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The ability of cryotherapy to effect vertical jump and single-legged hop test

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The Ability of Cryotherapy to Effect Vertical Jump and Single-Legged Hop Test

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Chapter One

Introduction

Cryotherapy is an important component in the management and rehabilitation of musculoskeletal injuries that occur due to sports participation. Cryotherapy is described as the "therapeutic application of any substance to the body which results in the withdrawal of heat from the body" (Tsang, 1997). This cold modality is used initially when caring for injuries that are acute or chronic. The main reason for using cryotherapy in acute injury management is to lower the temperature of the injured tissue, which reduces the metabolic rate and helps the tissue to survive the period of hypoxia following an injury (Merrick, 1993). The effects of cryotherapy include pain relief, reduction of muscle spasm, and a decrease in cellular metabolism. This cooling will also decrease nerve conduction velocity, cause joint stiffness, and can also prolong a muscle's action potential (Evans, 1995).

According to Starkey, the therapeutic application of cold ranges in temperature from 0° to 18.3° C (Starkey, 1993). However, the literature supports the fact that a decrease in blood flow can occur between 12.83°C-15° C. The types of cryotherapy being used are ice bags, commercial ice packs, ice cups, cold immersion, and vapocoolant sprays (Tsang, 1997).

A common concern when applying cryotherapy to a body part is what effect will it have on functional performance. When an athletic trainer administers a cryotherapy treatment, will it affect the athlete's performance? An athletic trainer needs to know the effects of cryotherapy on an athlete because it could affect his or her performance.

The purpose of this research project was:

1. To determine the effect of muscle cooling on power.
2. To determine the rate of rewarming after the cryotherapy has been applied.
3. To determine the effect of muscle rewarming on improvements in power.

Operational Definitions

The following contains definitions that operationalize the variables that were used in this study as well as specialized terminology specific to cryotherapy and functional performance.

Agility-is the combination of speed of movement and coordination.

Cryotherapy- the use of ice or other forms of cold application for therapeutic purposes.

Functional Performance- physical activities that stimulate the muscular and joint stresses. encountered during athletic events (Cross, 1996).

Power-the time rate of doing work. This is a combination of strength and speed of movement (Knight, 1995).

Proprioception-is the ability to determine the position of a joint in space (Arnheim, 1997).

Strength-the maximal force that a muscle or muscle group can generate at a specific velocity.

Work-force expressed through a distance but with no limitation on time (unit: joule or kilojoule) (McArdle, Katch, and Katch, 1996).

Basic Assumptions

1. Application of cryotherapy will decrease the tissue temperature.
2. Subjects will perform to their best ability during testing.

Basic Limitations

1. Subjects will not perform to their maximum potential.
2. Fatigue will play a role in the outcome of the study.

3. The cryotherapy treatment will not decrease the temperature enough to make a difference in the subject's functional performance.
4. There will not be enough subjects in this project to make a significant difference.

Null Hypotheses

1. There will be no significant difference in mean vertical jump height following ice application.
2. There will be no significant difference in mean single-leg hop time following ice application.

Chapter Two

Review of Literature

Cryotherapy is simply applying a cold modality to the human body (Starkey, 1993). This is a technique that is used to treat injuries that are both acute as well as chronic. Modes of application for cryotherapy modalities include: ice pack, ice massage, cold water immersion, and vapocoolant sprays (Knight, 1995). First we must understand the physiological effects of cryotherapy before we apply them to the body. The effects can be summarized into six categories: (1) circulatory effects (decreased and/or increased) (2) decreased pain (3) decreased muscle spasm (4) decreased metabolism (5)inflammatory effects (decreased and increased) and (6) increased tissue stiffness (Knight, 1985). These categories are universally accepted but some are subject to scrutiny. Some explanations contradict others, and some are even self-contradictory (Knight, 1995).

Inflammatory Response

Inflammation is the body's response to an irritant (Tortora, 1996). There are five cardinal signs of inflammation: pain, swelling, redness, heat, loss of function. These five signs indicate that inflammation is taking place. The goal of cryotherapy is to limit the inflammation but not stop inflammation (Knight, 1995). The body's initial response to trauma is vasoconstriction, which will prevent blood loss to the injured area. Coagulation, or clotting, begins to repair the damaged area when the blood vessels are in the state of vasoconstriction. This state of vasoconstriction does not last long until active vasodilatation will occur causing an increase in blood volume to the injured area (Tortora, 1996).

Gaps form between the cells which will increase permeability to proteins and fluids (Starkey, 1993). An exudate is formed which will deliver leukocytes (white blood cells) to the area to remove any harmful materials. Edema occurs due to the presence of fluid and cell debris. As swelling increases, blood flow to and from the area is decreased (Starkey, 1993).

There are other substances that contribute to the inflammatory process. Histamine is a substance that is found in many of the body's cells. Histamine is released immediately when an injury occurs. Phagocytes attracted to the site of injury will also release histamine (Tortora, 1996). Histamine causes vasodilatation and increased permeability of blood vessels (Tortora, 1996). Another substance that is released is a group of prostaglandins.

These lipids are released by damaged cells and intensify the effects of histamine (Tortora, 1996). Prostaglandins stimulate the emigration of phagocytes through capillary walls (Tortora, 1996). Prostaglandins will intensify and prolong pain associated with the inflammation process.

Circulatory Effects

Once an ice pack is administered to the body, vasoconstriction will occur immediately (Knight, 1985). Cold induces vasoconstriction by sympathetic reflex and by its direct effects on the smooth muscle of blood vessels (Kaul, 1994). Blood flow to the area is decreased with ice immersion and cold pack application and remains decreased for at least 45 minutes following the cryotherapy treatment (Knight, 1985). There is speculation that cold reduces blood flow by increasing viscosity and causes vasoconstriction, which will reduce the blood flow to the injured area (Dolan, 1997).

Decreased Pain

Explaining how cryotherapy affects pain can be difficult to explain. The definition of pain is also difficult. According to Knight (1995), pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage. Once the treatment begins, the subject will experience four sensations: cold, burning, aching, and then numbness. Cryotherapy causes relief of pain by effecting the nerve and nerve endings. All nerves are affected by cryotherapy; small myelinated pain fibers are affected first; followed by the large myelinated pain fibers; finally unmyelinated fibers are affected (Kaul, 1994). This causes the nerve conduction to decrease significantly. By stimulating the large-diameter neurons, cold inhibits pain transmission, acting as a counterirritant (Starkey, 1993). Furthermore, he reports that research has shown that not all athletes will experience the same sensation during cold application. In one particular study, numbness was not reported until 18 to 21 minutes following the initial application and analgesia was never achieved.

Ohkoshi (1999) found that there are a number of mechanisms, which cause pain. He also found that the elevation of the tissue pressure due to bleeding and edema, stimulation of the free nerve endings, and the effects of chemical mediators that are released due to hypoxic tissue damage. Cryotherapy shows activity in providing pain relief by inhibiting the muscle spindle activity, reducing the conduction velocity of nerves, and elevating the pain threshold.

The temperature at which pain occurs depends on the rate of change of the temperature; meaning, the faster the cutaneous temperature is decreased, the lower the pain threshold temperature (Knight, 1995). The relationship between pain temperature and rate of cooling, it has been found that with faster cooling of the skin the deeper tissues do not cool as fast (Knight, 1995). But, by the time the deep tissues are cooled enough for the pain receptors to be stimulated, the surface temperature has decreased (Knight, 1995).

