THE EFFECT OF CRYOTHERAPY ON THE SINGLE LEG VERTICAL JUMP

A THESIS

Submitted to the Faculty of the School of Graduate Studies and Research
of
California University of Pennsylvania in partial fulfillment
of the requirements for the degree of

Master of Science

by
Christine Marie Stache

Research Advisor, Dr. Thomas F. West

California, Pennsylvania
2010

CALIFORNIA UNIVERSITY of PENNSYLVANIA
CALIFORNIA, PA

THESIS APPROVAL

Graduate Athletic Training Education

We hereby approve the Thesis of

Christine Marie Stache
Candidate for the degree of Master of Science

Date	Faculty
4/29/10	Thomas F. West, PhD, ATC (Chair)
4-29-10	Bruce D. Barnhart, EdD, ATC, PTA
4-29-10	Robert H. Kane, Jr., EdD, ATC, PT

ACKNOWLEDGEMENTS

I would like to take this opportunity and thank everyone who helped me with this year. I would like to thank my parents and sister for their support and believing in me this year and always. I like to thank my family for encouraging me to apply to graduate school and to move closer to home. I also would like to thank my grandparents, aunts and uncles for support and encouragement. I would like to thank my old and new friends for keeping in touch and encouraging me through everything.

I would also like to thank my chair, Dr. West, and my two committee members, Dr. Kane and Dr. Barnhart for helping me with this thesis. I would also like thank all the volunteers in this study. Each volunteer was kind enough to take time out of their busy schedule to help with participation. Thanks so much to everyone.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Cryotherapy is a key therapeutic modality in athletic training. Cryotherapy can be used for numerous types of injuries and can also be used on many parts of the body.[1-7] The effect of cryotherapy on functional performance has greatly been debated.[7-14] The purpose of the study is to examine cryotherapy research and the effects cryotherapy has on the lower extremity and functional performance.

Nadler et al. defined cryotherapy, as "the therapeutic application of any substance to the body that removes heat from the body, resulting in decreased tissue temperature".[1] Cryotherapy is and can be used in all three phases of the injury process, including the acute phase, repair phase and remodeling phase. The acute phase is from the point of injury to approximately forty eight hours after the injury. The repair phase, immediately follows the acute phase, can last forty eight hours to approximately six weeks after the initial injury. The remodeling phase typically starts three to six weeks following the initial trauma and can last up to twelve months, depending on the severity of the injury.[2]

Cryotherapy is commonly utilized to help decrease swelling and pain at an injury site.[1-7] Cryotherapy can help prevent and/or reduce swelling, depending on severity, after an acute injury and can continue to reduce swelling and pain through all three injury phases when used appropriately.[1-7]

There are many uses for cryotherapy but there are also several contraindications.[1-7] Contraindications include applying cryotherapy before extreme exercise and applying cryotherapy to patients that may suffer from cold allergies, arthritis, anesthetic skin and/or cardiovascular disease.[2-5]

There are four common physiological effects of cryotherapy: vasoconstriction of the blood vessels, decrease tissue hypoxia, decrease pain and decrease muscle spasm. Vasoconstriction is the ability of the blood vessel to become narrow which leads to a decrease in swelling at the injured site.[2,4,5] Secondly, tissue hypoxia is the loss of or a decreased amount of oxygen to the tissue site.[4] This leads to a decrease in oxygen supply and metabolic demands at the injury site. If this is not treated immediately it can lead to secondary tissue hypoxia. Thirdly, cryotherapy can be used to decrease pain.[1,4,5] Fourth, researchers believe that a decrease in muscle spasm

is caused by the decrease in responsiveness of muscle spindles therefore, each individual responds differently to muscle spasm.[4,6]

Research has shown various results for determining the effects cryotherapy has on functional performance. Most studies show that cryotherapy does in fact have an effect on functional performance, specifically the single-leg vertical jump.[7-14] For the following study the researcher is specifically looking only at vertical jump results.

Richendollar et al. performed a study to examine the effects of cryotherapy and warm-up on functional performance. Results showed that the vertical jump had a decrease larger than one centimeter. The authors also found that overall results for the vertical jump had improved with the ice and warm-up group but not for the ice and no warm-up group.[8]

Fischer et al. examined the effects of cryotherapy on the shuttle run, co contraction and the single-leg vertical jump. Results for the single-leg vertical jump had decreased significantly after the ten minute cryotherapy application. The authors determined that the amount of time the cryotherapy has been applied and immediate functional activity are closely correlated.[9]

Cross et al. examined cryotherapy on the shuttle run, six meter hop and single-leg vertical jump. Results determined that the single-leg vertical jump significantly decreased with the application of cryotherapy.

Patterson et al. examined the effects of cryotherapy on the vertical jump, 40 yard sprint, t-test and active range of motion. Results showed that mean vertical jump scores were significantly lower than pretest scores and average power was significantly lower than pretest scores.[11]

Kinzey et al. examined the effect of cryotherapy on the vertical jump, specifically the vertical jump impulse, peak vertical ground reaction force and average vertical ground reaction. Results showed that vertical impulse and peak vertical ground-reaction force had decreased and the average vertical ground-reaction force was not changed.[12]

Jameson et al. performed a study to examine the effects of cryotherapy and vertical ground reaction force. Results showed that there were no significant differences between pretest and posttest results within each group.[13] Hart et al. examined the effects of cryotherapy on the knee and the single leg vertical jump. The authors found no significant changes in ground reaction force, range of motion and muscle activity.[14] Jameson et al. and Hart et al. both found no significant differences between pretest

and posttest results. Both studies would suggest that cryotherapy does not have an effect on functional performance, specifically the vertical jump.[13,14]

Five out of the seven studies found an effect which cryotherapy had on the vertical jump.[8-14] Further research is warranted to determine a more definitive conclusion. This information will allow certified athletic trainers to make a more informed decision in regards to return to play following the application of cryotherapy.

METHODS

The purpose of the study is to determine if cryotherapy had an effect on functional performance over time as measured by the single-leg vertical jump. The following is included in the discussion of the methods: (1) research design, (2) subjects, (3) preliminary research, (4) instruments, (5) procedures, (6) hypotheses and (7) data analysis

Research Design

The type of experiment was a quasi-experimental, within subjects, repeated measures design. The first independent variable in the experiment was the treatment condition with two levels. The first level of the treatment condition was to apply cryotherapy to the anteriolateral aspect of the ankle. The second level was to not apply cryotherapy to the anteriolateral aspect of the ankle. Subjects were asked to perform under both conditions.

The second independent variable in the experiment examined the effect of the passage of time on performance. Performance was measured at five time periods in this study. The first level of time was the pretest, second was the posttest, third was five minutes after the posttest, fourth was ten minutes after the posttest and fifth was twenty minutes after the posttest. The dependent variable was the maximal peak force (maximal height) generated during a series of five single-leg vertical jumps on the force platform.

Subjects

The subjects that volunteered were 14 healthy, physically active individuals. Haskell et al. recommends performing aerobic activity for either five days per week at moderate intensity for thirty minutes or three days a week at hard intensity for twenty minutes to maintain proper health.[15] Haskell et al. also recommends resistance training two days a week to maintain proper health.[15] For the purpose of this study, physically active individuals are defined as being active three times a week for twenty minutes or more. Being active included cardiovascular exercise and/or strength training three or more times a

week. All individuals participating were screened for previous conditions such as lower extremity injury, head injury/concussion, neurological disorders, cold allergies, Raynaud's, poor circulation, diminished sensations, slow healing wounds, arthritis and any other condition relating to the application of cold. The subjects were a combination of 5 male and 9 females.

The study was approved by the Institutional Review Board (IRB) at California University of Pennsylvania (Appendix C1) prior to the collection of data. All subjects that were involved in the study signed an approved Informed Consent Form prior to the study. All information on the subjects was kept confidential.

Preliminary Research

A pilot study was performed on one subject, whom also performed in the study, for the researcher to become familiar with the use of the force platform and the amount of time needed to perform the treatments and the single-leg vertical jumps. The pilot results showed there was a need for change to the methods. Due to the time allotted the researcher had to limit the study to only two cryotherapy conditions (cryotherapy and no cryotherapy). The

researcher also made the decision to only have five timing conditions (pre-test, posttest, five minute posttest, ten minute posttest and twenty minute posttest) and eliminating thirty minute posttest due to the findings of the preliminary testing.

Instruments

Instruments that were used in the experiment included a demographic form (Appendix C2), AMTI 6-7 force platform (AMTI Force Plate and Amplifier, Advanced Technology, Inc) to measure peak force during the single-leg vertical jump, ice bags, compression wraps to apply the ice and the stationary bicycle.

Demographic Form

The information that was gathered on the demographic sheet included age, year of school, gender, previous lower extremity injury, head injury/concussion, neurological or cardiovascular disorders, contraindications of ice and cryotherapy disorders, that the subject may react negatively towards with the application of cryotherapy. All individuals were screened prior to the study with the researcher present.

Force Platform

The force platform, also known as the force plate, was used to measure peak force (power) of the subject's individual single-leg vertical jump. For this study the AMTI 6-7 (AMTI Force Plate and Amplifier, Advanced Technology, Inc) was utilized. The force platform was connected to a detector-transducer which detects the subject's maximal peak force during a jump. It then converts the force to an electrical signal which is comparative to the individual's maximal peak force. The signal is then interpreted by the AMTI Netforce data software as a maximal force number. The number was then analyzed by the AMTI Bioanalysis software for extraction of the dependent variable, peak force.[16,17]

Peak force is also known as ground reaction force or force impulse. For the purpose of this study the researcher used the term peak force. Peak force is the measure of maximal force production of an individual's contact with the force platform. In simple terms, the individual jumped and the force platform measured the amount of maximal force as the individual lands on the force platform. Basically, peak force measures maximal jump height. The peak force number is the number the

researcher used to determine if there is a significant difference with cryotherapy and timing variables.[16,17]

Cryotherapy Treatment

The cryotherapy treatment included an ice bag placed directly on the skin for twenty minutes. The ice used was cubed ice and the bag and ice weighed approximately two pounds. The ice was placed on the anteriolateral aspect of the ankle. The ice bag was wrapped on the anteriolateral aspect of the ankle with a compression wrap.

Stationary Bicycle

The warm-up consists of five consecutive minutes on the stationary bicycle at a comfortable tempo for the subject. The bike seat was set at an appropriate position for each individual. Appropriate shoe wear and workout entire were suggested to the subjects.

