.

APPENDIX D

RECORDING SHEET

APPENDIX D

Recording Sheet

Subject #________

Skinfold Measurements L: 1)________2)_________3)_________

R: 1)________2)_________3)_________

Dominant Leg __________

Room Temperature ___________

Girth : L_________ R___________

Are you comfortable?

Temperatures During Treatment Of:

Ice Alone		Ice & Stim	Ice Alone		Ice & Stim
	1:00			61:00	
	2:00			62:00	
	3:00			63:00	
	4:00			64:00	
	5:00			65:00	
	6:00			66:00	
	7:00			67:00	
	8:00			68:00	
	9:00			69:00	

Ice Alone	Ice & Stim	Ice Alone	Ice & Stim
10:00		70:00	
11:00		71:00	
12:00		72:00	
13:00		73:00	
14:00		74:00	
15:00		75:00	
16:00		76:00	
17:00		77:00	
18:00		78:00	
19:00		79:00	
20:00		80:00	
21:00		81:00	
22:00		82:00	
23:00		83:00	
24:00		84:00	
25:00		85:00	
26:00		86:00	
27:00		87:00	
28:00		88:00	
29:00		89:00	
30:00		90:00	
31:00		91:00	
32:00		92:00	
33:00		93:00	

Ice Alone		Ice & Stim	Ice Alone		Ice & Stim
	34:00			94:00	
	35:00			95:00	
	36:00			96:00	
	37:00			97:00	
	38:00			98:00	
	39:00			99:00	
	40:00			100:00	
	41:00			101:00	
	42:00			102:00	
	43:00			103:00	
	44:00			104:00	
	45:00			105:00	
	46:00			106:00	
	47:00			107:00	
	48:00			108:00	
	49:00			109:00	
	50:00			110:00	
	51:00			111:00	
	52:00			112:00	
	53:00			113:00	
	54:00			114:00	
	55:00			115:00	
	56:00			116:00	
	57:00			117:00	

Ice Alone		Ice & Stim	Ice Alone		Ice & Stim
	58:00			118:00	
	59:00			119:00	
	60:00			120:00	

APPENDIX E

INSTRUCTIONS FOLLOWING TESTING PROCEDURE

APPENDIX E

Instructions Following Testing Procedure

You will receive a follow-up phone call twenty-four to thirty six hours following the test.

If you have any questions or problems following the treatment please report them to Sally Grutzner (408)978-5917 or Jack Ransone (408)924-3019.

Please keep the calf clean with soap and water and covered with an elastic bandage for 24 hours.

The second dose of 500 mg Cephalexin should be taken six hours following the first dose. Please take the second dose at ____________

The third dose should be taken 12 hours following the first dose. Please take the third dose at ______________

Thank you for your cooperation.

Sally Grutzner

APPENDIX F

HUMAN SUBJECTS APPROVAL

San José State
UNIVERSITY

Office of the Academic Vice President

Associate Vice President Graduate Studies and Research

One Washington Square
San Jose, CA 95192-0025
Voice 408-924-2480
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E-mail gstudies@wahoo.sjsu.edu
http://www.sjsu.edu

TO: Sally Grutzner
1623 Ixias Ct.
San Jose, CA 95124

FROM: Serena W. Stanford *Serena W. Stanford*
AAVP, Graduate Studies & Research

DATE: March 10, 1997

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"The Effects of Galvanic Current and Ice on Muscle Temperature"

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Serena Stanford, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

The California State University:
[illegible]