Many studies have been done to determine a person's perception of pain. Streator et al. (1995) studied subjects' perception of cold-induced pain and could it be influenced by the type of information provided before the treatment, such as "the pain will be crushing" or "the pain will be flickering." Streator et al (1995) found that if athletes' are given sensory information about the noxious stimulus that they are about to receive, their perception of pain is decreased. Their results supported the idea that providing athletes' with some form of verbal sensory information before cold therapy reduces sensory, affective, and evaluative pain when compared with athletes who are not provided with sensory information.

Decreased Muscle Spasm

The pain-spasm cycle is the primary cause for a muscle spasm(Starkey,1993). With this cycle, pain originating anywhere in the sensory-motor chain can lead to a muscle spasm. Compression from the muscle spasm results in additional pain, and the cycle continues (Knight, 1995). Once the cycle begins, it is easily prolonged and often continues after the initial painful stimulus has ceased (Knight, 1995). Cryotherapy is very effective in the reduction of muscle spasms. According to Starkey (1993), cold reduces muscle spasm in two ways: (1) it decreases pain by reducing the threshold of afferent nerve endings, and (2) it decreases the sensitivity of muscle spindles. Starkey explains that a 9°F decrease in surface skin temperature decreases the sensitivity of the muscle spindles. The decrease in muscle spindle activity, along with the decreased rate of afferent nerve impulses, inhibits the stretch reflex and results in a decrease of muscle spasm. Research has shown that cryotherapy decreases spasm by breaking the pain-spasm cycle (Knight, 1985). Pain that originates anywhere in this chain will result in a muscular spasm and a locking sensation in that particular joint. According to Knight (1985), elimination of pain at any point of the cycle will result in the breaking of the chain, and will allow the muscle to relax. Cryotherapy seems to be an affective modality in the reduction of muscle spasms.

Decreased Metabolism

One of the most important effects of cold application is decreased metabolism, meaning a decreased need for oxygen (Knight, 1995). The main reason for using cryotherapy in management of injuries is to decrease the temperature of the injured tissue, which will then reduce the tissue's metabolic rate and help the tissue survive the period of hypoxia. Research shows that as tissue becomes hypothermic, the metabolic rate will decrease (Merrick,1993). Cryotherapy will also decrease the cellular metabolic rate, which will decrease the amount of oxygen needed by the cells to survive (Starkey, 1993). Cold therapy can also decrease energy requirements, which can play a major role in the treating of acute injuries. These reduced energy requirements may compensate for vasocongestion, edema, and microvascular injury (Kaul, 1994).

Inflammatory Effects

When cryotherapy affects the metabolism, as well as affect the amount of inflammation to the area. Cryotherapy will suppress the inflammatory process by (1) reducing the release of inflammatory mediators (2) decreasing prostaglandin synthesis (3) decreasing capillary permeability (Starkey, 1993). A study by Hecht et al (1983) demonstrated edema reduction in patients who underwent total knee arthroplasty. The subjects were divided into a cold pack group and a heat pack group. The cold-treated group had less edema and discomfort when compared to the heat pack group. Cryotherapy will help reduce the inflammatory mediators, which will then reduce the degree of pain and inflammation (Starkey, 1993).

Increased Tissue Stiffness

Research has shown that decreased temperature accompanying cryotherapy causes tissue stiffness (Knight, 1985). Increased joint synovial fluid viscosity, impaired function of the muscles that surround the joint, and the decrease of elasticity of the connective tissue encourages this phenomenon (Knight, 1985). Once the tissue becomes stiff both range of motion and motor control are hindered. Hunter et al (1952) demonstrated that a decrease in temperature increased the resistance to movement and decreased the speed at which the joint could be moved. This research shows that cryotherapy has some effect on a joint, and will cause joint stiffness.

Neurological Effects

Cryotherapy can result to changes in the nervous system when applied to the body. Once a cryotherapy treatment is applied, some neurological pathways are excited, but some are depressed. Cooling a nerve can cause two reactions to take place: (1) the firing rate of the nerve fiber that carries the impulse from the cold center to the brain is increased, (2) the rate of impulse transmission along the nerve fiber is decreased in return (Knight, 1995). Once cryotherapy is applied to the body, cold receptors are stimulated. These cold receptors are located throughout the body. The face, fingers, and ears have the largest number of cold receptors. The thighs and feet have the smallest number of cold receptors (Knight, 1995). As the temperature of the cryotherapy modality decreases, the transmission will decline until the conduction is lost completely. Other types of fibers also respond to cold. Mechanoreceptors, which detect pressure, and nocioreceptors, which detect pain, both respond to cold sensations and they influence the response to the cold sensation (Knight, 1995).

The Effects on Proprioception

Proprioception is a vital component of the rehabilitation process. Proprioception is important in maintaining posture, balance, joint position, and coordination of multi-joint movements (Thieme, Ingersoll, Knight, & Ozmun, 1996). Decreased proprioception could be a factor resulting from an injury. It is thought that cryotherapy will effect a person's proprioception, but it does not. Thieme et al (1996), found that a 20-minute ice treatment had no effect on proprioception. Thieme (1996) reported than even though the subjects walked awkwardly to the Kin-Com machine after the ice application, the ice had no affect on the subject's proprioception. Cold decreases cutaneous input, and the sensitivity of muscle spindle fibers, both of which are essential for proprioception (Knight, 1995). Thieme (1996) also reported that the trend in the data suggested that ice application actually improved the subject's proprioceptive ability. However, the research that has been done shows that ice has no direct effect on proprioception (Thieme, Ingersoll, Knight, Ozmun,1996).

Effects of Cryotherapy on Strength

Research concerning strength changes following a cryotherapy treatment has been limited to isometric contractions (Ruiz, Myrer, Durrant, Fellingham, 1993). The research is inconclusive; strength may increase or decrease following a cryotherapy treatment. Ruiz et al. (1993)

conducted a study and concluded that both eccentric and concentric strength is decreased following a 25-minute cryotherapy treatment (Ruiz, Myrer, Durrant, Fellinham, 1993). They found that this loss of strength does not last long. In this particular study, it was noted that 20 minutes after the test the strength levels had almost returned to pretest levels. Ruiz also recommends, that with this decrease in strength it is advised that an athlete not return immediately after a cryotherapy treatment.

Another study was performed by Kimura et al (1997) to determine the effect of cryotherapy on isokinetic eccentric plantar flexion peak torque at various speeds. This study found that all subjects produced significantly higher eccentric peak torque values at 120°/sec than at 30°/sec (Kimura, Gulick, Thompson, 1997). This study also found that the subjects were able to produce more total work. According to Kimura et al (1997), there were reasons for this increase: decrease pain during the exercise, decrease rate of torque decline, increased muscle viscosity, a decrease in metabolic byproducts, and a more gradual increase in muscle temperature during the exercise bout. These were all reasons believed to effect total work. Kimura et al. (1997) showed that cryotherapy does not affect eccentric peak torque but did increase muscle endurance.

<u>Indications</u>

These are reasons for the use of cryotherapy recommended by Starkey (1993).

1. Acute injury
2. Chronic Injury
3. Muscle Spasm
4. Postsurgical pain and inflammation
5. First Degree burns

<u>Contraindications</u>

Very rarely does anyone have a reaction to cryotherapy, but some people are hypersensitive to this type of treatment. Here is a list of contraindications for the use of cryotherapy (Starkey, 1993).

