EFFECT OF RE-WARMING ON FUNCTIONAL AGILITY IN COLLEGIATE ATHLETES AFTER CRYOTHERAPY TREATMENT

A THESIS

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INTRODUCTION

The application of ice is one of the most commonly used modalities to treat athletic injuries. The physiological responses to this modality can be beneficial to facilitate rehabilitating injuries by reducing tissue temperature, metabolism, inflammation, pain and muscle spasms.[1-14] When cryotherapy is utilized to take advantage of the physiological responses, further decisions about the type of cold therapy must be decided, such as, ice bag, cold whirlpool, cold immersion, gel pack, or frozen peas.[1-14] Due to the ability to undergo the physical property changes during treatment,[1-4] evidence shows ice bag, cold whirlpool, and ice-water immersion are superior in tissue cooling efficiency over ice massage, gel packs or frozen peas.[1,5,6] In comparing the more effective methods of cryotherapy, ice bags are commonly used for cryotherapy due to its effectiveness, convenience, low cost, and ease of transportation.[7] To increase the effectiveness of an ice bag treatment, factors that also need to be considered include the type of ice, amount of ice, time of application, and compression application.[5-12]

Recent evidence shows that cryotherapy treatment can inhibit an athlete's ability to perform maximally after treatment.[15-19] Cross et al[15] used pre-activity ice immersion on the lower extremity and then tested functional ability to perform a shuttle run, 6-meter hop test and single-leg vertical jump. Main results showed a decreased ability to perform the shuttle run and vertical jump tests.[15] Functional ability was also researched after a cold whirlpool treatment utilizing a counter movement vertical jump, T-test, 40-yard dash and active range of motion.[16] Patterson et al[16] measured performance tests during the recovery period over 32 minutes. The results demonstrated that functional test performance can be reduced after cold whirlpool treatments, but will regain performance levels gradually. Further, after 32 minutes, not all performance measures returned to full ability. The authors suggested that the timing of returning athletes to play should be carefully considered after cold whirlpool treatments.[16] Studies suggest that cryotherapy treatments showing impaired performance could leave athletes at risk for injury.

In order for an athlete to prepare to play in competition, proper warm-up and/or pre-activity exercise is widely accepted. Typically, pre-activity exercise includes

a warm-up and stretching exercises to enhance performance and prevent injuries.[20-39] Performing a warm-up before activity is most beneficial from temperature-related physiological responses, including increasing core temperature, blood flow, and preparing the body for exercise.[20]

The stretching method utilized in the warm-up protocol has also been shown to influence the effectiveness of the warm-up protocol.[20-37] Static and dynamic stretching techniques are widely used for pre-participation warm-ups. Static stretching is when the muscle is stretched to a point of discomfort and then held at that point for an extended period of time.[21,22] Recent research has shown acute, static stretching might decrease performance ability and not reduce risk of injury.[22-27]

Dynamic stretching utilizes full range of motion movements with the body's own weight and force production.[20] Fletcher[23] defines dynamic warm-up as a controlled movement through the active range of motion for each joint.[23] A comparison of four stretch protocols resulted in significant improvement in sprint times when active dynamic stretching was utilized before testing.[23] After concluding that dynamic stretching was better than both static and no stretching in improving agility, Little et al[28] suggested

that static stretching can be used, but in combination with other exercises is most favorable to minimize decreasing effects on power-based performance.[28]

During athletic competitions, individuals who are treated with cryotherapy often want to return to play as soon as possible. With the known detrimental effects from cryotherapy on performance ability,[15-19] it may not be in the best interest of the athletes to return to play without overcoming the physiological responses from the cold treatment. Richendollar et al[17] investigated the effects of re-warming after ice bag application to the anterior thigh on performing functional tasks. Anterior thigh was chosen to examine the effects of cold application to a major muscle group, such as the quadriceps, on functional performance.[17] Treatment with the ice bag significantly decreased performance in all three performance tests, including single leg vertical jump, shuttle run and 40-yard sprint. The 6.5 minute warm-up after ice application significantly increased performance on all three tests. The warm-up consisted of a 3-minute jog, 3-minute stretch, and 10 2-legged vertical jumps. The study suggests, even when a with a warm-up is implemented, the subject may not able to return to maximal performance level.[17] Further research needs to be conducted to determine the warm-up criteria

that will allow performance ability to return to the level of maximal performance level. It would be beneficial to have a protocol for an active warm-up that would counter the negative effects of cryotherapy so athletes could return to play at a maximal functional performance level. Key elements to maximal functional performance may include strength, power, speed, and agility.

Agility is a measurable component of functional performance and is crucial for optimal athletic performance.[21,40-42] During high level competitions, when athletes suffer an injury, they are commonly treated with ice bags on the sidelines. It would be beneficial for clinicians to know the amount of re-warming necessary to return an athlete full agility performance level in order for them to return to the competition. Therefore, the purpose of the study was to investigate warm-up lengths on functional agility, measured using the T-test, after ice bag application to the anterior thigh.

METHODS

The primary purpose of this study was to examine the effect of re-warming on functional agility in collegiate athletes after cryotherapy treatment. The following is included in this section: (1) research design, (2) subjects, (3) preliminary research, (4) instruments, (5) procedures, (6) hypothesis, and (7) data analysis.

Research Design

This study was a quasi-experimental, within-subject repeated measures design. The independent variables were the agility test (pre and post) and the level of re-warming (no warm-up, short warm-up, long warm-up) after cryotherapy treatment. The dependent variable was time on functional agility test (T-test). Measurements were administered on three separate days. An advantage of this design was that each subject acted as their own control in the no warm-up condition.