Procedures

The first day the subjects reported to complete the demographic form and signed the IRB approved informed consent form. At this time subjects also had the procedures explained and had an opportunity to perform

practice jumps on the force platform. Each subject was required to come in twice to perform the study, one time under each treatment condition. Once the informed consent form was completed and the procedures had been explained, the subject bicycled for five consecutive minutes for warm-up. The subjects performed five pretest single-leg vertical jumps on the force platform. After the pretest the subjects participated in either the cryotherapy condition or no cryotherapy condition. The subjects with the cryotherapy condition sat with an ice bag over the anteriolateral aspect of the dominant ankle for twenty minutes. The subjects with no cryotherapy condition sat for twenty minutes. Immediately after the twenty minutes, (cryotherapy or no cryotherapy) the subjects performed five posttest single-leg vertical jumps. The subjects again sat and were retested with five single-leg vertical jumps five minutes, ten minutes and twenty minutes after removal of cryotherapy (posttest).

Single-leg Vertical Jump

Each time subjects were to perform the single-leg vertical jumps the following procedures were utilized. One set of single-leg vertical jumps consisted of five individual single-leg vertical jumps. There were five sets

of single-leg vertical jumps. The first set was the pretest, second set was posttest, third set was five minutes after posttest, fourth set was ten minutes after posttest and fifth set was twenty minutes after posttest. Each set consisted of five individual single-leg vertical jumps. The best peak force was chosen from each series of five individual single-leg vertical jumps.

The subject was instructed to start and land on the dominant leg. The contralateral leg was placed at ninety degrees to prevent contact with the force platform. Countermovement of the lower extremity was permitted: dorsiflexion of the ankle, flexion of the knee and hip. Countermovement of the upper extremity was not permitted. Arms were crossed across each subject's chest or hands were placed on the subject's hips to prevent an increase of peak force. The subject was instructed to jump when verbally cued. Between each of the five individual vertical jumps approximately five seconds of rest was given to each participant. The subject was instructed to "stick" the landing or results would not be included in the study. The subject was instructed to sit when not performing.

Hypothesis

The following hypothesis is suggested by the researcher prior to the study.

Hypothesis: There will be a difference in peak force production during a single-leg vertical jump depending on cryotherapy condition and timing of the test.

Data Analysis

All data was analyzed by the SPSS version 17. Data was analyzed to determine if cryotherapy and timing had an effect on the single-leg vertical jump. The research hypothesis was analyzed using 2 × 5 repeated measures factorial analysis of variance (ANOVA). An alpha level of .05 was set a priori to determine statistical significance.

RESULTS

The purpose of the study was to determine if cryotherapy and the passage of time has an effect on functional performance measured by the single-leg vertical jump. The single-leg vertical jump was tested on the force platform to analyze peak force. The following section includes: demographic information, hypothesis testing and additional information.

Demographic Data

Fourteen physically active California University of Pennsylvania students with a mean age of ± 21.8 years participated in the study. Subjects completed a demographic form with information including age, year of school, dominant leg, injury history, head injury/concussion, neurological disorder, cryotherapy use, cold allergies and contraindications. The volunteered subjects included 5 males and 9 females. The subjects included 7 graduate students, 2 senior undergraduate students, 3 junior undergraduate students and 2 sophomore undergraduate students. All but one subject was right leg

dominant. All participants were without neurological disorders, cold allergies, were symptom free from head injury/concussion for more than a year and were symptom free from lower extremity injury for at least four months. The demographic information and the IRB approved consent form was completed before each study was started.

Hypothesis Testing

The following hypothesis was tested in the study. The hypothesis was tested with the significance level set at $\alpha \leq 0.05$. A 2 × 5 repeated measures Factorial Analysis of Variance was used to analyze the hypothesis.

Hypothesis 1: There will be a difference in peak force production during a single-leg vertical jump depending on cryotherapy condition and timing of the test.

Conclusion: Hypothesis 1 was not supported. Mean and standard deviation of peak force production under the various conditions can be found in Table 1. Cryotherapy condition did not affect peak force production during a single-leg vertical jump ($F(1,13) = .039$, $p=.847$). Timing also did not affect peak force production during a single-leg vertical jump ($F(4,52) = .851$, $p=.500$). Finally, there

was no interactive effect between cryotherapy condition and timing ($F(4,52) = .989$, $p=.422$).

Table 1. Peak force scores dependant on cryotherapy condition and time of test

	Cryotherapy		No Cryotherapy	
Time	Mean (N)	SD	Mean (N)	SD
Pre test	3449N	1566.5	3218N	1334.4
Post test	3053N	1555.0	3117N	1487.7
5 min	3223N	1506.4	3429N	1577.5
10 min	3332N	1342.2	3236N	1624.3
20 min	2928N	1559.5	3270N	1481.7

Table 2. ANOVA Results for Main Effects and Interaction between Cryotherapy and Time Conditions

Factor	df	df(error)	F	P
Cryotherapy	1	13	.039	.847
Time	4	52	.851	.5
Cryo. X Time	4	52	.989	.422

Additional Findings

An additional ANOVA was done to examine the interaction between cryotherapy, timing and gender. An additional ANOVA was done to examine the interaction between cryotherapy, timing and dominant leg. No significant differences were present in the findings.

DISCUSSION

The general purpose of this study was to determine if cryotherapy had an effect on the single-leg vertical jump. In addition, the effect of re-warming was also examined. The following section is divided into three subsections: Discussion of Results, Conclusions and Recommendations.

Discussion of Results

The single-leg vertical jump was performed on the AMTI force platform to measure peak force. Fourteen physically active college students volunteered to perform in the study. The study entailed a warm-up on the stationary bicycle for five minutes, followed by performing five single-leg vertical jumps at five different time intervals.

This study demonstrated that cryotherapy does not have an effect on the single-leg vertical jump. The researcher's original hypothesis was that there would be a difference in peak force production during a single-leg vertical jump depending on cryotherapy treatment and time. It was hypothesized that there would be a decrease of force produced immediately following cryotherapy treatment with a

gradual increase over time. The results did not support the hypothesis. The mean test scores for peak force dependant upon cryotherapy condition can be found in Table 1. There was no significant difference between cryotherapy treatment. This shows that the application of cryotherapy over the anteriolateral aspect of the ankle did not cause a decrease or increase in performance for the single-leg vertical jump.

The mean test scores for peak force dependant upon timing of test can be found in Table 1. There was no significant difference between timing condition. This shows that over a period of time there was no increase or decrease in performance with either treatment condition for the single-leg vertical jump, regardless of test time.

The results in this study were different from results in several other studies. A table summarizing the results of previous research can be found in Appendix C5. For example, Richendollar et al. examined the effects of cryotherapy on the vertical jump, forty yard dash and the shuttle run. The authors found that the vertical jump was reduced greater than one centimeter. Richendollar et al. also found that overall results showed that the vertical jump had improved with ice and warm-up group over ice and no warm-up group.[8]

Fischer et al. performed a study to determine the effects of cryotherapy on the single-leg vertical jump, co contraction and shuttle run. The results showed that the single-leg vertical jumps were significantly lower after the ten minute cryotherapy application and immediately posttest.[9]

Cross et al. performed a study to examine cryotherapy and the effect it had on the shuttle run, 6m hop and single-leg vertical jump. Cross et al. found that the cryotherapy group(experimental) had decreased results in the single-leg vertical jump.[10] The resting group (comparison) did not use cryotherapy and the single-leg vertical jump results were unchanged.[10]

Patterson et al. studied the cold whirlpool and the effects on the vertical jump, forty yard dash, t-test and active range of motion. Results for the vertical jump showed that mean jump scores were all significantly lower than pretest scores following cold whirlpool. Average power for the vertical jump was significantly lower than pretest scores and peak power was also significantly lower than pretest scores.[11]

Kinzey et al. studied the effects of cryotherapy on vertical jump impulse, peak vertical ground reaction force and average vertical ground reaction. Kinzey et al. found

that vertical impulse had decreased in sets two and three compared to sets four and five. Peak vertical ground-reaction force was greater in set two then four and five. Average vertical ground-reaction force was not changed.[12]

Overall, results of the studies vary slightly but most results show vertical jump results will decrease with the application of cryotherapy.[8-14]

A few studies did agree with the present findings. Jameson et al. studied the effect of crushed ice on a specific joint and measured the effect it would have on vertical ground reaction force. Results showed no significant differences between pretest and posttest results within each group.[13] Hart et al. performed a study to examine the effects of cryotherapy on the knee and vertical jump measurements. Hart et al. also found results which showed that there were no significant changes in ground reaction force, range of motion and muscle activity.[14]

There could be several reasons for discrepancies in the studies. First, one main difference was the type of cryotherapy chosen to cool a specific area. Cross et al, Patterson et al. and Kinzey et al. used ice immersion as the method of cooling a specific area.[10,11,12] Fisher et al, Richendollar et al, Hart et al. and Jameson et al. used

either cubed or crushed ice bag(s) as the method of cooling a specific area.[8,9,13,14] The second main difference was the area chosen to apply the cryotherapy. Cross et al. and Patterson et al. chose the ice immersion for the lower leg.[10,11] Richendollar et al. and Fischer et al. chose an ice bag placed on the thigh.[8,9] Hart et al. specifically chose an ice bag covering the anterior, lateral and medial aspect of the knee.[14] Jameson et al. chose an ice bag placed on the ankle and/or knee.[13] Kinzey et al. chose ice immersion of the leg.[12] The third main difference was the amount of time the cryotherapy was on a specific joint. Richendollar et al, Cross et al, Patterson et al, Kinzey et al, Jameson et al. and Hart et al. choose to apply the cryotherapy treatment to a specific area for twenty minutes.[8,10-14] Fisher et al. chose to apply the cryotherapy treatment to a specific area for only three and ten minutes.[9] These three differences could be why results slightly differed between the researcher's study and other studies.

Conclusions

The significance of these results would allow professionals that may use cryotherapy on a regular basis

to feel comfortable with that decision without repercussions on performance. The results of this study have shown that there were no negative effects on the single-leg vertical jump with the cryotherapy condition and lapse of time. Results were slightly varied between the cryotherapy application, no cryotherapy and time factor but no significant differences were found.

There have been several different studies on functional performance, specifically the vertical jump. Most studies indicate that cryotherapy can have a negative effect on the vertical jump and other functional performances. Therefore, by this study alone it does not indicate that an athlete should return to play right after the application of ice. It is recommended that further research is needed.

Recommendations

The results of this study demonstrate that cryotherapy did not have a negative effect of the single-leg vertical jump. There still is insufficient evidence to conclusively rule out an effect of cryotherapy on performance. However, most studies would disagree with the findings in this study and have found that cryotherapy does have a negative effect

on functional performance. It is very important that Athletic Trainers take the time to analyze the athlete's injury, the use of cryotherapy and when the proper time is to return the athlete to play after the use of this modality. It is recommended that the Athletic Trainer recommend a warm-up or time to pass before the athlete immediately returns to play. Further research in this area is warranted to have a more definitive answer.