1. Open or uncovered wounds
2. Hypersensitivity
3. Cardiac or Respiratory problems
4. Poor circulation
5. Raynaud's Phenomenon- a reaction to cryotherapy that causes vasospasm of the digital arteries especially of the hands.

Rewarming Following Application

Following cold applications, the cooled body part rewarms due to heat conduction from the atmosphere, surrounding tissue, and circulating blood (Knight, 1995). Rewarming has been evaluated in two ways: return to contralateral-body part temperature, and return to the temperature of the body part prior to the cryotherapy treatment (Knight, 1995). The tissue will return to normal body temperature, but could take some time. This seems to be a question asked frequently. The reason is because of these two factors: extended inactivity of the body part, and exposure of the body part to an unnatural environment (Knight, 1985). The inactivity of the body part will cause a decrease in the body metabolism and will also cause decrease in body heat production. The rewarming process can take some time. This will depend on two factors: (1) how much heat was removed from the body, (2) the amount of heat available to rewarm the area (Knight, 1985). Some body parts will rewarm faster than others due to the increased circulation available to that area. For some areas it will take longer. Previous research found that finger temperature returned to pre-immersion levels within 15 minutes. However, in the forearm and ankle, it took over two hours for the tissue to return to pre-immersion levels (Knight, 1985).

Rewarming is also delayed depending on the type of cold application. Knight (1985) reports on a study measuring skin temperature for 50 minutes following a 10-minute ice massage. The mean temperature of 16 subjects was 2°C below their contralateral calves (Knight, 1985). Another study measured rewarming of the forearm for 90 minutes following a 30-minute ice pack application. Skin temperatures were 4.3 to 5.0°C below contralateral arm temperatures at 90 minutes post-application (Knight, 1985). Rewarming basically depends on the depth of the measurement and the length of the application. The longer the cold is applied, and the deeper the tissue, the slower the rewarming will be (Knight, 1985).

A study performed by Myrer (2000) also found that exercise can increase the rewarming rate in the muscle being treated. This study found that moderate walking significantly enhanced the rewarming of the muscle group being tested after a standard ice-pack treatment. This would imply that if the prolonged affects of ice are desirable in the treated structure, then the body part should not be exercised immediately after the removal of the cold application.

Application

The average length of application can vary. The most common is between 15 to 20 minutes (Knight, 1985). A cryotherapy treatment is not left on more than 30 minutes because of the fear of frostbite. Some use intermittent application because they believe cold induced vasodilatation will increase blood flow to the area if cold is applied for longer than 10 to 12 minutes (Knight, 1985). Knight (1985) suggest that initial cryotherapy treatment should last at least 20 minutes so the body part can pass through a three to five minute period of vasodilatation and be in a second period of vasoconstriction. Knight also feels that if the cryotherapy is left on too long that frostbite or nerve palsy can result. The cryotherapy treatment should be applied for at least 20 minutes and preferably 30 minutes. Applications of cryotherapy of less time than this would not effectively lower the temperature of deeper tissues and, therefore, would not exert a beneficial influence at the site of the injury.

In a study performed by Ho et al. (1995), they compared various icing times, from five to 25 minutes. At five minutes they found cryotherapy produced a small decrease in blood flow and metabolism in the deep tissues of the knee joint. They also found that a maximal response can be produced with 25 minutes of icing, fourfold greater than that seen at five minutes. Ho et al. (1995) also noted that at 10 minutes there was a increase in arterial blood flow which suggests a possible reflex vasodilatation in the arterial blood vessels in response to cooling, but decreases were again noted at 15, 20, and 25 minutes of cooling.

Best Mode of Application

There are many different ways to perform a cryotherapy treatment. Studies show that ice chips in a plastic bag is the most effective mode of cryotherapy, followed by frozen gel packs, endothermic chemical reaction packs, and, finally, inflatable plastic envelopes injected with a gas refrigerant (Kaul & Herring, 1994).

The ice bag is a method which is used to apply deep, penetrating cold (Bryant, 1996). The cooling effect of ice bags last long and is more effective than some of the superficial methods like the ice massage (Bryant, 1996). The weakness of the ice bag is that it is difficult to shape the ice bag to the contour of the body (Bryant, 1996). The ice bag will form nicely if crushed ice is used and if you do not fill the ice bag all they way.

The frozen gel packs are convenient and reusable. These packs contain water, an antifreeze to keep them from freezing and gelatin or shredded paper to give the pack substance. These packs are very convenient for general training room use. There are some disadvantages to using these gel packs. They do not cool the body as much as an ice pack (Knight, 1995). They cannot be taken on the court or field and held for later use because they will not stay cold. They can be dangerous because they will cool the skin faster than the ice bag, and they could cause frostbite (Bryant, 1996).

The chemical reaction packs are convenient, but they do not get as cold as the gel packs and they can be expensive. They are convenient for emergency use, but they are not suitable substitutes for the ice pack or gel pack (Knight, 1995). They do not lower the body temperature, and the fluid can leak out, causing a chemical burn (Knight, 1995).

Ice massage involves rubbing ice on the skin with a circular motion (Bryant, 1996). This is a method which ables you to focus on only the injured area. Apply to bony areas for seven to 10 minutes, and double the time when applying to fatty areas such as the quadriceps or buttocks (Bryant, 1996). The drawback to this method is that it does not penetrate very deep and the effects do not last as long as other methods (Bryant, 1996).

Ice immersion is the preferred technique for cooling the feet, ankles, hands, and elbows. This technique provides very complete and concentrated cold exposure to the entire injured area (Bryant, 1996). Some therapists also use ice immersion to treat the lower back. Ice immersion is not recommended to be used to take care of acute injuries. The proper temperature for ice immersion is debatable. The optimal temperature is 33° to 36° F, but some use 49° to 59° F for body parts like the back (Knight, 1995). Body parts besides the foot, hand, and elbow do not respond well to immersion, because too much of the uninjured area is exposed to the cryotherapy treatment (Bryant, 1996).

Vapocoolant sprays have been shown to be effective especially with stretching techniques. Research shows that this spray can drop the skin temperature to about 45 degrees (Kaul & Herring, 1994). Muscle 1.25 inches deep and intra-articular knee temperatures showed drops in temperature of about 9°F. These sprays are effective but are not being used because they can harm the ozone layer.

Thermal cooling blankets are also being used especially in postoperative situations. These blankets are giving great results to patients who have had surgery. Patients receiving these blankets have had better outcomes regarding effusion, walking, range of motion, quadriceps function, and pain (Kaul & Herring, 1994).

Contrast baths is a method that is also being used quite often. There are many techniques, including beginning and ending treatment with cryotherapy. The reason for using this method is the belief of the alternating vasoconstriction and vasodilatation producing a pumping effect that can reduce intercellular fluid.

<u>Cryotherapy Injuries</u>

Cryotherapy, like other therapeutic modalities, is not without problems. These types of problems can cause the clinician to be too conservative and enabling the patient to receive the benefits from cryotherapy. Cryotherapy is contraindicated for people who have hypertension during a cryotherapy treatment or have cold allergies. This treatment should not be applied to areas that have decreased skin sensitivity or patients who have developed Raynaud's syndrome. Cryotherapy is also contraindicated to patients who have peripheral vascular disease because the treatment could cause further reduction of blood flow.