Subjects

Healthy National Collegiate Athletic Association (NCAA) Division II men's and women's soccer players were presented with the opportunity to participate in this study. Twenty-three athletes (10 male, 13 female) volunteered to participate after being presented with the opportunity by the researcher. The purpose and concept of the study was explained verbally and with written documents before any testing began. Subjects who participated were volunteers without any obligation by coaches or faculty. Volunteers were eliminated from the study if they were currently not participating in practice or competitions due to an injury, and/or any contraindications to cold therapy, such as Raynauds, cold allergy, etc.[2] All subjects read and sign the informed consent form (Appendix C1) prior to any participation in this study. Information was gathered in the demographic review included age and gender, preferred kicking leg, and was completed as a part of the individual data collection sheet (Appendix C2) prior to testing.

Preliminary Research

Preliminary research was conducted to gather information about the testing sessions. Using a longer, 16.5-minute long warm-up protocol was considered, as the 12-minute warm-up protocol was chosen for testing. The warm-up protocols included selected components from previous research to increase validity of this study.[17,28] The T-test that was used to measure agility performance has been closely examined in previous research to determine its reliability and validity in measuring leg power, leg speed and agility.[40] Final testing location was determined to be on air-filtered floors rather than in a gymnasium with hardwood floors due to availability. It was also determined that the intermittent sprint and agility section, which was a part of the long warm-up, would be changing directions in a square formation in order to fit in the available testing location. Further details for time and familiarization about setting up the cryotherapy treatment, conducting the warm-up protocols, and T-test were also examined in the preliminary research.

Instruments

The instruments that were used in this study included the T-test and warm-up protocols.

T-test

Agility was measured using a standard T-test. The T-test has resulted to have high reliability (r=0.94) for testing agility,[40] and therefore only one trial is necessary in each treatment condition. Before testing, subjects were allowed to walk through the T-test course to familiarize themselves with the set up and requirements on each day.

Testing took place indoors at a college multipurpose room on air-filtered floors to eliminate extraneous variables and maintain consistent surface and climate conditions. The T-test uses four cones (1 foot tall each) placed on the court in a T-shape (Appendix C3). An automatic laser timer, Speed Trap II Timer, was used to record time to the 1/1000th sec and eliminate human error.[43]

The method of assessing agility followed the T-test set up as outlined in previous research directly investigating the T-test by Paulo et al.[40] Before each T-test was conducted the subject was reminded to touch the cone when changing directions, not to cross their feet (or

grapevine), and to perform at maximal level. To start, the subject began with both feet behind the starting cone A. Start time was initiated from the subject crossing the laser at the first cone. The subject sprinted forward 9.14m (10 yards) to cone B, lateral shuffled left 4.51m (5 yards) to cone C, lateral shuffled right 9.14m (10 yards) to cone D, lateral shuffled left 4.51m (5 yards) back to cone B, and ran backward 9.14m (10 yards) returning to cone A. Time stopped stop when the athlete crossed the line breaking the laser. Individual times were recorded in a data sheet to later be analyzed. Decreased time represented improved agility performance.

Warm-Up Protocols

The warm-up protocols were adjusted using selected components of previous research.[17,28] The warm-ups were adapted to examine various lengths of each warm-up. In order to use a combination of both static and dynamic stretching in both warm-ups, the active warm-up from Richendollar et al[17] and the warm-up from Little et al[28] were adapted to create a short (6.5 minutes) and long (12 minutes) warm-up.

The short warm-up used selected components from previous research, including a combination of jogging,

static and dynamic stretching (Appendix C4).[17] The components were aimed to simulate a jog and stretch that an athlete might perform quickly before returning to competition for 6.5 minutes. The short warm-up consisted of light jogging (3 minutes), five common static stretches (butterfly, figure-4, spinal twist, foot grab and calf) and one dynamic stretch (10 double-leg jump-tucks).[17] The short warm-up was adjusted from Richendollar et al by having the gastrocnemius static stretched in the push-up position and quadriceps static stretching only in the side-lying position. Each static stretch was held for 15 seconds on each side, except for the quadriceps, which were held for 30 seconds each side.

Again, from selected components of a previous research study, the long warm-up protocol included jogging, static stretching, dynamic stretching, and intermittent sprint and agility (Appendix C5).[28] The long warm-up aimed to simulate a full jog and stretch that an athlete might perform during halftime before returning to competition for 12 minutes. Each stretching method targeted major lower extremity muscles that are used for the agility test. First, jogging section included light jogging, side stepping, back jogging, and light jogging, which totaled two minutes. Static stretching included five common stretches (figure-4,

foot grab, spinal twist, butterfly, and calf) totaling 4.5 minutes. Dynamic stretching included, open and close gates, lateral lunges, forward walking lunges, straight-leg march, and heel-to-toe walking, to total three minutes. Agility and sprint included 10 double-leg jump-tucks and three running exercises. The three running exercises started at three-quarter speed 10m forward + 5m sidestepping, repeated twice. The second running exercise included 10m forward at three-quarter speed + 20m forward at full pace. The final running exercise was 30m forward at full pace. Adjustment were made from Little et al's warm-up protocol and stretching components in order to include both static and dynamic, generally by decreasing the time allotted for each area of jogging, static, dynamic and sprint.

The order of warm-up conditions for each subject was randomly assigned. The no warm-up condition allowed for one minute between cryotherapy treatment and agility performance with no stretching or unnecessary movements. The no warm-up condition aimed to simulate the athlete returning to play in competition after cooling down using an ice bag without any proper re-warming session. After each warm-up session, two minutes was allowed for a recovery period before performing maximal T-test.