REFERENCES

1. Nadler S, Weingand K, Kruse R. The Physiologic Basis and Clinical Applications of Cryotherapy and Thermotherapy for the Pain Practitioner. *Pain Physician.* 2004;7:395-399.

2. Swenson C, Sward L, Karlsson J. Cryotherapy in sports medicine. *Scand J Med Sci Sports.* 1996;6(4):193-200.

3. McMaster WC. A literary review on ice therapy in injuries. *Am J Sports Med.* 1977; 5(3):124-126.

4. Ciolek J. Cryotherapy: Review of physiological effects and clinical application. *Cleveland Clin Q.* 1985;52(2):193-201.

5. Meeusen R, Lievens P. The use of cryotherapy in sports injuries. *Sports Med.* 1986;3(6):398-414.

6. Kowal MA. Review of physiological effects of cryotherapy. *J Orthop Sports Phys Ther.* 1983;5(2):66-73.

7. Knight K. *Cryotherapy in Sport Injury Management.* Illinois. Human Kinetics. 1995.

8. Richendollar M, Darby L, Brown T. Ice bag application, active warm-up, and 3 measures of maximal functional performance. *J Athl Train.* 2006;41(4):364-370.

9. Fischer J, Branch, Van Lunen B, Branch D. J.D Pirone. Functional performance following an ice bag application to the hamstrings. *J Strength Condition Res.* 2009;23(1):44-50.

10. Cross KM, Perrin DH, Wilson RW. Functional performance following an ice immersion to the lower extremity. *J Athl Train.* 1996; 31(2): 113-116.

11. Patterson S, Udermann B, Doberstein S, Reineke D. The effects of cold whirlpool on power, speed, agility and range of motion. *J Sports Sci Med.* 2008;7:387-394.

12. Kinzey SJ, Cordova ML, Gallen KJ, Smith JC, Moore JB. The effects of cryotherapy on ground reaction forces produced during a functional task. *J Sport Rehabil*. 2000;9:3-14.

13. Jameson A, Kinzey S, Hallam JS. Lower Extremity-Joint-Cryotherapy does not affect Vertical Ground Reaction Forces During Landing. *J Sport Rehabil*. 2001;10: 132-142.

14. Hart JM, Ingersoll CD, Leonard JL. Single-leg landing strategy after knee-joint cryotherapy. *J Sport Rehabil*. 2005;14:313-320.

15. Haskell W, Pate R, Powell K, Blair S, Franklin B, Macera C, Heath G, Thompson P, Bauman A. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Ex*. 2007;1423-1434.

16. Cronin J, Hing R, McNair P. Reliability and validity of a linear position transducer for measuring jump performance. J Strength Condition Res. 2004;18(3):590-593.

17. Barlett R. *Introduction to Sports Biomechanics*. Oxfordshire. Spon Press: Taylor & Francis Ltd. 1997.

APPENDICES

APPENDIX A

Review of Literature

REVIEW OF LITERATURE

The ankle is one of the most commonly injured joints.[16-20] The study was performed because cryotherapy is most commonly used for ankle injuries. Specifically, cryotherapy is used most commonly for the lateral aspect of the ankle.[1-7] It is a small, complex joint with many anatomy components, including musculoskeletal, ligaments and neurovascular components.

Anatomy of the Ankle

Musculoskeletal Anatomy

The lateral aspect of the ankle includes the fibula which contains three borders, the interosseous border, anterior and posterior border. The fibula also contains three surfaces, medial surface, lateral surface and posterior surface. The distal end of the fibula forms the lateral malleolus.[7]

The two muscles located in the lateral compartment are the fibularis longus and the fibularis brevis. The fibularis longus originates on the upper aspect of the fibula, head of the fibula and the tibial condyle. It inserts into the lateral aspect and distal end of the

medial cuneiform and the base of the first metatarsal. It is innervated by the superficial fibular nerve. As the function, the fibularis longus performs eversion and plantarflexion of the foot and also helps to support the arches. The fibularis brevis originates on the lower lateral shaft of the fibula. It inserts into the lateral tubercle at the base of the fifth metatarsal. It is innervated by the superficial fibular nerve. As the function, the fibularis brevis performs eversion of the foot.[7]

The lateral ligament is made of three ligaments, the anterior talofibular ligament, the posterior talofibular ligament and the calcaneofibular ligament. The anterior talofibular ligament is from the anterior aspect of the lateral malleolus to the talus. The posterior talofibular ligament is from the lateral malleolus to the posterior aspect of the talus. The calcaneofibular ligament is from the lateral malleolus to the lateral aspect of the calcaneus.[7]

Neurological Anatomy

The main nerve in the lateral compartment of the ankle is the superficial fibular nerve. The sciatic nerve begins in the posterior compartment of the upper thigh and then

becomes the common fibular nerve. The common fibular nerve then divides into two branches. The one branch is the superficial fibular nerve and the second is the deep fibular nerve.[7]

Indications of Cryotherapy

Nadler et al. defined cryotherapy "as the therapeutic application of any substance to the body that removes heat from the body, resulting in decreased tissue temperature."[8] Cryotherapy is one of the most widely used modalities in athletic training and can be used for various reasons.[1-29] Cryotherapy is and can be used in all three phases of the injury process after the trauma has occurred, including the acute phase, repair phase and remodeling phase.[9] The acute phase of inflammation is from the point of injury or trauma to about forty eight hours after the injury.[9] The acute phase is especially vital for the fact that time is of the essence.[8-14] Studies have shown that the quicker the ice has been applied the faster the recovery process tends to be.[10] Hocutt et al. performed a study which involved eighteen patients that had second-degree ankle sprains and nineteen patients with greater than second degree ankle sprains. Each patient was chosen for one of three groups. The first

group was the early cryotherapy group (immediately after injury), the second group was the late cryotherapy group (36 hours after injury), the third group was the early thermotherapy group. Patients in the early cryotherapy group were twice as effective as the late cryotherapy group. Both early and late cryotherapy was more effective than the thermotherapy group.[10]

The repair phase immediately follows the acute phase and can last from 48 hours to approximately six weeks after the initial injury. The repair phase is a crucial step in the recovery process. This is the stage where the athlete gradually starts a rehabilitation program consisting of range of motion (ROM) exercises as well as strengthening the injured area. The combined use of ROM and strengthening exercises with ice is also known as cryokinetics. Cryokinetics allows for an increase in blood flow and allows for remodeling and re-organization of collagen. Last is the remodeling phase which usually starts around three to six weeks and can last up to twelve months depending on the severity of the injury.[9]

The Use of Cryotherapy

The most common and main reasons why healthcare providers take advantage of the use of cryotherapy are to help decrease swelling and pain at the injury site.[8-14] Cryotherapy reduces swelling after an acute injury and can continue to reduce swelling and pain through all three phases when used appropriately.[8-14] By reducing the amount of swelling at the injury site, the process of secondary tissue hypoxia can be reduced and help to reduce rehabilitation time.[12]

Cryotherapy not only aids with swelling and pain but can also help to reduce muscle spasms, cramps and helps to relieve pain when medications are injected to a specific site.[9,10] Cryotherapy also aids in orthopaedic surgery, cryosurgery and the rehabilitation process.[10]

Cryotherapy can be used for both acute and chronic conditions. Acute injuries are classified as fractures, sprains, strains and inflammatory injuries.[9] Chronic injuries that warrant the use of cryotherapy are bursitis, tendonitis, muscle spasms, trigger points and osteomyelitis.[8-10]

Contraindications

Cryotherapy is one of the most widely and commonly accepted modalities because there are very few contraindications. Contraindications include applying cryotherapy before extreme exercise or activities and applying cryotherapy to patients that may suffer from cold allergies, arthritis, anesthetic skin and/or cardiovascular disease.[9-13] It is also debated about the time that ice should be left on an injured area due to damage that may occur. If the application of cryotherapy has been left on the injured site for an extended amount of time the patient may experience frost-bite or nerve palsy.[9] Cryotherapy is a common modality but like any other modality precautions must be taken.[8-14]

Physiological Effects of Cryotherapy

There are four common physiological effects of cryotherapy, the first being the vasoconstriction of the blood vessels to decrease swelling and inflammation, the second is to decrease tissue hypoxia, third is to decrease pain and fourth is to decrease muscle spasm.[12]

The first physiological effect is vasoconstriction which is the ability of the blood vessels to get narrower. Vasoconstriction is the "first response for the superficial blood vessels through an axon reflex arc that is a projection of the peripheral autonomic system controlling sympathetic vasoconstriction" after the trauma has occurred.[12] Vasoconstriction can also work through the reflexes of the spinal cord. After this process the cooled blood then "returns to the general blood and activates the posterior hypothalamus to help increase vasoconstriction."[12] This leads to a decrease in vascular permeability which allows for the cell wall to draw in closer and it allows a decrease in the amount of fluid that goes into the extracellular spaces. It also allows for an increase in blood viscosity and a decrease in blood flow to the specific injured area. This entire process is called the principal mechanism.[12]

The second physiological effect is a decrease in tissue hypoxia. After the initial injury there is a tissue disturbance at the injury site. Tissue hypoxia is the loss of or a decreased amount of oxygen to the tissue site. This leads to a decrease in oxygen supply and metabolic demands at the injury site. If this is not taken care of immediately it can lead to secondary tissue hypoxia.[12]

Knight determined that when ice is immediately applied to an individual with an injury there is less secondary hypoxia and extravascular edema.[12]

The third physiological effect is a decrease in pain. It is difficult to accurately measure pain in an objective manner. As healthcare providers, we can only measure pain subjectively as to what the patient has described to us. There has been no such study proving why there is a decrease in pain when applying cryotherapy. Many hypotheses suggest it may be because of the decrease in nerve conduction velocity. Olson and Stravino found that it is cold that produces a temporary numbness to the area which then decreases nerve conduction.[12] DeJesus et al. found that cold does in fact produce a decrease in nerve conduction but there are specific classes of fibers which are more sensitive than other fibers.[12] Lehmann and DeLateur agreed that there are specific classes of fiber and these specific fibers depend on myelination and diameter to produce a decrease in nerve conduction velocity.[12] Most researchers believe there is a decrease in nerve conduction but further studies need to be done in this area to be completely accurate and understand why there is a decrease in nerve conduction. [12]

The last physiological effect is a decrease in muscle spasm. Researchers are lead to believe that a decrease in muscle spasm is caused by the decrease in responsiveness of muscle spindles. Researchers have also found that each individual responds differently to the response of spasm and cryotherapy. A few studies show that some individuals did not feel relief after the use of cryotherapy. Further research is needed to be done in this area.[12,14]