Frostbite is another reaction that can occur to cryotherapy. Frostbite occurs when the skin temperature falls below freezing (Starkey, 1993). If the subcutaneous temperature falls below 55°F, damage to the tissue can occur. If the treatment is applied below the recommended temperature or if the duration of the treatment exceeds the recommended time, the risk of frostbite increases (Starkey, 1993).

The risk of frostbite is present when using the reusable cold packs. These packs contain water mixed with antifreeze and are stored at temperatures that are below freezing (Starkey, 1993). Since these packs are at temperatures below freezing, some type of medium should be applied between the skin and the cold pack to reduce the chances of frostbite.

If frostbite does occur, it will probably affect only the superficial tissue. A red spot or a welt may be present when you remove the ice pack, but a blister may form later on (Knight, 1995). Massage is not advised to the skin because it will look worse than it is. If a blister does form, do not pop the blister. Place a sterile guaze over the blister and secure it with tape. The athlete's activity needs to be altered to protect the blister. Eventually new skin will form underneath the blister.

Raynaud's phenomenon is also a condition that can result from too much exposure to cryotherapy. This is a condition that causes vasospasm of digital arteries lasting for minutes to hours, which could lead to tissue death (Arnheim and Prentice, 1997). The symptoms will be skin blanching or cyanosis of the fingers or toes, skin pallor followed by redness, and finally the return to normal color (Arnheim and Prentice, 1997). This is usually not painful, but numbness and tingling may occur after this response.

Peripheral nerve injury can result from improperly applied or excessively applied cryotherapy. Clinicians need to be aware of the location of the major peripheral nerves, the thickness of the subcutaneous fat, the duration of tissue cooling, and the possible cryotherapy sensibility of the individual (Malone, Englehardt, Kirkpatrick, and Bassett, 1992). The patient will have symptoms like decreased sensibility, decreased motor weakness, and numbness and tingling over the affected area. Fortunately, it seems that these symptoms do not last a long period of time and the patient has bee able to make a full recovery. The authors recommend that cryotherapy treatments not to last more than 20 minutes especially in areas of the body where peripheral nerves may be some what superficial, and that extreme care used in the application of compression with the use of cryotherapy (Malone, Engelhardt, Kirkpatrick, and Bassett, 1992). This condition is temporary, but interim care may require the restriction of activities that would place the patient at risk.

Skin Temperature

Upon applying cryotherapy to the skin, the skin temperature will immediately decline. The rate of cooling slows until the temperature plateaus above the temperature of the modality used (Knight, 1995). After application, the temperature will sharply increase but will take a while before reaching preapplication temperature (Knight, 1995). This was proven in a study performed by Mancuso et al. The results of their study where in agreement with the literature that shows that there is a rapid decrease in skin temperature followed by a slower and steady decline with cold application (Mancuso and Knight, 1992).

The type of cryotherapy treatment used will affect the magnitude of the difference between the modality temperature and the plateaued tissue temperature, and whether or not the tissue temperature begins to rise before the modality is removed (Knight, 1995). For example, if you were using an ice bag and an ice bath. The ice bag may initially be colder than the ice bath at first, but the ice bag does not have as great of a heat capacity and therefore cannot cool the body part as much as the ice bath. The ice bag will begin to warm to the point where it is extracting less heat from the body part than the circulation is providing to that body part (Knight, 1995).

A study performed by Palmer et al. (1996), proved that skin and subcutaneous tissue temperature decrease immediately with ice applications. They found that there was a rapid decrease in the ankle and thigh skin temperatures during the first few minutes, followed by a slow and steady decline through the remainder of the treatment. They found that ice should be reapplied immediately after activity rather than being delayed (Palmer and Knight, 1996).

<u>**Intraarticular Temperature**</u>

According to Knight (1995), intraarticular temperature behaves much like other tissues in that the temperature seems to be a function of the magnitude of heat lost. The intraarticular temperature will decrease more than the adjacent muscle (Knight, 1995). Intraarticular temperature also depends on the length of treatment. The longer the treatment lasts, the lower the temperature will decline. The lowest temperature in the joint is not reached until after the treatment has ceased. A study done by Ohkoshi (1999), showed that cryotherapy did reduce the intraarticular temperature in ACL reconstructive patients. Ohkoshi also found that the cryotherapy decreased the intraarticular temperature and showed a three phase pattern change with time: (1) a low temperature phase that began immediately after surgery and lasted for about 2 hours; (2) a temperature rising phase in which the temperature increased, and (3) finally there was a thermostatic phase.

Functional Performance

Functional performance tests enable an athletic trainer to watch an athlete perform physical activities that stimulate the muscular and joint stresses encountered during athletic events (Cross, Wilson, and Perrin, 1996). By monitoring these tests an athletic trainer can determine whether or not an athlete is capable to return to activity. If an athlete is unable to perform the desired tasks, they should not return to activity. These two tests are described as reliable indicators of lower extremity functionality (Cross, Wilson, and Perrin, 1996).

Vertical Jump

The developing of power in the legs is vital to any athlete that competes. A basketball player needs power to rebound, a volleyball player for blocking, as well as a football player. Power is defined as the time rate of doing work. One method of measuring power is by doing a vertical jump (Klavora, 2000). The vertical jump provides an effective measurement of power as an indirect measure of performance (Klavora, 2000). According to Cordova et al. (1996), the vertical jump appears to provide a useful means of estimating lower extremity functional strength. The vertical jump has become very important to coaches and trainers because it shows how effective a strengthening program can be.

The Single-Leg 6 Meter Hop-Test

To perform the single-leg six-meter hop test, the person should have good proprioception and agility. This test has been used by many to test functional performance. Sekiya et al. (1998), investigated the significance of the single-legged hop test to the anterior cruciate ligament-reconstructed knee as it specifically relates to knee muscle strength recovery and residual anterior laxity. Sekiya also found that it was an effective way of finding data about the quadriceps and hamstring muscle strength recovery. The overall feeling was that the single-legged hop test is an effective way of measuring strength without the use of expensive equipment. This test will also be a great test in determining a person's functional ability.

Indications and Contraindications

These two tests will tell a lot about a person's ability to function. As stated previously, the vertical jump is a great indicator of an individuals lower extremity functional strength and power. The single-leg hop test will tell a lot about a person's agility and proprioception. This test will also tell about their quadriceps and hamstring strength. These tests also have a lot of risk.

While performing a vertical jump, a person could sprain his or her ankle. The subject could also damage their achilles tendon from pushing off. The person could fall causing a contusion. While performing the single-leg hop test the person could fall from fatigue. These tests need to be properly performed, but also need to be done safely.

Cryotherapy and Functional Performance

Cryotherapy is a vital component in the athletic training field. Cryotherapy is used as a means of helping return an athlete return to athletic competition. Before allowing them to return to activity, we must functionally test them. If pass all functional test, they may return. But if an athlete uses a form of cryotherapy before returning to activity, will it affect their performance level? What needs to be determined is what affect does cryotherapy have on a muscle and how long it takes for that muscle to rewarm and become functional.

Conclusion

In conclusion, cryotherapy plays a vital role in the athletic training field. This is a modality that is used by many to treat both acute and chronic injuries. Cryotherapy has been known to have an effect on the body, which could hinder an athlete's performance. The purpose of this study was to decide how much cryotherapy will hinder functional performance, if any at all.