Procedures

This study was approved by the California University of Pennsylvania Institutional Review Board (IRB) (Appendix C6). Athletes at California University of Pennsylvania men's and women's soccer teams were targeted to participate in the study through email contact and pre-practice discussion. Each athlete was verbally presented the purpose of the study. Without the presence of coaching staff, an informed consent form (Appendix C1) was reviewed for further explanation of subjects' qualifications, as well as the risks and benefits of involvement in the study.

Each subject reported to the athletic training facility on three separate days with at least 24 hours between performance sessions. On each test day, the subjects were instructed to wear athletic shoes and comfortable conditioning clothes. Each day consisted of a pre-warm up, a daily baseline T-test (pretest), a standard cryotherapy treatment, one of three warm-up conditions (no warm-up, short warm-up, long warm-up), and performance of a maximal T-test (posttest) to assess agility. The orders of the three warm-up conditions were randomly assigned. Between pre-warm up, cryotherapy, warm-up condition and agility testing, the athlete was allowed 2 minutes to

prepare. One re-trial T-test performance was allowed for the baseline T-test and/or maximal T-test if subjects failed to complete the task as described. All data, including the date, age, self-selected leg preference, order of level re-warming condition, T-test times, and observations were recorded on an individual data collection sheet (Appendix C2).

A pre-warm up was allowed to prepare the subjects to perform the baseline T-test. The pre-warm up consisted of an individual warm up for 10-15 minutes, including 3-5 minutes of light jogging, followed by stretching. These pre-warm up guidelines were taken from the study that evaluated the reliability and validity of the T-test.[42] Following the pre-warm up, the subjects performed a baseline T-test and proceeded to the cryotherapy treatment.

Each cryotherapy session was administered at the site of the testing procedures. Cryotherapy procedures included procedures from previous research to increase effectiveness of treatment using an ice bag (Appendix C7). Before testing began the subject was asked to choose the leg that he or she felt most comfortable kicking a soccer ball, the self-selected leg identified which leg would be iced during cryotherapy treatment. Subjects wore shorts and sat for a 30-minute ice bag treatment on the anterior thigh of the

subject's self-selected leg. The ice bag contained wetted ice as defined by Dykstra et al[7] with 2000mL of ice and 300mL of room temperature water. Compression was applied using plastic wrap. To insure consistency, compression pressure was measured at the beginning of the treatment session between 40-45mmHg using a blood pressure cuff, as identified by Janwantanakul.[8] However, controlling for exact amount of compression did not affect tissue temperature outcomes because increasing the amount of compression only increases the rate of cooling compared to no compression applied.[8]

Following the cryotherapy treatment, each subject completed the warm-up condition assigned as explained in the instruments subsection, followed by performing a maximal performance T-test. Results for pretest and posttests (T-test times) were recorded for each condition.

Hypotheses

The following hypotheses were based on previous research and the researcher's review of the literature:

1. Re-warming protocols (short and long warm up) will cause significant improvement in functional agility (T-test) after cryotherapy treatment.

2. The long warm-up protocol will cause significant improvement in functional agility (T-test) when compared to the short warm-up protocol after cryotherapy treatment.

Data Analysis

A within-subjects repeated measures ANOVA was used to determine the differences within subjects on two tests (pre- and post-test) and among three conditions (no re-warming, short warm-up and long warm-up). A Paired-Sample T-test was also performed, as a Post-Test, to determine the differences among the three levels of re-warming (no re-warming, short warm-up and long warm-up). All data was analyzed using SPSS version 18.0 at an alpha level of ≤ 0.05.

RESULTS

The purpose of the study was to investigate the length of re-warming exercise on functional agility after cryotherapy treatment. Agility was measured using the T-test with three separate re-warming conditions (no warm-up, short warm-up, and long warm-up). The following section includes: demographic data, hypothesis testing, and additional findings.

Demographic Data

Twenty-three subjects volunteered to participate in this study. Before testing began, three volunteers were eliminated from the study due to injury and schedule conflicts. Further, after Day 1 of testing was completed, three more individuals dropped out of the study due to injury and schedule conflicts.

A total of 17 subjects (6 male, 11 female), mean age of 19.41 ± 1.064, completed this study. All of the subjects were volunteers and collegiate athletes, participating in NCAA Division II soccer at California University of Pennsylvania. During the time of testing, the subjects who

completed this study did not have any injury that prevented them from participating in practice or competitions due to an injury, and/or did not have any known contraindications to cold therapy, such as, Raynauds, cold allergy, etc.[1] A total of 16 athletes self-selected their right leg for treatment, one athlete selected left leg. Demographic data were collected by the researcher at the beginning of the study (Table 1).

Table 1. Demographic Data

Total (n=17)		**Minimum**	**Maximum**	**Mean**	**SD**
Age	**(yrs)**	18	21	19.41	1.064
Male (n=6)					
Age	**(yrs)**	18	20	19.33	.816
Female (n=11)					
Age	**(yrs)**	18	21	19.45	1.214

Hypothesis Testing

Hypothesis testing was performed using data from 17 subjects who completed three testing sessions each. Descriptive statistics for the three warm-up conditions (no

warm-up, short warm-up, and long warm-up) are shown in Table 2.

Using a within-subjects repeated measures ANOVA, the two hypotheses were tested at an alpha level of ≤ 0.05. For final analysis, the change in agility times was computed between pre- and post-test agility times (posttest – pretest). A positive difference indicates a deficient posttest agility time. A negative difference indicates an improved posttest agility time.