Temperature

Cryotherapy is a common modality used to rapidly reduce temperature.[15-19] There is still much debate on how temperature affects functional performance. Feretti et al. found that temperature influences both anaerobic and aerobic power. The reduction in temperature may cause a change in rate of adenosine triphosphate (ATP) hydrolysis and/or synthesis. Therefore, it is hypothesized that a decrease in anaerobic power is related to the decrease in temperature as well as a decrease in ATP hydrolysis.[15]

Bender et al. studied the superficial and intramuscular temperature of the triceps surae. The subjects first reported for a baseline temperature (pre treatment) and then proceeded to treatment. The treatment

consisted of the cryotherapy application, which was an ice bag placed on the triceps surae for thirty minutes at rest or an ice bag placed on the triceps surae for thirty minutes while walking on the treadmill. Results found that superficial temperatures decreased over a period of time with the resting group and treadmill walking group. Results also found that intramuscular temperature had decreased over a period of time in the resting group compared with the treadmill walking group.[16]

Johnson et al. studied the intramuscular temperature difference of the gastrocnemius in the cold whirlpool. The treatments consisted of baseline temperature (pre treatment), treatment and recovery (post treatment). The treatment period consisted of submersion of the lower leg into the cold whirlpool for thirty minutes. Results showed a significant decrease with intramuscular temperature in the treatment leg compared to the contralateral leg. After four hours (post treatment) both lower legs had an overall decrease in temperature compared to before the cryotherapy treatment.[17]

Myrer et al. studied the intramuscular temperature on the mid-belly of the gastrocnemius and two different cryotherapy applications. Myrer et al. chose to examine two cryotherapy applications which were the crushed ice bag

and cold whirlpool. The treatment consisted of either crushed ice placed on the left gastrocnemius or the cold whirlpool on the left gastrocnemius. Results showed that there were no significant differences in intramuscular temperature. There was a significant decrease in subcutaneous temperature with the crushed ice group compared to the cold whirlpool group. The crushed ice group also showed significantly more temperature re-warming than the cold whirlpool group.[18]

Palmieri et al. studied the core temperature and surface temperature of the anterior ankle and soleus. The procedures consisted of baseline temperatures, an ice bag placed over the anterior aspect of the ankle and temperature were assessed immediately, ten minutes, twenty minutes of trial and ten and twenty minutes after the ice bag was removed. Results showed that there was no significant change in core temperature with conditions and time. Results also showed that the ankle and soleus muscle surface temperatures were different.[19]

Neurological Effects

Studies have found various neurological effects with the use of cryotherapy. This paragraph will discuss the

various types of nerves and how the nerves react to cryotherapy.

"Sensation can be divided into three categories: superficial, deep and combined."[20] The superficial sensation or superficial sensory nerves react with touch, temperature and pain. Deep sensation or deep sensory nerves react with "muscle, joint position sense, deep muscle pain and vibration sense."[20] There can also be a combination between superficial sensory nerves and deep sensory nerves.[20] Ingersoll et al. performed a study to analyze the effect sensory nerves had on three types of neurological examinations. Twenty one subjects had to submerge the ankle in either hot or cold water for twenty minutes. After the subjects completed the twenty minutes the three examinations were given, topagnosis, two-point discrimination and postural balance. Ingersoll et al. found no significant difference between the three neurological examinations.[20]

Research has also discovered that cold induced sensations are carried by a variety of nerves to the brain. The cold sensation is mediated by very small myelinated A delta fibers but cold induced pain is mediated by small unmyelinated polymodal nocieptors. As temperature decreases, as with the case of cryotherapy, the velocity of

the sensory nerve impulse transmission will decrease with temperature. As temperature decreases conduction will slowly decrease until eventually it is blocked. The conduction will slowly decrease but sensory nerve action potentials will increase in duration. As the action potentials increase this will also increase or extend refractory periods.[10]

Denny-Brown et al. found that sensory nerve conduction is blocked at temperatures below 10° Celsius. Blocking of the sensory nerves is considered to be time dependent. Denny-Brown et al. determined that the longer the duration of cryotherapy at a given temperature the greater the loss of function for sensory nerves.[10] Research has also shown that with the use of cryotherapy applied to cold receptors this can increase activity and transmission to the central nervous system. Applying cryotherapy to the sensory nerve, which is carrying the impulse, decreases the transmission.[10]

Algafly et al. analyzed the effect of the decrease in pain when cryotherapy is applied. There are four main reasons for a decrease in pain with application of cryotherapy: "decrease in nerve conduction velocity, inhibition of nociceptors, decrease in muscle spasms or metabolic enzyme activity levels."[21] Algafly et al. analyzed the effect of cryotherapy applied to the posterior

lateral aspect of the lateral malleolus, including the tibial nerve. Results found that "nerve conduction velocity was decreased by seventeen percent at fifteen degrees Celsius." [21] Nerve conduction velocity decreased "by thirty three percent at ten degrees Celsius."[21]

Measuring the Vertical Jump

The vertical jump is one of the best measurements to measure anaerobic power. The vertical jump is a measure of functional lower extremity strength and is one of the most sport specific measurements.[22] There are two versions of the vertical jump: the one-legged or single-leg vertical jump and the two-legged vertical jump. For the purpose of this study the focus is on the single-leg vertical jump. The single-leg vertical jump mimics the movement which creates similar stresses which are placed upon the body during a sport.[12,9] The single-leg vertical jump is also a measurement for coordination, center of mass and proprioception. The two-legged vertical jump can be defined as the individual's "ability to perform daily functions." [22]

Cryotherapy and the Effects on the Vertical Jump

Analyzing cryotherapy and functional performance is an important aspect in athletic training. It is important to measure a specific aspect of functional performance such as the vertical jump.

Richendollar et al. included twenty four physically active men for the study. The study was a 2 × 2 repeated measures design. Richendollar et al. divided the subjects randomly into four separate groups. The first group was the control group which consisted of no ice and no warm-up. The second group was the experimental group which consisted of no ice and a warm-up. The third group was the experimental group which consisted of ice and no warm-up. The fourth group was the experimental group which consisted of ice and warm-up. Three functional tests were performed which included the single-leg vertical jump, the forty yard dash and the shuttle run. For the purpose of this specific literature review the researcher is looking at the vertical jump results. Richendollar et al. found that the vertical jump decreased greater than one centimeter after the use of cryotherapy. Richendollar et al. also found that overall results showed that the single-leg vertical jump had

improved with ice and warm-up (fourth group) over ice and no warm-up group (third group).[23]

Jameson et al. studied the effect of crushed ice on a specific joint and measured the effect it would have on vertical ground reaction force. The study was a 2 × 4 repeated measures multivariate analysis of variance (MANOVA). The subjects included in the study were ten physically active men. Each subject was divided into four separate groups. The first group was the control group which consisted of no ice. The second group consisted of ice on the ankle. The third group consisted of ice on the knee. The fourth group consisted of ice on the ankle and knee. The second, third and fourth group had crushed ice bags on both lower extremities and on the instructed specific joints for twenty minutes. The subjects were allotted an orientation session which consisted of a trial run through the actual icing and vertical jump. The testing session consisted of a pretest with five jumps each with a minute of rest in-between. The vertical jump was a two-legged jump at ninety percent of the subject's ability. The researcher then instructed the second, third and fourth group to ice the specific joint for twenty minutes. After icing, the subjects concluded with a posttest consisting of five jumps each with a minute of rest in-between. The

testing session was conducted for four consecutive days. Results showed no significant differences between pretest and posttest results within each group.[24]

Kinzey et al. studied the effects of cryotherapy on vertical jump impulse, peak vertical ground reaction force and average vertical ground reaction. The study was a 1 × 5 factorial repeated measures. Kinzey et al. had fifteen physically active subjects perform a total of twenty five one-leg jumps on the subject's preferred leg. The subjects first performed the first set of five one-leg vertical jumps and then received a twenty minute cold whirlpool treatment with the preferred leg. The subjects were instructed to be out of the whirlpool and ready to jump within two minutes. The subjects completed four sets of five one-leg vertical jumps after the whirlpool session. Kinzey et al. found that vertical impulse (VI) had decreased in sets two and three compared to sets four and five. Peak vertical ground-reaction force (PVGRF) was greater in set two then four and five. Average vertical ground-reaction force (AVGRF) was not changed.[22]

Patterson et al. performed a study analyzing the cold whirlpool and the effects it would have on the counter movement vertical jump, 40 yard sprint, t-test and active range of motion. The study was a repeated measures pre-

test-posttest design, including twenty one healthy individuals. The subjects first performed the pre-test and were then instructed to place both lower extremities in the cold whirlpool for twenty minutes. Each posttest was performed at seven, twelve, seventeen, twenty two, twenty seven and thirty minutes after the cryotherapy treatment. Specifically, the results for the vertical jump were measured by mean vertical jump, average power and peak power. Mean vertical jump scores, average jump scores and peak power scores were all significantly lower than pre-test scores.[25]

Hart et al. performed a 1 × 4 repeated measures time series to examine the effects of cryotherapy on the knee and vertical jump measurements. Twenty physically active subjects volunteered to perform the study. The subjects performed five single-leg landings before the use of cryotherapy. The subjects were instructed to place an ice bag on the anterior, lateral and medial aspect of the knee (all but the posterior aspect of the knee) for twenty minutes. After the cryotherapy session the subjects performed five single-leg landings. The subjects then performed five single-leg landings fifteen and thirty minutes after the cryotherapy treatment. Results showed

that there were no significant changes in ground reaction force, range of motion and muscle activity.[26]

Cross et al. performed a pre-test-posttest with an untreated control group to find if cryotherapy had an effect on the shuttle run, 6m hop and single-leg vertical jump. Twenty volunteers were randomly chosen for two groups, the cryotherapy group or the rest group. The subjects were allowed one practice trial. The subjects were instructed to do a pre-test of each functional activity. The cryotherapy group was then instructed to put their lower leg in the cold whirlpool for twenty minutes while the other group rested with no cryotherapy. Subjects performed a posttest after the use or non-use (depending on the group) of cryotherapy. Cross et al. found that the cryotherapy group(experimental) had decreased results in the single-leg vertical jump.[27] The resting group (comparison) did not use cryotherapy and the single-leg vertical jump results were not changed.[27]

Fischer et al. performed a study to determine the effects of cryotherapy on the shuttle run, co contraction time and single-leg vertical jump. Twenty five women and seventeen men volunteered for the study. The study included three separate groups; the no ice bag group, three minute ice bag and the ten minute ice bag. The study first

began with warm-up consisting of a five minute stationary bicycle warm-up and a thirty second hamstring stretch. The subjects were then instructed to perform a pre-test for the shuttle run, co contraction test and the single-leg vertical jump. The subjects were then randomly assigned to a specific cryotherapy group. After the cryotherapy session the subjects performed a posttest and twenty minutes posttest. The results for the single-leg vertical jump were significantly lower after the application of the ten minute ice bag. Overall, results showed to be significant because of the interaction between the ice bag time and trial session.[28]

In summary, cryotherapy seems to have an effect on functional performance in most situations. Cross, Richendollar and Fischer et al. tend to think that the "negative effects of cryotherapy on muscle contractions and a decrease in nerve conduction velocity may explain the immediate decrease in performance." [23,27,28] Further research is needed to determine the exact effects of cryotherapy on the vertical jump.