Chapter Three

Methodology

A repeated measures design was used with an untreated control group. Subjects were randomly assigned to one of two conditions: ice pack group (age= 26.3 ± 3.9 yrs.) or resting group (29.0 ± 5.3 yrs.). Before and immediately following the treatment, subjects performed two functional performance tests: vertical jump and single-leg hop test.

Trying minimize the effects of fatigue, I allowed approximately 30 seconds rest in between each test. Each subject performed the treatment for 15 minutes, and then performed the functional test after waiting the appropriate amount of time. Subjects repeated the same steps until they had been measured at 15 minutes, 30 minutes, and finally 45 minutes.

Subjects

The subjects were 14 volunteer employees (seven males and seven females) from HealthSouth Western Hills in Parkersburg, West Virginia. Subjects with a lower extremity injury within the previous three months were not permitted to participate in this study. An informed consent form describing the procedures involved and the potential risks and benefits was given to each subject and must have been signed (Appendix H).

Procedures

Each subject reported to HealthSouth Western Hills for one day of testing. The subject's wore T-shirts, shorts, and tennis shoes. The subjects were not allowed to stretch or warm up before pretest measurements or posttest measurements were taken. During the orientation session, subjects were introduced to the two tests that were being used for testing. Each subject was given the opportunity to practice each test three times before results were taken. Following a brief rest, the subjects performed each test three times. These scores were used as a baseline for comparison after the treatment. The dominant leg was determined by having them use the leg they would use to kick a ball. The chosen extremity was used for the pretest and posttest trials and received the treatment.

To administer the six-m hop test, two strips of tape were placed on the floor six meters apart. Using their dominant leg, subjects were told to hop to the line in front of them, touch it with their foot, turn, and then hop back to the starting line twice for a total of 24.0 meters (See Figure 1, Appendix A). During each testing session, they performed three trials of each test. Time was started when the subject made the initial movement to start the test. Upon completion of the last lap, the trial ended and the clock was stopped. To minimize fatigue, we allowed 30 seconds of rest between each time trial. Each subject was encouraged to finish the test in the minimum amount of time possible. The results were not given to the subjects during or after the practices or test trials.

The single-leg vertical jump was measured by obtaining the difference between their standing reach and the height to which they subject could jump (See Figure 2, Appendix A). The subject's were given an ink pad and told to put ink on their index and middle fingers of their dominate hand. After measuring the subject's standing reach, they were instructed to begin in a crouched position on one leg and jump as high as possible off the same leg and make an ink mark on the wall with the two fingers (See Figure 3, Appendix B). The difference between the height of the subject's jump and their standing reach was recorded in inches as the trial score. Before each trial, the subject's were encouraged to give their maximal effort and to jump whenever ready. No knowledge of their results was given during or after practice and test trials.

Subjects were allowed to practice before the pretest measurements were taken but not before posttest measurements were taken. The subjects completed three test trials for each functional performance test during both the pretest and posttest. The subjects were allowed to rest 30 seconds between each trial of the single-legged hop test. Subjects completed three trials of the vertical jump at their own pace. The two functional performance tests took approximately four minutes to complete.

Following the pretest session, all subjects were placed onto a table where the cryotherapy treatment was administered. Those in the control group relaxed on a table for fifteen minutes between each testing session without a cryotherapy treatment. The experimental group subjects had an ice bag placed on the belly of the quadriceps six inches above mid-patella (See Figure 4, Appendix B). After fifteen minutes, the subjects performed each functional test three additional times. When finished, they sat for fifteen minutes and performed each test again. They followed this pattern until forty-five minutes had past. After performing the two tests at the forty-five minute mark, the testing was complete.

Chapter 4

Results

The purpose of this study was to determine if cryotherapy effected vertical jump and single-legged hop test. A multiple analysis of variance (MANOVA) with repeated measures was used to determine if there was any overall significant difference existed between the ice bag group and the resting group.

1. ***There will be no significant difference in mean vertical jump height following ice application.***

   The null hypothesis was accepted because the data failed to meet a .05 level of significance using a multiple analysis of variance.

2. ***There will be no significant difference in mean single-leg hop time following ice application.***

   The null hypothesis was accepted because the data failed to meet a .05 level of significance using a multiple analysis of variance

There was no significant difference in vertical jump or single-legged hop test scores between the ice bag group and the control group (See Chart One, Appendix C). Vertical jump was not effected by the ice treatment enough to be significant (See Graph One, Appendix D). Comparing vertical jump at pretest and posttest, there was no significant difference noted (See Chart Two, Appendix E). Single-legged hop test was not effected at all by the ice bag treatment (See Graph Three, Appendix F). Pretest measurements were not different compared to the numbers obtained after the ice bag treatment (See Graph Four, Appendix G).

Chapter 5

Discussion

Cryotherapy is one of the most commonly used modalities in athletic training. This particular modality is used frequently in the athletic environment. Athletic trainers commonly administer ice bags during athletic competition and practices. Athletic trainers are known to return athletes to activity after a cryotherapy treatment. The results of this study indicate that a 15-minute ice bag treatment does not affect functional performance. However, the difficulty in recruiting more athletic subjects willing to participate, the power for each of the two functional tests was less than optimal. Consequently, differences may exist, but we were unable to detect them. Vertical jumps following the cold application were lower, but not statistically different from the control treatment group for both of the functional tests.

The statistical analysis did not support the current research on cryotherapy. A study performed by Cross et al. (1996) found that with ice immersion, there was a decrease in vertical jump but not in the single-legged hop test. My findings were different with the vertical jump but was the same concerning the single-legged hop test.

The vertical jump is a mode of determining an athlete's lower extremity functional ability (Cross, Wilson, and Perrin, 1996). It has been used to assess an athlete's anaerobic power and for other athletic abilities. The vertical jump is particularly useful for measuring the power output of the quadriceps, second to the hip extensors, for vertical displacement (Cross, Wilson, and Perrin, 1996).

In this study, it is important to isolate the treated extremity to reduce possible overcompensation with the non-treated leg. As a result, the subjects had to perform the vertical jump with the single extremity instead of using both extremities. This is supported by many who suggest that two-leg tests are associated with the ability to perform daily activities, whereas the single-leg vertical jump is more closely associated with functional stability encountered during vigorous activities.

These findings did not agree with those of Cross et al. (1996). The cryotherapy treatment had some effect on the quadriceps muscle group, but not enough to show statistically. This particular treatment did not effect the stretch reflex, which would have then affected the vertical jump.

The single-legged hop test did not permit an accurate analysis of the elapsed time differences between the experimental and control groups. There was no significant difference found between the two groups. The distance was increased to 24.0 meters, and no difference was found. Thus, it has been suggested that the single-legged hop test may not be an adequate functional test to assess functional performance.

Improvements/Future Research

When referring to this study, readers should note the limitations to this study. Subjects were selected from a healthy population who had not injured either lower extremity within the past 3 months. The members from this population rarely receive cryotherapy treatments before activity. Thus, these findings may not apply to an injured population who receive a cryotherapy treatment on a daily basis. Fatigue is also another limitation in this study. Each one of the subjects performed the two tests a total of 15 times. These subjects were not athletes so it is hard to believe that they were able to perform to their fullest ability on each test. Fatigue is something that could have definitely affected the results. This project also needed more subjects. For this project to show any significant differences, more people were needed to participate.