Table 2. Descriptive statistics for warm-up conditions

	Minimum	**Maximum**	**Mean**	**SD**
No Warm-Up	-.16	2.14	.6471	.57116
Short Warm-Up	-.47	.71	.0635	.33582
Long Warm-Up	-1.11	.47	-.2341	.38466

Hypothesis 1: Re-warming protocols (short and long warm up) will cause significant improvement in functional agility (T-test) after cryotherapy treatment.

Hypothesis 2: The long warm-up protocol will cause significant improvement in functional agility (T-test) when compared to the short warm-up protocol after cryotherapy treatment.

Conclusion: A within-subjects repeated measures ANOVA was calculated comparing the three levels of warm-up conditions (no warm-up, short warm-up and long warm-up). A significant effect was found ($F(2,32) = 19.316$, $P < .001$).

Follow-up analysis using Paired-Sample T-tests, used as a Post-Hoc, were significant among all three pairs (Control – Short, Control – Long, and Short – Long). The short warm-up was significantly better than no warm-up. The long warm-up was significantly better than no warm-up and the short warm-up, providing the best change in agility time.

Additional Findings

A warm-up x gender between-subjects ANOVA was calculated to examine the effect of warm-up (no warm-up, short warm-up, and long warm-up) and gender (male and female). There was no significant main effect found ($F(2,30) = 2.494$, $P = .100$). Descriptive statistics between warm-up and gender are shown in Table 3. The change in agility time (posttest – pretest) was not influenced by gender.

Table 3. Descriptive statistics between warm-up and gender.

Gender	Warm-Up	Mean	SD
Male	**No Warm-Up**	.4217	.52943
	Short Warm-Up	.1333	.41515
	Long Warm-Up	-.0567	.34396
Female	**No Warm-Up**	.7700	.57853
	Short Warm-Up	.0255	.29958
	Long Warm-Up	-.2341	.38466

DISCUSSION

Discussion of Results

The effect of functional agility was investigated using different re-warming lengths after ice bag application to the anterior thigh. The main findings were that no warm-up, the short warm-up (6.5 minutes), and the long warm-up (12 minutes) were all significantly different. No warm-up and short warm-up produced slower change in posttest scores on the agility test, indicated by the average difference being positive when compared to the long warm-up. The short warm-up showed a significantly better agility time with an average change of .0635 seconds compared to no warm-up at .6471 seconds. The long warm-up showed the best improvement in agility time, shown with average change of -.2341 seconds being a faster posttest agility time.

These findings are consistent with findings of a previous study by Richendollar et al.[17] Richendollar et al examined effects of re-warming after ice bag application on the anterior thigh. Uninjured male subjects, participating in physical activity, intramural or varsity athletics at

least 3 times a week volunteered for the study. The cryotherapy conditions were no ice/no warm-up, no ice/warm-up, ice/no warm-up, and ice/warm-up. Functional performance tests included an agility shuttle run, single-leg vertical jump and 40-yd sprint. Treatment with ice bag decreased performance in all three performance tests,[17] which is consistent with our study, which also decreased agility performance. Additionally, when implementing the warm-up after icing, performance ability statistically increased ability on all three performance tests. Even though the 6.5-minute warm-up did not return participants to the pre-ice level of performance, it is worth noting the improvement.[17] We used the 6.5 minute warm-up adapted from Richendollar et al for our study as the short warm-up, which also showed a significant improvement in performance after ice bag application, compared to the no warm-up.

Richendollar et al[17] also made conclusions regarding effects from the active warm-up. When the active warm-up was implemented, with no ice, all three performance tests showed improvement.[17] Little et al[28] used another warm-up that included jogging, side stepping, back jogging, dynamic stretching and intermittent sprint and agility runs, which also showed an improvement in agility. No differences were shown in sprint time or vertical jump.[28] When conducting

Little et al's warm-up in our study as the long warm-up, after ice bag application, improvement in agility performance, compared to both no warm-up and the short warm-up, was significant.

Performance ability has also been shown to decrease after cryotherapy in other studies.[15-19] Similar to Richendollar et al,[17] Patterson et al[16] stated after cold whirlpool treatment, functional tests, including vertical jump, T-test and 40-yard dash decreased. Cross et al[15] reported decrease ability to perform the shuttle run and single-leg vertical jump test after ice immersion. However, results also showed no difference when performing the 6-meter hop test. Within the same study, following the same treatment protocols before functional tests shows that maybe the effect of cryotherapy has to do with which skills was being measured.[15]

Contrary to studies producing similar results to our study[15-19], Evans et al[41] showed no statistical difference in any of the three agility tests measured after cold immersion treatment. Interestingly, cold therapy treatments consisted of ice immersion to the level about 8cm above the lateral malleolus, which only submerged the foot and ankle.[41] The contrast in results compared to our study and other studies,[15-19] shows that after differing cryotherapy

treatment locations can have different effects on performance. Cross et al[15] used a cryotherapy treatment submerging a single-leg lower leg to the level of the fibular head in a cold whirlpool. Patterson et al[16] also used a cold whirlpool for cryotherapy treatment, with bilateral lower leg immersion to the level of the fibular heads. Both of these studies supported cryotherapy decreasing performance ability,[15,16] similar to Richendollar et al.[17] These findings suggest cooling on the anterior thigh (quadriceps)[17] or lower leg (gastrocnemius and soleus),[15,16] which are a major muscular areas of the lower extremity, produces greater decreases in performance than cryotherapy applied to a more distal join region, such as the ankle.[41]

Physiological responses of cryotherapy[1-14] and warming up[20-39] have been individually researched as well. Cryotherapy is used commonly as a modality to facilitate rehabilitating injuries by reducing tissue temperature, metabolism, inflammation, pain and muscle spasms.[1-14] These habilitating responses to cryotherapy are an explanation for the decrease in performance immediately post treatment. Warm-ups are widely used to prepare for activity for temperature-related physiological responses, including increasing core temperature and blood flow.[20] Although

tissue temperature was not measured in this study, it is plausible that partaking in a warm-up after cryotherapy treatment is beneficial by allowing the tissue to counter the diminishing temperature-related responses of cold therapy with increasing temperature-related responses from the warm-up.