Summary

In conclusion, it is exceptionally important to understand the anatomy components of the ankle. The ankle is a complex structure and is a structure that is frequently injured. Since the ankle is commonly injured; healthcare professionals most commonly use a form of cryotherapy. When using cryotherapy it is important to take in consideration the physiological effects, indications and contraindications.

Cryotherapy is widely used after functional activity and sometimes used during functional activity. There are numerous studies found on the research of cryotherapy and the effects of functional performance, specifically the vertical jump.[22-28] In conclusion, this study was performed to analyze the effects of cryotherapy on the vertical jump to determine when it is safe to return an athlete to play.[22-28]

APPENDIX B

The Problem

THE PROBLEM

The purpose of the experiment is to examine the effects of cryotherapy and the amount of time to determine if it has an effect on functional performance, the single-leg vertical jump. Most research shows that cryotherapy does have an effect on the vertical jump. The results can better help determine when to return athletes to play after cryotherapy treatment.

Definition of Terms

The following definition of terms will be defined for this study:

1) Cryotherapy- In this study, the use of cubed ice for twenty minutes directly placed on the skin.
2) Single-leg Vertical jump- In this study it is the maximal height at which an individual can jump and land on the dominant leg.
3) Functional performance- In this study it is the performance that is a functional activity, closely related to a sport movement, such as the single-leg vertical jump.
4) Peak force- In this study it is maximal jump height from a single-leg vertical jump.

5) Physically active- In this study the subject performs three days a week of cardiovascular or weight lifting activity.

Basic Assumptions

The following are basic assumptions of this study:

1) The subjects will complete the demographic information sheet to the best of their knowledge and will not forge any given information.
2) The subjects will fully understand the instructions and have performed the task correctly in the amount of time.
3) The subjects will perform to the best of their ability during testing sessions.

Limitations of the Study

The following are possible limitations of the study:

1) The subjects are limited to physically active individuals at California University of PA and therefore it will not be randomized.
2) There may be a practice effect while performing the vertical jump.

Significance of the Study

The significance of this study is to help certified athletic trainers determine when it is best to return an athlete back to play after the treatment of cryotherapy. This is an important aspect to study because many athletic trainers use cryotherapy before, during and/or after athletic participation. Knowing if cryotherapy can decrease performance before an athlete participates in the sport can affect when athletic trainers apply cryotherapy to an athlete. If there is a decrease or harmful effect to applying cryotherapy we know to apply a warm-up or allow time to pass before allowing an athlete to return to play after the use of cryotherapy.

APPENDIX C

Additional Methods

APPENDIX C1

Informed Consent Form

Informed Consent Form

1. Christine Stache, who is a Graduate Athletic Training Student at California University of Pennsylvania, has requested my participation in a research study at California University of Pennsylvania. The title of the research is The Effect of Cryotherapy on the Single Leg Vertical Jump

2. I have been informed that the purpose of this study is to examine if cryotherapy, and warm-up has an effect on functional performance measured by the single-leg vertical jump. I understand that I must be 18 years of age or older to participate. I understand that I have been asked to participate along with the fact that I do not have a previous medical history of cold allergies. arthritis, anesthetic skin, Raynaud's and/or any other cold related illness. I may only participate if I do not have a previous history of neurological or cardiovascular disorders and I must be free from lower leg injury for at least one year. (Sprains, strains, fractures, dislocations, etc.)

3. I have been invited to participate in this research project. My participation is voluntary and I can choose to discontinue my participation at any time without penalty or loss of benefits. My participation will involve…

For the purpose of this study, physically active individuals will be needed and are defined as being active three times a week for thirty minutes or more. Being active included cardiovascular exercise and/or strength training three or more times a week. The participant must meet this requirement to be eligible for the study.

I will be required to fill out a demographic form. The information on the demographic form includes age, gender, lower extremity injury, contraindications of ice, cryotherapy disorders, neurological and cardiovascular disorders. This is to ensure I do have a previous medical history that may predispose me to injury or further risk. Any questions or concerns should be brought to the researcher at this time.

The next step I will take is that the researcher will explain what is included in the experiment and how the experiment will be conducted. The first concept I should

understand is how to perform the single-leg vertical jump. The subjects will have to perform five consecutive single-leg maximal vertical jumps for five, ten, twenty and thirty minute periods. I will be instructed to start and land on my dominant leg. The contralateral leg is placed at ninety degrees to prevent contact with the force platform. Countermovement of the lower extremity was permitted, dorsiflexion of the ankle, flexion of the knee and hip. Countermovement of the upper extremity was not permitted. Arms were crossed across the chest to prevent an increase of peak ground-reaction force. I will be instructed to jump when verbally cued. Between each of the five vertical jumps thirty seconds of rest will be given. I will be instructed to sit in the chair which will be placed next to the force platform when resting.

The second concept I should know and understand is how the force platform works. The force platform, also known as the force plate, was used to measure peak force of each single-leg vertical jump. Peak force is the measure of maximal force production of one's (my) contact with the force platform. In simple terms, I will jump and the force platform will measure the amount of maximal force when I land on the force platform. The detector-transducer will then detect my maximal force and allows the force to turn into an electrical signal which is proportional to my maximal force.

The third concept I should know and understand is the cryotherapy treatment. The cryotherapy treatment will include an ice bag directly on the skin for twenty minutes. The ice used that will be used is cubed ice and the bag and ice will weigh approximately two pounds. The ice will be placed on the anteriolateral aspect of the ankle. The ice bag was wrapped on the anteriolateral aspect of the ankle with an elastic bandage.

The fourth concept I should know and understand is the warm-up procedure. The pre warm-up condition and warm-up (treatment) followed by the cryotherapy treatment consists of five consecutive minutes on the stationary bicycle at eighty five to ninety repetitions per minute (RPM). The bike seat has been set at an appropriate position. Appropriate shoe wear and workout entire are strongly suggested.

Last is the testing schedule. On testing days, I will participate in the initial warm-up followed by five single-

leg pretest vertical jumps. The peak forces of the pretest vertical jumps will be recorded followed by an application of the treatment condition for twenty five minutes. Treatment conditions consisted of twenty minutes of cryotherapy followed by five minutes of rest, twenty minutes of cryotherapy followed by five minutes of warm-up on the stationary bike, or twenty five minutes of rest. I will be asked to perform five single-leg vertical jumps five, ten, twenty and thirty minutes after the five minutes stationary bike warm-up. Peak force results will be recorded for each single-leg vertical jump.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. With participation in a research program such as this there is always the potential for unforeseeable risks as well. The possible risks and/or discomforts include possible ice injury and/or injuries due to falling from loss of balance. To minimize these risks I need to be completely honest when filling out the demographic form. The researcher will also stand by closely to help minimize risks and to answer questions.

5. I understand that, in case of injury, I can expect to receive treatment or care in Hamer Hall's Athletic Training Facility. This treatment will be provided by the researcher, Christine Stache, under the supervision of the CalU athletic training faculty, all of which can administer emergency care. Additional services needed for prolonged care will be referred to the attending staff at the Downey Garofola Health Services located on campus.

6. There are no feasible alternative procedures available for this study.

7. I understand that the possible benefits of my participation in the research is to help Certified Athletic Trainers to understand the effects of returning an athlete to play after the use of cryotherapy.

8. I understand that the results of the research study may be published but my name or identity will not be revealed. Only aggregate data will be reported. In order to maintain confidentially of my records, Christine Stache will maintain all documents in a secure location on campus and password protect all electronic files so that only the student researcher and research advisor can access the data. Each subject will be given a specific subject number

to represent his or her name so as to protect the anonymity of each subject.

9. I have been informed that I will not be compensated for my participation.

10. I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by:

Christine Stache, ATC
STUDENT/PRIMARY RESEARCHER
Sta1344@cup.edu
724-263-3359

Dr. Thomas F. West, PhD, ATC
RESEARCH ADVISOR
West_t@cup.edu
724-938-6033

11. I understand that written responses may be used in quotations for publication but my identity will remain anonymous.

12. I have read the above information and am electing to participate in this study. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

13. This study has been approved by the California University of Pennsylvania Institutional Review Board.

14. The IRB approval dates for this project are from: 02/01/10 to 02/01/11.

Subject's signature:_____
Date:_____

Witness signature:_____
Date:_____

APPENDIX C2

Institutional Review Board –

California University of Pennsylvania

Institutional Review Board
California University of Pennsylvania
Psychology Department LRC, Room 310
250 University Avenue
California, PA 15419
instreviewboard@cup.edu
instreviewboard@calu.edu
Robert Skwarecki, Ph.D., CCC-SLP,Chair

Christine Stache,

Please consider this email as official notification that your proposal titled "The Effect of Cryotherapy on the Single Leg Vertical Jump" (Proposal #09-037) has been approved by the California University of Pennsylvania Institutional Review Board as amended.

The effective date of the approval is 2-26-2010 and the expiration date is 2-26-2011. These dates must appear on the consent form .
Please note that Federal Policy requires that you notify the IRB promptly regarding any of the following:

(1) Any additions or changes in procedures you might wish for your study (additions or changes must be approved by the IRB before they are implemented)
(2) Any events that affect the safety or well-being of subjects
(3) Any modifications of your study or other responses that are necessitated by any events reported in (2).
(4) To continue your research beyond the approval expiration date of 2-26-2011 you must file additional information to be considered for continuing review. Please contact instreviewboard@calu.edu

Please notify the Board when data collection is complete.
Regards,
Robert Skwarecki, Ph.D., CCC-SLP
Chair, Institutional Review Board

Proposal Number
Date Received

California University of Pennsylvania

PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects

(Reference IRB Policies and Procedures for clarification)

Project Title ***The Effect of Cryotherapy on the Single Leg Vertical Jump***

Researcher/Project Director ***Christine Stache***

Phone # ***724-263-3359*** ***E-mail Address*** ***sta1344@calu.edu***

Faculty Sponsor (if required) ***Dr. Thomas West***

Department ***Health Science***

Project Dates ***January 1, 2010*** ***to*** ***December 1, 2010***

Sponsoring Agent (if applicable) _____

Project to be Conducted at *California University of PA*

Project Purpose: ☒ ***Thesis*** ☐ ***Research*** ☐ ***Class Project*** ☐ ***Other***

Keep a copy of this form for your records.

Please attach a typed, detailed summary of your project AND complete items 2 through 6.