<u>Conclusion</u>

Cryotherapy is used often by athletic trainers. It is common to apply a cryotherapy treatment to a joint and the immediate surrounding areas. Future research should attempt to define the effects of other types of cryotherapy applications and what effect they might have on functional performance. Other tests to determine good functional performance should also be considered. Even though this study showed no significant difference; these results should not be undervalued. Athletic trainers must consider the possible outcomes of cryotherapy before they return treated athletes to competition.

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APPENDIX A

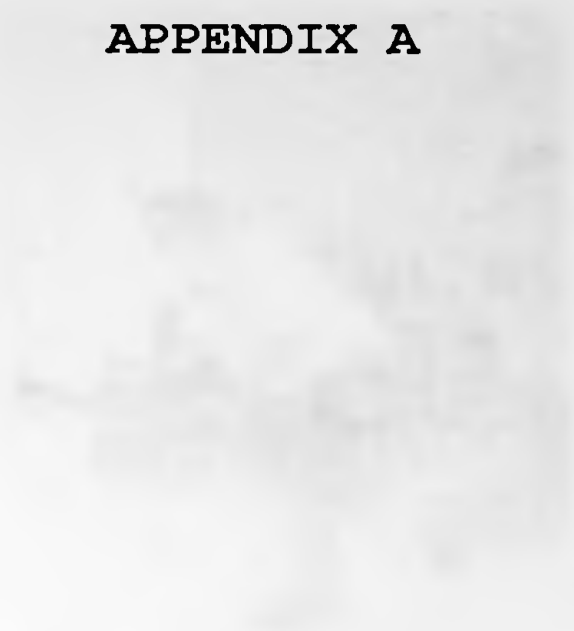


Figure 1

[illegible]

Figure 2

[illegible]

Figure 1

When performing the single-legged hop test, they were to use their dominant leg and go as fast as they could go.

Figure 2

The subjects standing reach was obtained first before they performed a vertical jump.

APPENDIX B

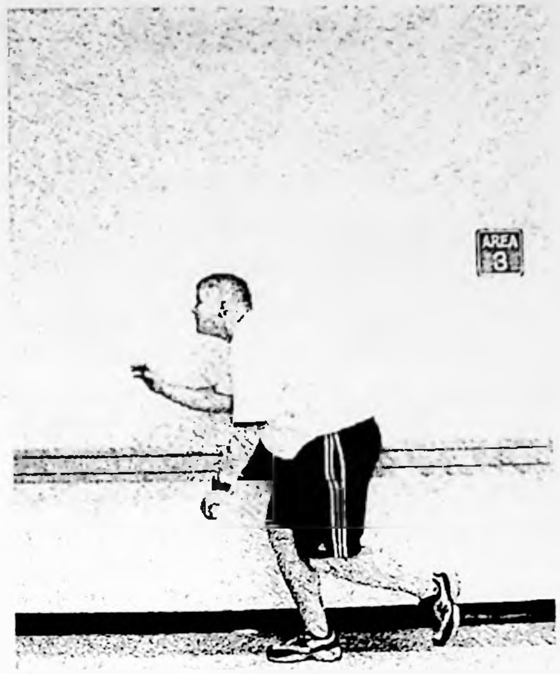


Figure 3

When performing the vertical jump, they were to use their dominant leg and not go further than 90° of flexion.

Figure 4

The placement of the ice bag should be six inches above mid-patella.

APPENDIX C

Appendix C;
Chart One

	Vertical Jump #1	Vertical Jump #2	Vertical Jump #3	Vertical Jump #4	Vertical Jump #5
Mean	10.46	10.65	10.6	10.65	10.7
N	5	5	5	5	5
Std. Deviation	3.3046	3.1205	3.4397	2.8592	3.4569
Mean	10.3611	9.5833	10.5833	11.1667	11.4444
N	9	9	9	9	9
Std. Deviation	2.9504	3.2307	3.6207	4.7418	3.9839
Mean	10.3964	9.9643	10.5893	10.9821	11.1786
N	14	14	14	14	14
Std. Deviation	2.9529	3.1146	3.4217	4.0519	3.6852