It is also important to consider the time span between cryotherapy and warm-up condition during the testing sessions. During the control in our study, when no warm-up was conducted after ice bag application, athletes were allowed one minute to prepare for the maximal performance (posttest) T-test. With supporting evidence that after cryotherapy, performance abilities will regain gradually,[16] it is plausible that time allotted to complete the short warm-up (6.5 minutes), or the long warm-up (12 minutes), allowed for additional muscular re-warming.

Conclusions

Re-warming after ice bag application to the anterior thigh will increase agility performance ability in Division II collegiate soccer athletes. Further, after cryotherapy, a 12-minute warm-up will show more improvement in agility performance compared to a 6.5-minute warm-up. Additionally,

gender does not appear to relate to the effectiveness of the warm-up protocol when it is implemented after cryotherapy to prepare for maximal agility performance.

Recommendations

Our findings suggest that there is a difference between no warm-up, a short warm-up (6.5 minutes) and a long warm-up (12 minutes) when it is implemented after cryotherapy to prepare for maximal agility performance. As previous researchers discussed, when performance ability is compromised due to cold therapy, it can increase the risk of injury.[20] Therefore, by implementing a longer warm-up Certified Athletic Trainers can instruct athletes appropriately to counter the detrimental cryotherapy effects before returning to play. As there are limited studies that have investigated re-warming protocols after cryotherapy, further research is needed in this area. There are limited studies that have consistent cryotherapy treatment methods, therefore it would be beneficial to uniform cryotherapy method when assessing functional ability and re-warming lengths. Moreover, when lengths of warm-ups are examined a control condition should be utilized with no ice to determine if the maximal length of

warm-up is enough time to return to full level of performance. The site of cryotherapy treatment should also be investigated, comparing major muscular areas to various joints of the lower extremity. Further, expanding future studies to include a variety of performance measures, such as power, speed, strength and balance, would be beneficial for clinicians to help assess athletes' functional ability when investigating lengths of re-warming after cryotherapy.

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APPENDICES

APPENDIX A

Review of Literature

REVIEW OF LITERATURE

Cryotherapy is commonly accepted as a modality to treat a wide variety of injuries. Cryotherapy can be used to immediately manage injuries by reducing tissue temperatures, metabolism, inflammation, pain and muscle spasms.[1-14] Cryotherapy has been shown to inhibit an athlete's ability to perform directly after treatment.[15-19] During athletic competitions, individuals who are treated with cryotherapy often want to return to play as soon as possible. Although, including a warm-up before returning to play after a cryotherapy treatment has been studied,[15] there has not been research investigating lengths of warm-up criteria in the same situation. Therefore, the purpose of this review of the literature is to discuss cryotherapy, pre-activity warm up, functional assessment, and the effect of cryotherapy on function.

Cryotherapy

Cryotherapy can be defined as "cold therapy"[1,2] and is one of the most commonly used modalities in athletic training.[1,2] Cryotherapy causes a physiological response when it is applied that can be beneficial for

rehabilitation after an injury.[1-14] The ability for cryotherapy to be effective is determined by the physical property changes it undergoes during treatment sessions.[1-4] Other factors such as, method of cold therapy, type of ice, and compression, also influence the effectiveness of the cryotherapy treatment.[1,2,5-14]

Physiological Response

The physiological effects of cryotherapy can be broken down into nine categorizes: decreased temperature, tissue destruction, increased or decreased inflammation, decreased metabolism, decreased or increased pain, decreased muscle spasm, increased tissue stiffness, decreased arthrogenic muscle inhibition, and decreased circulation. All of these responses are discussed in depth by Knight in the textbooks, *Therapeutic Modalities: The Art and Science*[1] and *Cryotherapy in Sport Injury Management.*[2]

Decreased temperature begins immediately by heat moving away from the tissue and into the cold modality. As the temperature changes throughout the tissue, it is not consistent or immediate in all the areas. Tissue cooling is gradual as the heat is withdrawn from each layer of tissue, starting with the surface, then to subcutaneous and then intermediate tissues. Tissue will remain decreased in

temperature after application due to a thermal gradient that is developed in the tissue during application.[1,2] Many factors influence the depth and length decreased tissue temperature will be sustained. Tissue destruction is used to destroy and remove tissue, such as to remove warts, using extreme temperatures (-4°F to 94°F).[1] Tissue temperature also plays a direct role in its metabolism; the greater reduction in temperature, the greater decrease in metabolism.[1]

Cryotherapy has been used to delay or decrease inflammation during the inflammatory phase of acute trauma. More accurately, using cryotherapy to decrease inflammation is more effective in cases of treating post-surgical wounds, arthritis, and subcutaneous medicine injections.[1]

An undisputable use of cryotherapy is for pain management. In order to decrease pain, cold therapy must reach the point of numbness in the injured area. Before becoming numb, pain may be increased for the first few minutes of cold application, but patients will become accustomed to the cold pain. Cryotherapy decreasing pain directly effects how it decreases muscle spasms. Muscle spasm is defined as muscle tightness. One theory of how cold decreases muscle spasm is by breaking the pain—spasm—pain cycle. By decreasing pain, the spasms also deminish.[1]