1. *Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(ses)or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.*

The purpose of the study is to determine if cryotherapy and warm-up has an effect on functional performance measured by the single-leg vertical jump.

Research Design

The type of experiment is a quasi-experimental, within subjects, repeated measures design. There are two independent variables, treatment condition (ice) and time. The first level of the treatment condition is to apply cryotherapy to the subject's ankle, the second level is to apply cryotherapy to the subject's ankle plus a five minute warm-up on the stationary bike and the third level is not applying cyrotherapy to the ankle and there is no warm-up. The second independent variable in the experiment is time, with six levels. The first level of time is the pretest, second is the posttest, third is five minutes after the posttest, fourth is ten minutes after the posttest, fifth is twenty minutes after the posttest and sixth is thirty minutes after the posttest. The testing is described in more detail below. The dependant variable is the peak force generated during a maximal vertical jump on the force platform.

Subjects

Approximately 20 healthy, physically active individuals will participate. Physically active individuals are defined as being active three times a week. Being active includes cardiovascular exercise and/or strength training three or more times a week. All individuals will be screened for previous conditions such as cold allergies, Raynaud's and any other condition relating to the application of cold. All individuals will be examined for lower leg injuries as well. The subjects will be a mix of male and females.

On each of the testing days, each subject will perform an initial warm-up which will consist of a five minute warm-up on the stationary bike. The warm-up will be followed by the pretest which consists of five single-leg vertical jumps. After the pretest, subjects will (1) have an ice bag applied to the anteriolateral aspect of the ankle for twenty minutes followed by five minutes of rest, (2) have an ice bag applied to the anteriolateral aspect of the ankle for twenty minutes followed by a five minute warm-up on the stationary bike or (3) have no ice or warm-up applied and will remain seated for twenty five minutes. After the treatment groups have been assigned the subjects will immediately perform the five maximal single-leg vertical jumps. The subjects will also perform five maximal single-leg vertical jump five minutes after posttest, ten minutes after posttest, and twenty minutes after posttest and thirty minutes after posttest. The warm-up, treatment condition and the vertical jump will be described in further detail in the procedure section. The order of the three treatments will be assigned to subjects in a counter balanced order. The subjects will be given a two week period to perform in all three treatment groups. All subjects will sign an approved Informed Consent Form prior to the experiment. All information on the subjects will be kept confidential.

Instruments

Instruments that will be used in the experiment are the demographic form, force platform to measure peak force during the single-leg vertical jump, the ice bag and the stationary bike.

The information that will be gathered on the demographic sheet will include age, gender, dominant leg, lower extremity injury, contraindications of ice, cryotherapy disorders, neurological and/or cardiovascular disorders that the subject may react negatively towards with the use of cryotherapy.

The force platform is located in Hamer Hall and it is located in the only classroom in the pool area. The force platform blends with the floor in a safe location. It is not elevated or inclined when the subjects are performing the single-leg vertical jump. All objects will be removed from the surrounding force platform site. The force platform and the floor are not wet, dirty or slippery and have no potential risk for injury. The subject will perform five single-leg vertical jumps and after each jump I will ask if the subject feels fine to continue. There is little to no potential risks for the subjects while using the force platform. The force platform will be used to measure peak force of the subject's individual single-leg vertical jump. Peak force is the measure of maximal force production during a functional activity. Specifically in this study I will measure the initial push-off the subject takes with the single-leg vertical jump. Each subject will be required to perform five maximal single-leg vertical jumps for a total of six jump series. After the subject will perform the five single-leg vertical jumps, the best jump out of the five jumps will be recorded. The subject will be performing five single-leg vertical jumps for the pretest, post test and four additional time periods for a total of six jump series.

The cryotherapy treatment will include an ice bag that will weigh approximately weigh two and a half pounds with cubed ice. The subjects will have the ice bag placed directly on the skin on the anteriolateral aspect of the ankle for twenty minutes. The ice bag will be wrapped on the anteriolateral aspect of the ankle with an elastic bandage.

The stationary bike will be used for a pre-warm-up for all subjects in the experiment. The subjects will also use the stationary bike for a warm-up after the cryotherapy treatment. The warm-up will consists of five minutes on the stationary bike.

Procedures

The first day the subjects will report to complete the demographic form and informed consent form. At this time subjects will have the methods explained and have an opportunity to perform a trial run of the experiment. Days two, three and four consist of the actual experiment. Sessions will be scheduled over a two week period. Again, all subjects will be selected in a random order.

On testing days, all subjects will participate in the initial or pre-warm-up followed by the pretest. The warm-up will be five minutes on the stationary bike. The pre-test will be five maximal single-leg vertical jumps. The subjects are to jump when verbally cued. The subject will be instructed to start and land on the dominant leg. The subjects will have ten seconds in-between each jump. The subject is to hold the landing for five seconds. Subjects will be required to sit when not being tested. The peak force of the pretest vertical jump will then be recorded. Next, the subjects, depending on the subject's random selection, will receive specific treatment condition protocol. Treatment conditions consist of (1) twenty minutes of cryotherapy followed by five minutes of rest or (2) twenty minutes of cryotherapy followed by five minutes of warm-up on the stationary bike, or (3) twenty five minutes of rest. Each subject will have each treatment condition on an assigned day. After the treatment condition, the subjects will then perform five single-leg maximal vertical jumps for the posttest. The posttest will follow the same procedure as the pre-test. The subjects are to jump when verbally cued. The subject will be instructed to start and land on the dominant

leg. The subjects will have ten seconds in-between each jump. The subject is to hold the landing for five seconds. Subjects will be required to sit when not being tested. The peak force of the posttest vertical jump will then be recorded. The subjects will be tested on the five maximal single-leg vertical jump five minutes posttest, ten minutes posttest, twenty minutes posttest and thirty minutes posttest. The five maximal single-leg vertical jump protocols will be exactly the same as the five maximal single-leg vertical jump pre-test protocol. The peak force will be recorded five minutes posttest, ten minutes posttest, twenty minutes posttest and thirty minutes posttest. The best out of the five jumps will be recorded for each jumping session.

The pre warm-up condition and warm-up followed by the cryotherapy treatment will consist of five consecutive minutes on the stationary bicycle. The cryotherapy treatment includes an ice bag applied directly on the skin for twenty minutes, a standard treatment utilized in the practice of athletic training. Cubed ice will be utilized and the bag and ice will weigh approximately two and a half pounds. The ice will be placed on the anteriolateral aspect of the ankle. The ice bag will be wrapped on the anteriolateral aspect of the ankle with an elastic bandage.

The pretest and all posttest vertical jumps consist of five single-leg maximal vertical jumps. The subject will be instructed to start and land on the dominant leg. The contra lateral leg will be placed at ninety degrees to prevent contact with the force platform. Countermovement of the lower extremity will be permitted and countermovement of the upper extremity is not permitted. Arms will be crossed across each subject's chest to prevent an increase of peak ground-reaction force. The subject will be instructed to jump when verbally cued. Between each of the five vertical jumps 10 seconds of rest will be given to each participant. The subject will be instructed to sit in the chair next to the force platform when resting.

Hypothesis

The following hypothesis is suggested by the researcher prior to the study.

There will be a difference in peak force production during a single-leg vertical jump depending on cryotherapy condition and timing of the test.

Data Analysis

All data will analyzed by the SPSS version 17 . Data was analyzed to determine if cryotherapy and warm-up condition had an effect on vertical jump. The research hypothesis was analyzed using 3 x 6 Repeated Measures Factorial Analysis of Variance. An alpha level of .05 was set a priori to determine statistical significance.

2. *Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.*

    a. *How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.*

    Before the study is performed the subjects are required to fill out a demographic form. The demographic form will include health related questions pertaining to the lower leg and cryotherapy. The demographic form will help to determine which

subjects will be able to perform the study with minimal risk. Subjects may also have the potential to injure the lower extremity from the single-leg vertical jump. The risks for the subjects are extremely low and unlikely but possible. If injury were to occur, the subjects will be under the supervision of the researcher and will treat the subjects to the appropriate medical care as needed. The researcher is (myself) is a Certified Athletic Trainer. I am qualified to assist a volunteer when medical help is needed while doing the vertical jump.

The subjects will perform the vertical jumps on a force platform. It is located in Hamer Hall which it is located in the only classroom in the pool area. The force platform blends with the floor in a safe location. It is not elevated or inclined when the subjects are performing the single-leg vertical jump. All objects will be removed from the surrounding force platform site. The force platform and the floor are not wet, dirty or slippery and have no potential risk for injury. The subject will perform five single leg vertical jumps and after each jump I will ask if the subject feels fine to continue. There is little to no potential risks for the subjects while using the force platform. If a possible injury does occur I am a Certified Athletic Trainer and I am certified to assist the subject in his/her medical needs. I am trained and certified in First Aid and Cardiopulmonary Resuscitation (CPR). I also know where the Athletic Training room is and where needed supplies are as well as I also know where the Automated External Deliberators (AED) are located if needed.

b. *How will you insure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.*

The subjects that will volunteer are approximately 20 healthy, physically active individuals. Volunteers will be recruited from the CalU Health Science and Exercise Science and Sport Studies populations. Children, prisoner, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons will not be included in the study. This is also not an in-class assignment and by no means will students feel coerced. Any participant may withdraw from the study at any time without any loss.

c. *How will you obtain informed consent from each participant or the subject's legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.*

The subjects will report to complete the informed consent form and demographic form on the first day. At this time subjects also will have the directions explained and will be allowed to ask questions about their participation. They also will have an opportunity to perform a trial run of the experiment. The subjects will not be allowed to perform in the study unless all required data (informed consent form and demographic form) have been completed. All informed consent forms and demographic forms will be kept strictly confidential and locked in a file cabinet.

d. *Show that the research plan makes provisions to monitor the data collected to insure the safety of all subjects. This includes the privacy of subjects' responses and provisions for maintaining the security and confidentiality of the data.*

All material and data are strictly confident and will be locked in a file cabinet in the Graduate Athletic Training Program Directors office. This will ensure the privacy rights of all subjects included in the trial. Only approved members of the study will be able to access the data.

3. *Check the appropriate box(es) that describe the subjects you plan to use.*

☒ *Adult volunteers*	☐ *Mentally Disabled People*
☒ *CAL University Students*	☐ *Economically Disadvantaged People*
☐ *Other Students*	☐ *Educationally Disadvantaged People*
☐ *Prisoners*	☐ *Fetuses or fetal material*
☐ *Pregnant Women*	☐ *Children Under 18*
☐ *Physically Handicapped People*	☐ *Neonates*

4. *Is remuneration involved in your project?* ☐ *Yes or* ☒ *No. If yes, Explain here.*

5. *Is this project part of a grant?* ☐ *Yes or* ☒ *No If yes, provide the following information:*

   Title of the Grant Proposal _____

   Name of the Funding Agency _____

   Dates of the Project Period _____

6. *Does your project involve the debriefing of those who participated?* ☐ *Yes or* ☒ *No*

   If Yes, explain the debriefing process here.