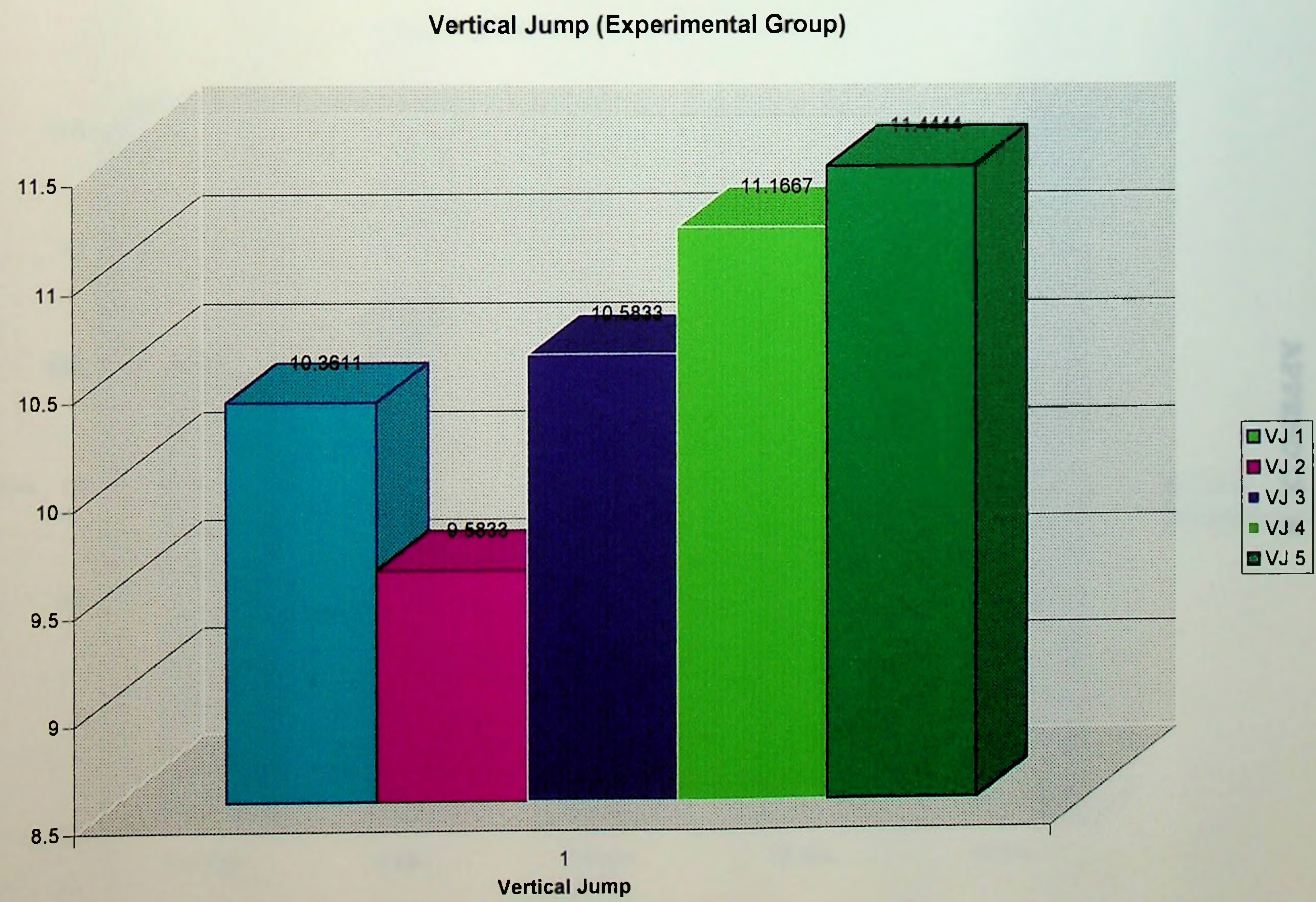
F= .000
P=.994

	Hop Test #1	Hop Test #2	Hop Test #3	Hop Test #4	Hop Test #5
Mean	10.906	10.646	10.796	10.902	10.778
N	5	5	5	5	5
Std. Deviation	1.1053	1.4166	1.3052	1.3759	1.0871
Mean	11.3722	11.5222	11.42	11.3378	11.28
N	9	9	9	9	9
Std. Deviation	1.5554	1.9192	2.5973	2.228	2.1276
Mean	11.2057	11.2093	11.1971	11.1821	11.1007
N	14	14	14	14	14
Std. Deviation	1.3851	1.7533	2.1845	1.9194	1.7921