By decreasing the temperature of tissues, this directly causes tissues to become less elastic and increase stiffness. Some clinicians follow the notion of the possibility of further injury, indicating to not allow exercise after cryotherapy.[1] This is supported by studies showing a decrease in muscular strength and functional ability post-cryotherapy treatments.[16,17] Other studies have shown that implementing cryokinetics as a part of a rehabilitation can be beneficial because cryotherapy does not decrease gross motor movement ability.[1,20]

Recent research also supports cryotherapy decreasing arthrogenic muscle inhibition (AMI). When there is tissue damage in a joint, the reflex of muscles surrounding the joint or area diminish.[1] In a recent study by Hopkins et al[21], the main findings support cryotherapy facilitating the motor neuron pool, stimulating motor neuron recruitment, by decreasing the AMI.[21]

Cryotherapy can have both positive and negative effects based on its many physiological responses. When determining therapeutic goals during rehabilitation, all of the physiological responses need to be factored in when considering how a patient can most benefit from a method of cryotherapy.[1,2]

Thermodynamic Properties of Cryotherapy

The effectiveness of cryotherapy is established by its ability to undergo thermodynamic phase changes during application.[3] During various application techniques of cold modalities, each method undergoes various phase changes, which directly determine cooling efficiency.[3,4] Two recent studies examined cooling efficiency using different cryotherapy methods with various thermodynamic properties.[3,4]

Merrick et al[3] measured surface and intramuscular temperatures from three cold modalities: ice bag, Wet-Ice and Flex-i-Cold. Each subject received all treatments on separate treatment days, in a random order. Results indicated on surface and 1cm subadipose depths, the ice bag and Wet-Ice were colder than the Flex-i-Cold treatment. At the 2cm subadipose depth, all cold treatments were not statistically different from one another. Before making conclusions, Merrick et al discuss the importance of thermodynamic changes during the application of cold modalities in order to cool tissues. The transfer of heat in cold modalities takes place from the warmth in the tissues transferring heat to the modality. Another aspect of heat transfer is the mode of heat transfer, conduction, convection, evaporation or a combination. Merrick et al

continued by concluding that cold modalities with different thermodynamic properties do have an influence on the temperatures from cold modality treatments.[3]

Kennet et al[4] expanded research by examining four common cryotherapeutic agents: crushed ice, gel pack, frozen peas and ice-water immersion. Each participant received all four separate treatments, which involved measuring skin temperatures and thermal imaging. Skin temperature results showed crushed ice reduced skin surface temperatures significantly more than a gel pack and frozen peas. In addition, cooling efficiency was decreased more with the crushed ice and ice-water immersion than a gel pack and frozen peas. Kennet et al wrapped up the study by discussing the clinical relevance of using crushed ice and ice-water immersion is the most effective for cooling efficiently.[4]

Methods and Application Techniques

When cryotherapy is utilized for treatment, further decisions about the type of cold therapy must be decided, such as, ice bag, cold whirlpool, cold immersion, or ice massage. Factors that also need to be considered when using the ice bag method are the type of ice, amount of ice, and time of application.

Methods of cryotherapy application are examined in a study by Zemke et al[7] and Myrer et al.[8] Zemke et al researched two methods, ice bag and ice massage. Two randomly assigned groups of seven subjects received a 15-minute treatment. Ice massage was applied over a 4 x 4 cm area, and the ice bag was laid on the treatment area. Intramuscular temperatures were measured every 30 seconds for the duration of the treatment. Initially, results showed the technique of ice massage decreased tissue temperature significantly more when compared to ice bag treatment. Between 6-7 minutes of treatment, temperature produced from the ice bag treatment decrease below temperatures from the ice massage. It is also important to note, no compression was applied with the ice bag treatment. Another limitation to mention is no post-treatment temperatures were measured.[7]

In the study by Myrer et al, they compared temperatures during and after treatment of either a crushed-ice pack or cold whirlpool immersion. Subjects were randomly selected for either a 20 minute crushed-ice pack or 30-minute cold whirlpool treatment. Both groups had temperatures measure for an additional 30 minutes for 30 minute post-treatment. Between the two groups, there was no significant different in intramuscular temperature during

treatment. However, results also showed, with the ice pack, subcutaneous temperatures are reduced more during treatment, but also re-warmed more quickly post-treatment. In conclusion, Myrer et al state, for rapid tissue temperature reduction, using a crushed-ice pack is better than a cold whirlpool. However, the authors also suggests, in order to keep a significant, prolonged decrease in tissue temperature, such as for cryokinetics, it is more effective to administer a cold whirlpool over an ice pack.[8]

To investigate types of ice, Dykstra et al[9] compared tissue temperatures produced with cubed, crushed and wetted ice. Surface and intramuscular temperature were collected during a 20-minute treatment period and 20-minute recovery period. In the results section, the authors revealed cubed-ice and wetted-ice reduce temperatures more than crushed-ice treatments. Also, wetted-ice treatment is more effective in reducing temperatures overall during treatment and recovery, while crushed-ice shows the least amount of temperature difference. Dykstra et al conclude by advising clinicians to utilize the results from the study when purchasing ice machines and recognizing type of ice treatment with making ice bags.[9]