7. *If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix___in the Policies and Procedures Manual.*

California University of Pennsylvania Institutional Review Board
Survey/Interview/Questionnaire Consent Checklist (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview or questionnaire?

☐ **YES**—Complete this form

☒ **NO**—You MUST complete the "Informed Consent Checklist"—skip the remainder of this form

Does your survey/interview/questionnaire cover letter or explanatory statement include:

☐ (1) Statement about the general nature of the survey and how the data will be used?

☐ (2) Statement as to who the primary researcher is, including name, phone, and email address?

☐ (3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

☐ (4) Statement that participation is voluntary?

☐ (5) Statement that participation may be discontinued at any time without penalty and all data discarded?

☐ (6) Statement that the results are confidential?

☐ (7) Statement that results are anonymous?

☐ (8) Statement as to level of risk anticipated or that minimal risk is anticipated? (NOTE: If more than minimal risk is anticipated, a full consent form is required—and the Informed Consent Checklist must be completed)

☐ (9) Statement that returning the survey is an indication of consent to use the data?

☐ (10) Who to contact regarding the project and how to contact this person?

☐ (11) Statement as to where the results will be housed and how maintained? (unless otherwise approved by the IRB, must be a secure location on University premises)

☐ (12) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)?

☐ (13) FOR ELECTRONIC/WEBSITE SURVEYS: Does the text of the cover letter or
explanatory statement appear before any data is requested from the participant?

☐ (14) FOR ELECTONIC/WEBSITE SURVEYS: Can the participant discontinue participation at any point in the process and all data is immediately discarded?

California University of Pennsylvania Institutional Review Board
Informed Consent Checklist (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview, or questionnaire?
☐ **YES**—DO NOT complete this form. You MUST complete the "Survey/Interview/Questionnaire Consent Checklist" instead.
☒ **NO**—Complete the remainder of this form.

1. Introduction (check each)
☒ (1.1) Is there a statement that the study involves research?
☒ (1.2) Is there an explanation of the purpose of the research?

2. Is the participant. (check each)
☒ (2.1) Given an invitation to participate?
☒ (2.2) Told why he/she was selected.
☒ (2.3) Told the expected duration of the participation.
☒ (2.4) Informed that participation is voluntary?
☒ (2.5) Informed that all records are confidential?
☒ (2.6) Told that he/she may withdraw from the research at any time without penalty or loss of benefits?
☒ (2.7) 18 years of age or older? (if not, see Section #9, Special Considerations below)

3. Procedures (check each).
☒ (3.1) Are the procedures identified and explained?
☒ (3.2) Are the procedures that are being investigated clearly identified?
☒ (3.3) Are treatment conditions identified?

4. Risks and discomforts. (check each)
☒ (4.1) Are foreseeable risks or discomforts identified?
☒ (4.2) Is the likelihood of any risks or discomforts identified?
☒ (4.3) Is there a description of the steps that will be taken to minimize any risks or discomforts?
☒ (4.4) Is there an acknowledgement of potentially unforeseeable risks?
☒ (4.5) Is the participant informed about what treatment or follow up courses of action are available should there be some physical, emotional, or psychological harm?
☒ (4.6) Is there a description of the benefits, if any, to the participant or to others that may be reasonably expected from the research and an estimate of the likelihood of these benefits?
☒ (4.7) Is there a disclosure of any appropriate alternative procedures or courses of treatment that might be advantageous to the participant?

5. Records and documentation. (check each)
☒ (5.1) Is there a statement describing how records will be kept confidential?
☒ (5.2) Is there a statement as to where the records will be kept and that this is a secure location?
☒ (5.3) Is there a statement as to who will have access to the records?

6. For research involving more than minimal risk (check each),
☒ (6.1) Is there an explanation and description of any compensation and other medical or counseling treatments that are available if the participants are injured through participation?
☒ (6.2) Is there a statement where further information can be obtained regarding the treatments?
☒ (6.3) Is there information regarding who to contact in the event of research-related injury?

7. Contacts.(check each)

☒ (7.1) Is the participant given a list of contacts for answers to questions about the research and the participant's rights?
☒ (7.2) Is the principal researcher identified with name and phone number and email address?
☒ (7.3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

8. General Considerations (check each)

☒ (8.1) Is there a statement indicating that the participant is making a decision whether or not to participate, and that his/her signature indicates that he/she has decided to participate having read and discussed the information in the informed consent?
☒ (8.2) Are all technical terms fully explained to the participant?
☒ (8.3) Is the informed consent written at a level that the participant can understand?
☒ (8.4) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)

9. Specific Considerations (check as appropriate)

☐ (9.1) If the participant is or may become pregnant is there a statement that the particular treatment or procedure may involve risks, foreseeable or currently unforeseeable, to the participant or to the embryo or fetus?
☐ (9.2) Is there a statement specifying the circumstances in which the participation may be terminated by the investigator without the participant's consent?
☐ (9.3) Are any costs to the participant clearly spelled out?
☐ (9.4) If the participant desires to withdraw from the research, are procedures for orderly termination spelled out?
☐ (9.5) Is there a statement that the Principal Investigator will inform the participant or any significant new findings developed during the research that may affect them and influence their willingness to continue participation?
☐ (9.6) Is the participant is less than 18 years of age? If so, a parent or guardian must sign the consent form and assent must be obtained from the child
  ☐Is the consent form written in such a manner that it is clear that the parent/guardian is giving permission for their child to participate?
  ☐Is a child assent form being used?
  ☐ Does the assent form (if used) clearly indicate that the child can freely refuse to participate or discontinue participation at any time without penalty or coercion?
☐ (9.7) Are all consent and assent forms written at a level that the intended participant can understand? (generally, 8th grade level for adults, age-appropriate for children)

California University of Pennsylvania Institutional Review Board
Review Request Checklist (v021209)

This form MUST accompany all IRB review requests.
Unless otherwise specified, ALL items must be present in your review request.

Have you:

☒ (1.0) FOR ALL STUDIES: Completed ALL items on the Review Request Form? Pay particular attention to:

- ☒ (1.1) Names and email addresses of all investigators
  - ☒ (1.1.1) FOR ALL STUDENTS: use only your CalU email address)
  - ☒ (1.1.2) FOR ALL STUDENTS: Name and email address of your faculty research advisor
- ☒ (1.2) Project dates (must be in the future—no studies will be approved which have already begun or scheduled to begin before final IRB approval—NO EXCEPTIONS)
- ☒ (1.3) Answered completely and in detail, the questions in items 2a through 2d?
  - ☐2a: NOTE: No studies can have zero risk, the lowest risk is "minimal risk". If more than minimal risk is involved you MUST:
    - ☐ i. Delineate all anticipated risks in detail;
    - ☐ ii. Explain in detail how these risks will be minimized;
    - ☐ iii. Detail the procedures for dealing with adverse outcomes due to these risks.
    - ☐ iv. Cite peer reviewed references in support of your explanation.
  - ☒ 2b. Complete all items.
  - ☒ 2c. Describe informed consent procedures in detail.
  - ☒ 2d. NOTE: to maintain security and confidentiality of data, all study records must be housed in a secure (locked) location ON UNIVERSITY PREMISES. The actual location (department, office, etc.) must be specified in your explanation and be listed on any consent forms or cover letters.
- ☒ (1.4) Checked all appropriate boxes in Section 3? If participants under the age of 18 years are to be included (regardless of what the study involves) you MUST:
  - ☐ (1.4.1) Obtain informed consent from the parent or guardian—consent forms must be written so that it is clear that the parent/guardian is giving permission for their child to participate.
  - ☐ (1.4.2) Document how you will obtain assent from the child—This must be done in an age-appropriate manner. Regardless of whether the parent/guardian has given permission, a child is completely free to refuse to participate, so the investigator must document how the child indicated agreement to participate ("assent").

☒ (1.5) Included all grant information in section 5?
☒ (1.6) Included ALL signatures?

☒ (2.0) FOR STUDIES INVOLVING MORE THAN JUST SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:
☒ (2.1) Attached a copy of all consent form(s)?
☐ (2.2) FOR STUDIES INVOLVING INDIVIDUALS LESS THAN 18 YEARS OF AGE: attached a copy of all assent forms (if such a form is used)?
☒ (2.3) Completed and attached a copy of the Consent Form Checklist? (as appropriate—see that checklist for instructions)
☐ (3.0) FOR STUDIES INVOLVING ONLY SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:
☐ (3.1) Attached a copy of the cover letter/information sheet?
☐ (3.2) Completed and attached a copy of the Survey/Interview/Questionnaire Consent Checklist? (see that checklist for instructions)
☐ (3.3) Attached a copy of the actual survey, interview, or questionnaire questions in their final form?

☒ (4.0) FOR ALL STUDENTS: Has your faculty research advisor:
☒ (4.1) Thoroughly reviewed and approved your study?
☒ (4.2) Thoroughly reviewed and approved your IRB paperwork? including:
☒ (4.2.1) Review request form,
☒ (4.2.2) All consent forms, (if used)
☐ (4.2.3) All assent forms (if used)
☐ (4.2.4) All Survey/Interview/Questionnaire cover letters (if used)
☒ (4.2.5) All checklists
☒ (4.3) IMPORTANT NOTE: Your advisor's signature on the review request form indicates that they have thoroughly reviewed your proposal and verified that it meets all IRB and University requirements.
☒ (5.0) Have you retained a copy of all submitted documentation for your records?