F= .335
P= .573

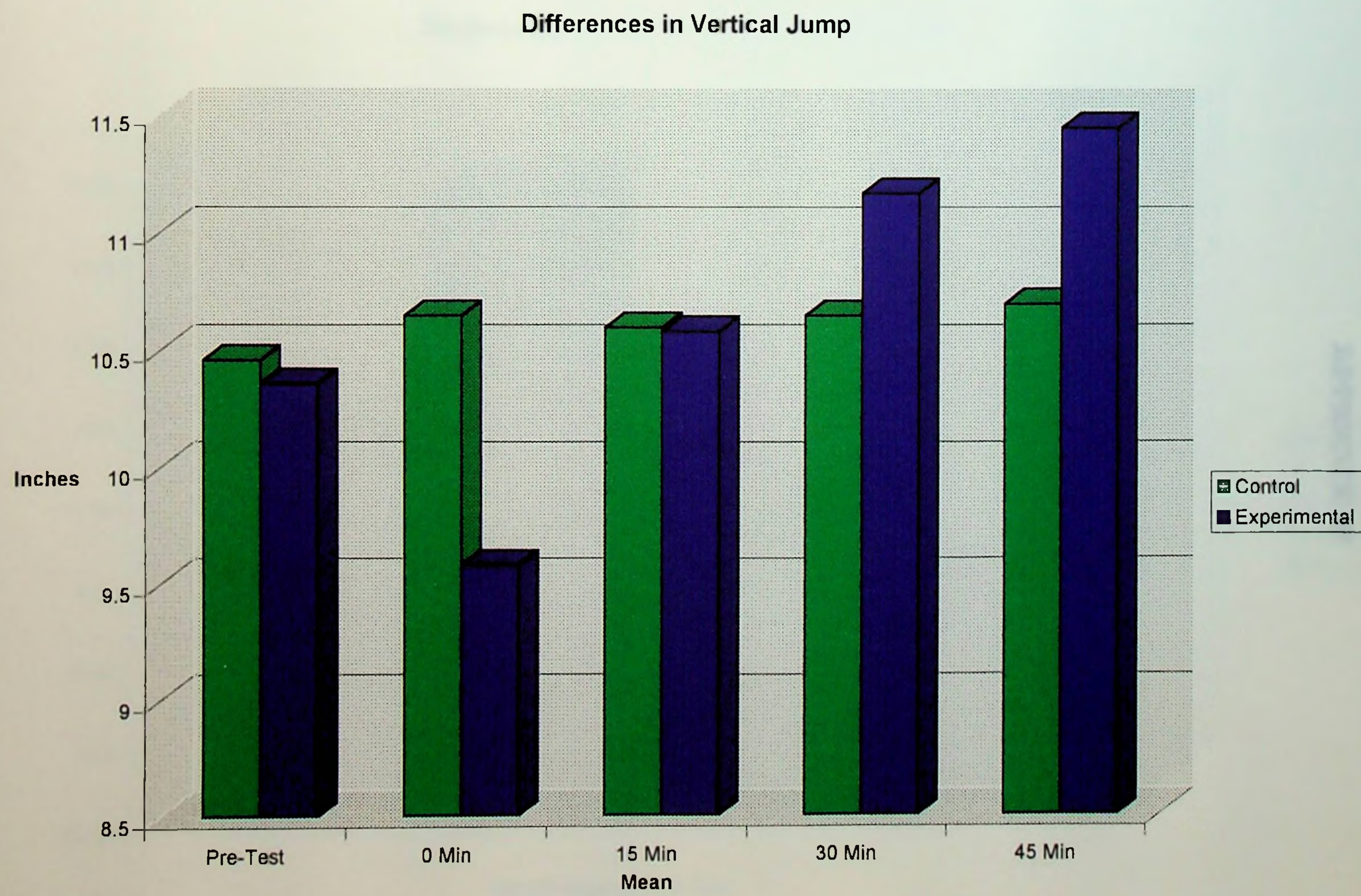
APPENDIX D

Appendix D;
Graph One



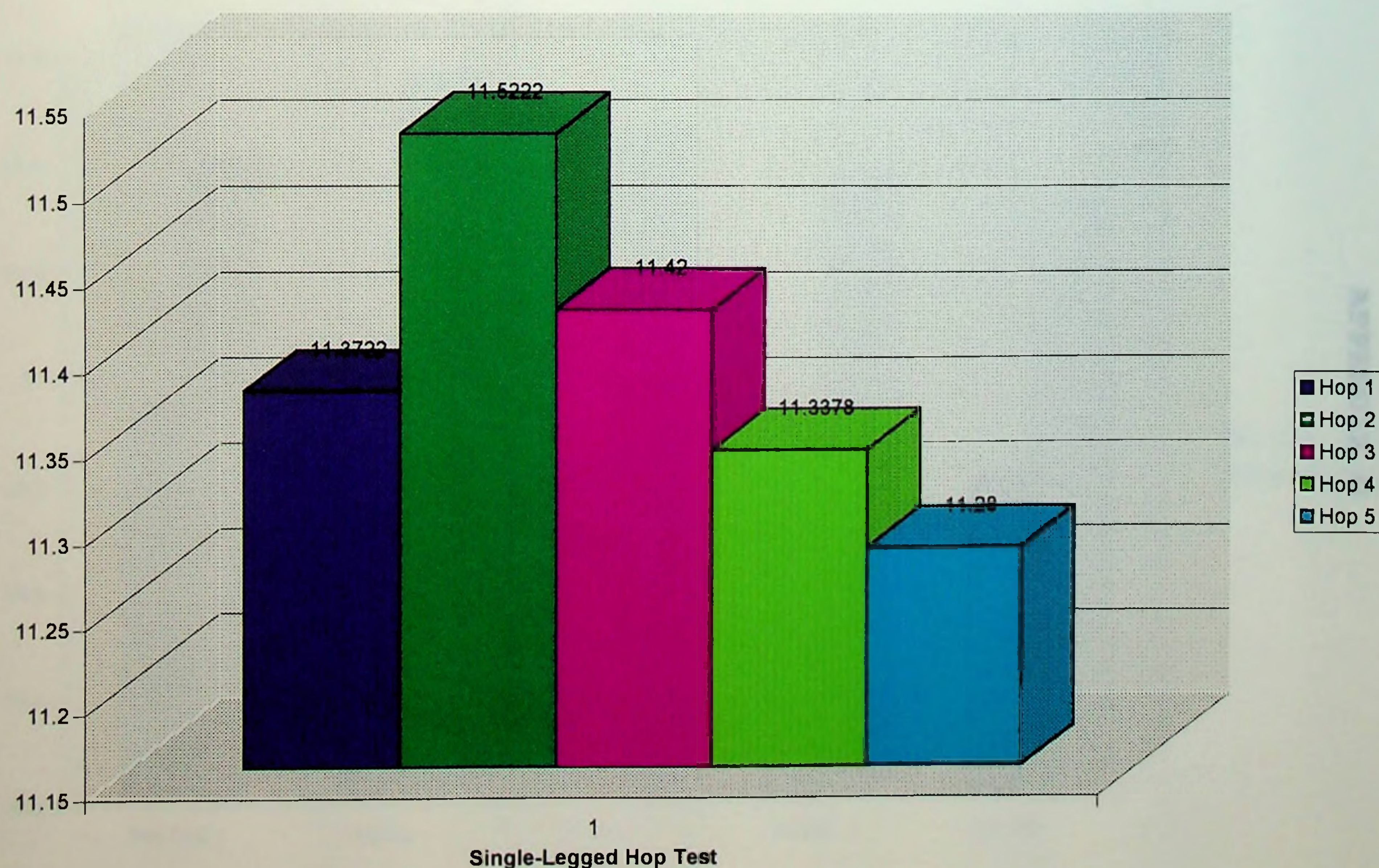
APPENDIX E

Appendix E;
Chart Two



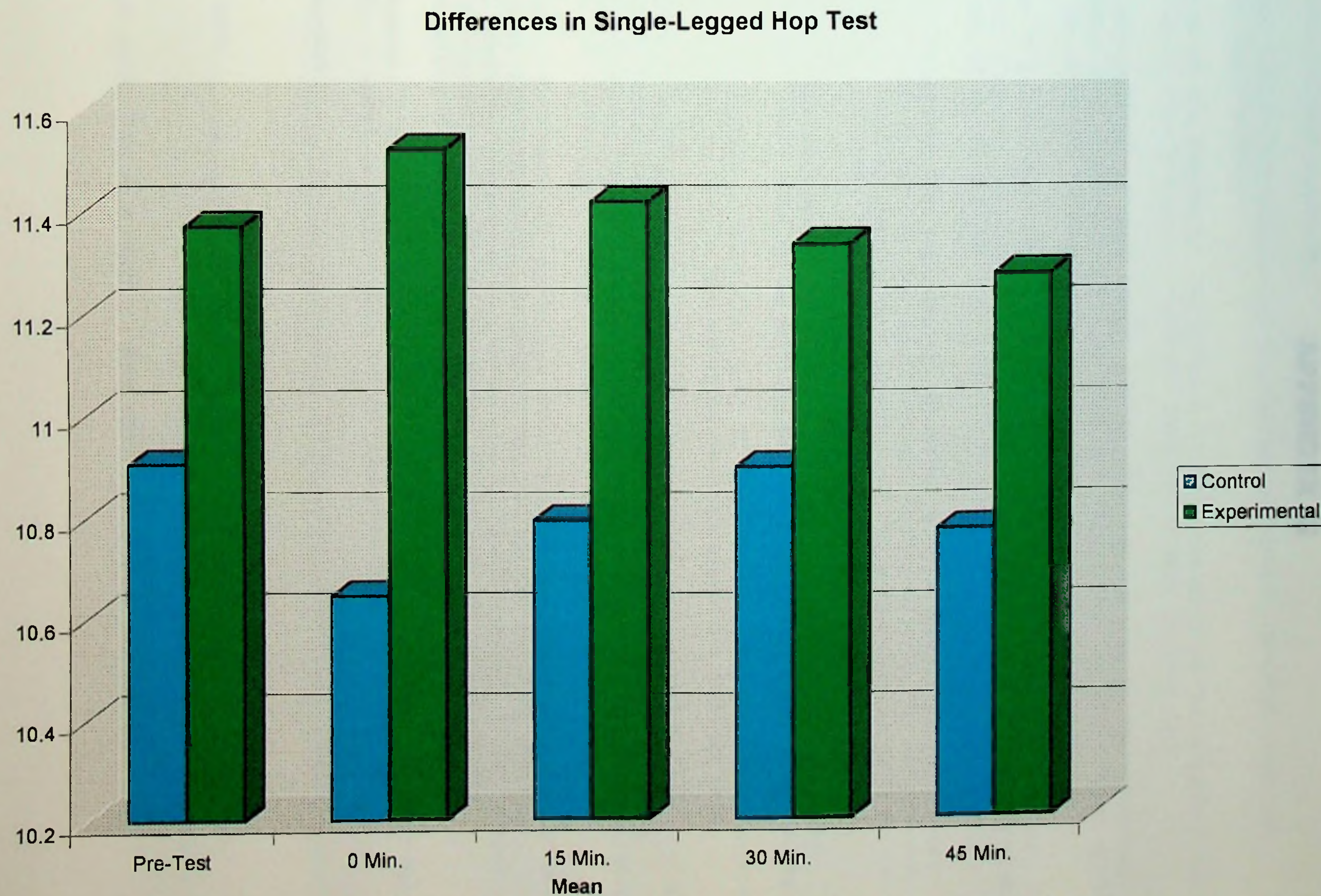
APPENDIX F

Appendix F;
Graph Three



APPENDIX G

Appendix G;
Graph Four



APPENDIX H

Informed Consent Agreement

Project Title: The Ability of Cryotherapy to Effect Vertical Jump and Single Leg Hop Test

Purpose of the Research: The purpose of this research is to determine the effects of cryotherapy on vertical jump and single leg hop test.

What you will do in this study: I will place an ice bag on the quadriceps and have them perform a vertical jump and single leg hop test. These tests will be repeated 3 times each.

Risks: I understand that if I have any hypersensitivity, allergies, or disease that contraindicates cold I may be at risk for the respected side effects of my condition.

Confidentiality: The information obtained in this experiment will remain confidential as the law and institutional policy allows. The information may be reviewed by appropriate Federal and State agencies as well as the Marshall University Institutional Review Board.

Voluntary Participation: My participation in this study is completely voluntary. There will be no penalty placed upon me for not participating.

Right to Withdraw: I have the right to withdraw from this study at anytime without penalty. I will the experimenter and leave the testing area.

Payment: I will receive no payment for participating in this study. In the event of injury or illness as direct result of participation in this research study, no compensation, financial or otherwise will be available from the investigators or Marshall University.

Contact: If I have any questions about this study, I may call Doug Branch at (304) 485-7384 extension 5003 or Dr. Dan Martin at (304) 696-2412. If I have questions regarding my rights as a research subject, I may contact Dr. Henry Driscoll, IRB Chairperson, at 1542 Spring Valley Drive, Huntington, WV 25704 or phone (304) 696-7320.

Agreement: I have read the consent form and understand the nature of this study. I agree to participate in the research study described above.

Signature:______________________________ **Date:**________________

Witness:______________________________ **Date:**________________

*** You will receive a copy of this agreement for your records.**