Amounts of ice and size of surface area covered during an ice bag treatment was examined by Janwantanakul[10] by

measuring surface temperature. He used twenty college-aged, healthy males, who each received four treatment conditions with varying amount of ice in the ice bag, which directly correlated to surface area covered. Despite the surface area covered, results illustrated ice pack with at least 0.6 kg of ice significantly increases cooling magnitude than a 0.3 kg of ice. From this research, it can be concluded when applying an ice bag treatment, it should hold enough ice to maximize the effects of the treatment, which means having at least 0.6 kg of ice in the bag.[10]

Length of application time for a cryotherapy treatment can also influence its effectiveness. Palmer and Knight,[11] when investigating this topic, used three different amounts of time for ice bag application: 20, 30, and 40 minutes. The authors also included a practical simulation of participants exercising and showering to increase skin temperature prior to treatment. Testing protocol referred to these periods as exercise, ice application, activity, first rewarming, ice application and second rewarming. Temperatures were measured during ice application and rewarming phases. Results showed there were greater temperature differences for 30-minute and 40-minute periods of application time than for 20-minute treatments. In conclusion, the study by Palmer and Knight supports the

concept of reapplying ice, for at least 30 minutes, immediately following an injury, as well as, any time following showering, changing clothes, moving around, in order to reduce tissue temperatures.[11]

Compression Application

When using an ice bag to apply a cryotherapy treatment, an important factor includes adding compression. To increase the effectiveness of adding compression, the amount of compression and method of application also need to be considered. In a study exploring intramuscular temperatures at three depths, Merrick et al[12] used four treatment set ups (control, only compression, only ice, and ice plus compression) to examine tissue temperatures. The treatment outcomes showed significantly that only compression produced slightly higher tissue temperatures. Most importantly, ice plus compression reduced tissue temperatures significantly more than ice alone.[12]

Other variables when using ice bags include the amount of compression and methods of application. Janawantanakul[13] researched surface temperatures with different amounts of compression using an elastic bandage. All forty healthy females received five compression conditions at 0, 14, 24, 34, and 44 mmHg. The main results showed significant

decrease in temperature correlating with increasing amounts of compression. The author concludes by stating more compression decreases the amount of time for tissue cooling.[13]

Methods of applying compression were examined in a study by Tomchuk et al[14] with surface and intramuscular temperatures on the posterior lower leg. The procedures included 2 depths (surface and intramuscular, at 2 cm below the surface), 3 compression types (no compression, Flex-i-Wrap, and elastic wrap) and 13 time measurements (0-90 minutes). The results showed that at 10 minutes and on, elastic wrap and Flex-i-Wrap decreased surface temperatures greater than no compression. Elastic wrap also decreased temperatures significantly more than Flex-i-Wrap, at 25 minutes and on. The final differences remained for 50 minutes post-application. In conclusion, clinicians should use elastic wrap for acute injury care with cryotherapy application to more effectively reduce tissue temperatures.[14]

Clinically, adding compression to cryotherapy with an ice bag has been established as an important factor. In conclusion, by decreasing tissue temperature, adding compression to the application of an ice bag is more

effective than only ice to reduce metabolism of an injured area.[12-14]

Pre-Activity Warm-Up

Including a warm-up before activity and athletic competitions is widely accepted as a method to enhance performance capabilities. The types of warm-ups used in competitive sports include passive and active warm-ups or general warm-ups.[22-24] Essential factors when structuring a warm-up can determine the effectiveness of facilitating performance abilities. Variables that can manipulate a warm-up to be effective also include, intensity, duration and allowed recovery periods.[24] Stretching techniques, such as, calisthenics, static, ballistic, potentiation, dynamic and combinations of each that are incorporated within a warm-up protocol could also influence the level of success of the warm-up.[22,25-41] Combinations of these methods incorporated in various warm-up protocols have claimed to increase performance ability, however there have also been claims that other techniques can lead to a short-term decrease in ability to perform.

Types of Warm-Ups

With the basic knowledge of various warm-up techniques, an individual will better understand the purpose and function of including a pre-activity warm-up before competition. A warm-up can be broadly divided into passive, general, or specific techniques.[22] General and specific warm-up techniques are used mainly before sports competitions due to the benefits from the physiological response of the body.[22,23]

Passive warm-up aims to raise muscle temperature or core temperature using an external factor, such as shower, saunas, or heating pads.[23] However, active warm-ups, both general and specific, are widely accepted as pre-activity exercise needed before competition. The purpose of an active warm-up is to increase blood flow to the extremities, increase heart rate and increase body core temperature by jogging, stretching, cycling, functional movements and/or sports-specific drills.[22-25,42]

Active warm-ups are used because of the physiological responses, mainly the increase in muscle temperatures.[22,23] General warm-up will also increase levels of dissociation of oxygen from hemoglobin and myoglobin, lower activation energy rates of metabolic chemical reaction, increase blood flow, reduce muscle viscosity, increase sensitivity of

nerve receptors and increase the speed of nerve impulses.[22,42] With these physiological responses, it is also believed that warm-up will also decrease risk of injury during activity.[22,42]

Factors Included in Warm-Up Protocols

Aspects of warm-up protocols are crucial to producing a successful pre-activity routine to optimize performance ability. Intensity, duration and recovery are three factors that can be manipulated in the structure of a warm-up in various degrees to achieve similar physiological and performance changes.[24]

Bishop[24] reviewed literature to address warm-up protocol elements, starting with intensity. Intensity of a warm-up has been previously researched and its effects on performance. Increasing the workload greater than ~60% VO_{2max} has shown a decrease in high-energy phosphate concentration and therefore has compromised short-term performance ability. A warm-up intensity of ~40-60% VO_{2max} is acceptable to raise muscle temperature, while limiting phosphate depletion. For moderate level athletes, it may be possible to increase intensity of a warm-up to ~70% VO_{2max} for intermediate performance, but only with careful consideration. In conclusion, Bishop states that a 3-5

minute warm up of moderate intensity will have the ability to improve short-term performance.[24]