Project Director's Certification

Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

Project Director's Signature

Department Chairperson's Signature

Student or Class Research

Student Researcher's Signature

Supervising Faculty Member's

Department Chairperson's Signature

Signature if required

ACTION OF REVIEW BOARD (IRB use only)

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

☐ Approved[_____] ☐ Disapproved

_____

Chairperson, Institutional Review Board Date

Appendix C3

Demographic Information

Demographic Information

Age: _____

Year school: _____

Gender: Male Female

Which is your dominant leg? Right or Left
(Which leg would you use to kick a soccer ball)

Injury History:

Any history of lower extremity injury? (i.e. hip, knee, ankle) Yes or No
If answered yes:
Date of last injury _____
Severity _____

Any history of head injury/concussion? Yes or No
If answered yes:
Date of last injury _____
Severity _____

Any neurological disorder that affect performance? Yes or No
If answered yes:
Please explain _____

Have you used ice before as an injury treatment? Yes or no

Raynauds phenomenon: Yes or no
(Disruption of blood flow in the extremities arteries)

Cold allergy: Yes or No

Poor circulation: Yes or No

Diminished sensation: Yes or No

Long-lasting/slow healing wounds: Yes or No

Arthritis: Yes or No

(Rhematoid, gouty, pseudogout, lupus, infectious, hemorrhagic, osteoarthritis, inflammatory, psoriactic, reactive and anklyosing spondylitis)

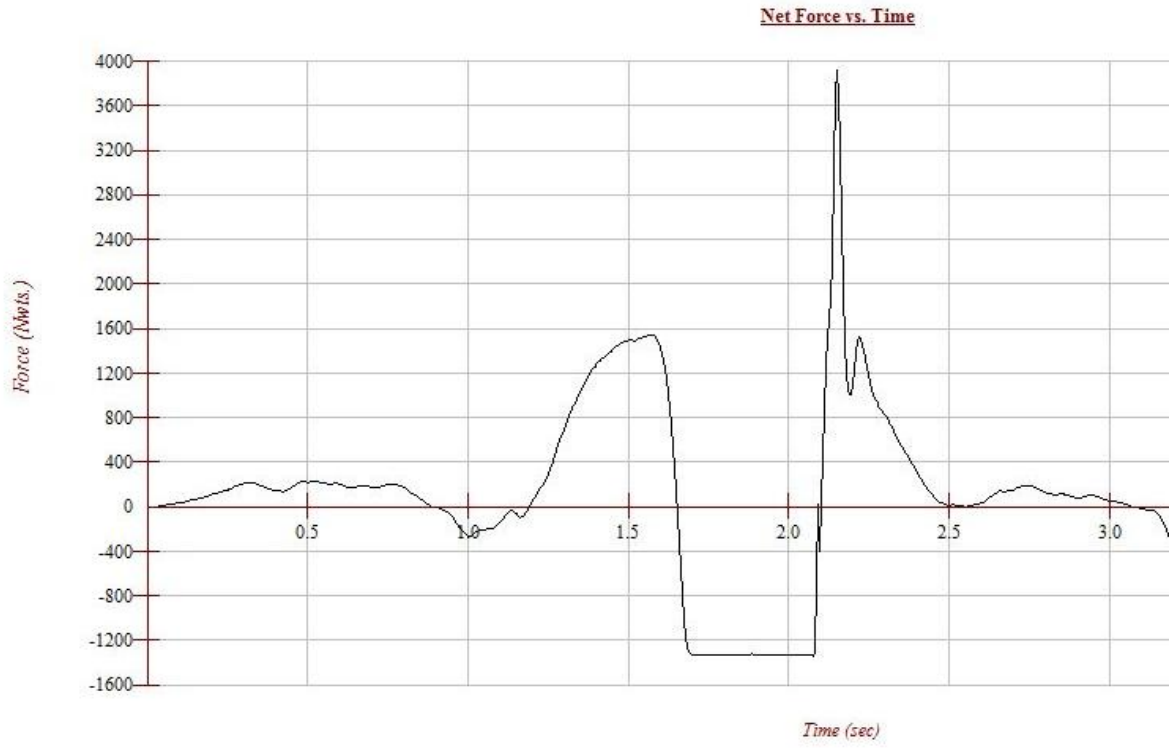
Any other cold allergy or cold condition not previously mentioned:

_____

Appendix C4

Peak Force Trial Example

Name : ,
Date :
Type :



Appendix C5

Summary of Previous Cryotherapy Research

	Results	Results
Study	Negative Effect on Functional Performance	No Effect on Functional Performance
Richendollar et al.	1. Vertical jump decreased more than 1 cm.[23] 2. Overall results improved with ice and warm-up over ice and no warm-up.[23]	
Jameson et al.		No significant differences of pretest and posttest results.[24]
Kinzey et al.	1. Vertical jump impulse decreased in sets 2 & 3 compared with sets 4 & 5.[22] 2. Peak vertical ground-reaction force was greater in set 2 then 4 & 5.[22] 3. Average vertical ground-reaction force was unchanged.[22]	
Patterson et al.	1. Mean vertical jump scores were all	

	significantly lower.[25] 2. Average power was significantly lower. [25] 3. Peak power scores were significantly lower. [25]	
Hart et al.		No significant changes in ground reaction force, range of motion and muscle activity. [26]
Cross et al.	The cryotherapy group had significantly lower results than the resting group for the single-leg vertical jump. [27]	
Fischer et al.	The results of the single-leg vertical jump were significantly lower after 10 minutes of ice bag and immediately posttest. [28]	

REFERENCES

1. Hatzel B, Kaminski T. The effects of ice immersion on concentric and eccentric isokinetic muscle performance. *Isokin Ex Sci*. 2000;(8):103-107.

2. Mohammad A, Hossein K, Hossein F, Soghrat F. Balance problems after unilateral lateral ankle sprains. *J of Rehabil Res and Dev.* 2006;43(7):819-824.

3. Eils E. The role of proprioception in the primary prevention of ankle sprains in athletes. *Int Sports Med J.* 2003;4(5).

4. Hertel J. Functional instability following lateral ankle sprain. *Sports Med*. 2000;29(5):361-371.

5. Hubbard T. Hicks-Little, C. Ankle ligament healing after an acute ankle sprain an evidence-based approach. *J Athl Train.* 2008;43(5):523-529.

6. Tik-Pui Fong D, Hong Y, Chan L, Yung P, Chan K. A Systematic review on ankle injury and ankle sprain in sports. *Sports Med*. 2007;37(1):73-94.

7. Drake R, Vogl W, Mitchell A. *Gray's Anatomy for Students.* Philadelphia. Elsevier. 2005.

8. Nadler S, Weingand K, Kruse R. The physiologic basis and clinical applications of cryotherapy and thermotherapy for the pain practitioner. *Pain Physician.* 2004;7:395-399.

9. Swenson C, Sward L, Karlsson J. Cryotherapy in sports medicine. *Scand J Med Sci Sports*. 1996;6(4:193-200.

10. Knight K. *Cryotherapy in Sport Injury Management.* Illinois. Human Kinetics. 1995.

11. McMaster WC. A literary review on ice therapy in injuries. *Am J Sports Med*. 1977; 5(3):124-126.

12. Ciolek J. Cryotherapy: Review of physiological effects and clinical application. *Cleveland Clin Q.* 1985;52(2):193-201.

13. Meeusen R, Lievens P. The use of cryotherapy in sports injuries. *Sports Med.* 1986;3(6):398-414.

14. Kowal MA. Review of physiological effects of cryotherapy. *J Orthop Sports Phys Ther.* 1983;5(2):66-73.

15. Ferretti G. Cold and muscle performance. *Int J Sports Med.* 1992;13 (S1):185-187.

16. Bender A, Kramer E, Brucker J, Demchak T, Cordova M, Stone M. Local ice-bag application and triceps surae muscle temperature during treadmill walking. *J Athl Train.* 2005;40(4): 271-275.

17. Johnson D, Moore S, Moore J, Oliver R. Effect of cold submersion on intramuscular temperature of the gastrocnemius muscle. *Phys Ther.* 59(10): 1238-1242.

18. Myrer W, Measom G, Fellingham G. Temperature changes in the human leg during and after two methods of cryotherapy. *J Athl Train.* 1998; 33:25-29.

19. Palmieri RM. Peripheral ankle cooling and core body temperature. *J Athl Train.* 2006;41(2):185-188.

20. Ingersoll CD. Sensory perception of the foot and ankle following therapeutic applications of heat and cold. *J Athl Train.* 1992;27(3):231-234.

21. Algafly AA. The effect of cryotherapy on nerve conduction velocity, pain threshold and pain tolerance. *Br J Sports Med.* 2007;41:365-369.

22. Kinzey SJ, Cordova ML, Gallen KJ, Smith JC, Moore JB. The effects of cryotherapy on ground reaction forces produced during a functional task. *J Sport Rehabil.* 2000; 9:3-14.

23. Richendollar M, Darby L, Brown T. Ice bag application, active warm-up, and 3 measures of maximal functional performance. *J Athl Train.* 2006;41(4):364-370.

24. Jameson A, Kinzey S, Hallam JS. Lower Extremity-Joint-Cryotherapy does not affect Vertical Ground

Reaction Forces During Landing. *J Sport Rehabil*. 2001;10:132-142.

25. Patterson S, Udermann B, Doberstein S, Reineke D. The effects of cold whirlpool on power, speed, agility and range of motion. *J Sports Sci Med.* 2008;7: 387-394.

26. Hart JM, Ingersoll CD, Leonard JL. Single-leg landing strategy after knee-joint cryotherapy. *J Sport Rehabil*. 2005;14:313-320.

27. Fischer J, Branch JD, Pirone J, Van Lunen B. Functional performance following an ice bag application to the hamstrings. *J Strength Condition Res.* 2009;23(1):44-50.

28. Cross KM, Perrin DH, Wilson RW. Functional performance following an ice immersion to the lower extremity. *J Athl Train.* 1996; 31(2): 113-116.

29. MacAuley D. Ice therapy: How good is the evidence? *Int J Sports Med*. 2001;22(5): 379-384.

ABSTRACT

Title: The Effects of Cryotherapy and the Single-Leg Vertical Jump

Researcher: Christine M. Stache

Advisor: Dr. Thomas F. West

Research Type: Master's Thesis

Context: Many studies suggest that there is a difference in functional performance after the use of cryotherapy. Some studies have conflicting findings suggesting there is not a difference in functional performance after the use of cryotherapy. Many studies analyzing functional performance have chosen to analyze the vertical jump. The vertical jump is a standard measurement of lower extremity functional strength and power.

Objective: The purpose of the study is to examine the effects of cryotherapy on the lower extremity and functional performance as measured by the single-leg vertical jump.

Design: Quasi-experimental, within subjects, repeated measures design.

Setting: Controlled laboratory setting.

Participants: 14 physically active college students who volunteered with no previous injuries or cold contraindications.

Interventions: Subjects were required fill out a demographic and approved informed consent form upon arrival for the first time. Subjects were required to come in twice for testing. Testing first started with a 5 minute warm-up on the bicycle. Immediately following the warm-up the subject was to perform five single-leg vertical jumps (pretest. The subject was then instructed to sit and received treatment (cryotherapy or no cryotherapy).

	Immediately after the treatment the subject performed five single-leg vertical jumps (posttest) and again performed five single-leg vertical jumps five minutes after posttest, ten minutes and twenty minutes after posttest.
Main Outcome Measures:	Peak force (maximal jump height was the measurement used to measure to compare two conditions: treatment (cryotherapy and no cryotherapy) and time.
Results:	The results showed that there was no significant difference with cryotherapy conditions: treatment and time. The results also showed there was no significant difference with the interaction of treatments and time.
Conclusions:	Results of this study would suggest it is safe to return an athlete to play immediately after cryotherapy has been applied. It is still recommended by numerous other studies that warm-up or an elapse of time should be given to the athlete before returning to play.
Word Count:	343