The factor of duration must be carefully weighed to balance increasing muscle temperature with causing minimal fatigue. Previous research has shown that rising muscle temperatures plateau between 10-20 minutes of exercise. Therefore, Bishop provides the guideline of duration to be the same, 10-20 minutes in combination with the intensity suggestion of ~60% VO_{2max}.[24]

Recovery time throughout phases of the warm-up is necessary to maximal ability to perform. Time to recover is necessary for the energy system to restore phosphocreatine (PCr) to replenish. Without allowing the muscle temperatures to decline significantly, or VO2 to reach baseline measurements again, recovery times should be sufficient in less than five minutes.[24]

Other factors that need to be considered when structuring a warm-up protocol are environmental factors, athletic ability of individuals, performance task required, and length of performance.[24] Warm-ups prior to activity have been considered to prevent the likelihood of musculoskeltal-associated injuries.[22] Warm-up protocols can also utilize various stretching methods and sports-specific exercises to further enhance benefits and performance.

Methods of Stretching

Stretching techniques have evolved over the years. The general purposes of stretching are to improve performance abilities, decrease risk of injury during activity, and improve flexibility.[26] Research has been done to investigate the various methods of stretching, including techniques called static, ballistic, proprioceptive neuromuscular facilitation (PNF), dynamic and potentiation.[22,25-41]

Static stretching is when the muscle is stretched to a point of discomfort and then held at that point for an extended period of time.[25,26] Static stretching can be done individually, or partner assisted. This traditional method is used by all ages to possibly increase flexibility and range of motion, decrease risk of injury and enhance performance abilities.[22] This method of stretching is theorized to increase flexibility by decreasing muscle spindle activity and motor neuron excitability.[25] Recently, research has show that acutely, static stretching might decrease performance ability and not reduce risk of injury.[26-30] Careful consideration should be advised when using only static stretching for pre-activity warm-ups.

Ballistic stretching is one of the oldest stretching methods. Ballistic stretching consists of repeated bouncing movement, near the end of the range of motion, intending to

further increase flexibility by stretching the musculoskeletal tissue.[22,25] Ballistic stretching is not widely used in contemporary warm-up routines because it is thought to cause microdamage to tissue and reduce performance ability.[22] In a recent study however, Unick et al's[26] research showed that static and ballistic stretching might not decrease performance ability in trained women.[26]

Proprioceptive neuromuscular facilitation (PNF) stretching technique involves alternating and combinations of contraction and relaxation of both agonist and antagonist muscles.[22] PNF was originally used by physical therapist to increase flexibility. Techniques used include slow-reversal-hold, contract-relax, and hold-relax. All three methods have been shown to improve flexibility.[12,22]

Dynamic stretching is using full range of motion movements with the body's own weight and force production.[22] Fletcher defines dynamic warm up as a controlled movement through the active range of motion for each joint.[31] Fletcher did a study investigating the different warm-up stretch protocols on 20-meter sprint performance using trained rugby players. With four stretch protocols, including passive static stretch (PCC), active dynamic stretch (ADS), active static stretch (ASST) and static dynamic stretch (SDS), each subject performed a 20-meter

sprint before and after each stretching protocol. Results showed significant decrease on sprint performance after both stretching protocols that included static stretching. With the active dynamic stretching protocols, sprint times significantly improved. In conclusion, Fletcher suggests that using static stretching might decrease short sprint performance ability.[31] In a master's thesis, Scheifelbein conducted a systematic review of dynamic warm-up protocols. Dynamic warm-ups have shown to increase athletic performance and it is necessary try to develop suggestions and guidelines for dynamic warm up protocols.[32]

Potentiation or postactivation potentiation is a newly developing technique aimed to increase flexibility and muscle temperature before activity.[33] The parameters for the protocol are unclear. Recent studies have used half-squats with varying loads, electrical muscles stimulation and plyometrics. Sale[33] defined some of the conditions as evoked twitches, evoked titanic contraction and sustained maximal voluntary contraction. Bazett-Jones et al[34] researched potentiation and stretching, determining fatiguing effects could be a detrimental factor in being able to prepare for activity or competition.[34]

Effect of Stretching on Performance Components

The stretching component of a warm-up is crucial to having an effective warm-up. It is important to know how the stretching components can influence an athlete's ability to perform in competition. Athletes need to be able to perform movements that require muscle activation, flexibility, strength, speed, power, and agility. Research has shown positive, negative and neutral results for these performance variables depending on various warm-up and specific stretching protocols.[26-31,33-39]

Looking at muscle activation, in the rectus femoris muscle, a significant difference after static stretching decreased EMG activity compared to a non-stretching warm up. However, conclusions were drawn that even though EMG activity decreased, it did not reveal a decrease in maximal voluntary contraction in the rectus femoris. Therefore, performance was not compromised when utilizing static stretching in a warm up.[36]

In measuring flexibility, there is mixed evidence comparing static and dynamic stretching. No significant difference was shown with hip and knee flexibility measurements after any of the testing protocols between static and dynamic stretching methods.[29] Specifically when trained women were tested, no flexibility scores showed any

significant difference between static or dynamic stretching.[29] Also, in children, no difference in flexibility was found.[27] However, a study to note is when a 6-week pre-activity routine was implemented, flexibility showed significant improvement in all groups, including ballistic and static stretching groups. Unfortunately, dynamic stretching was not included so there was no data to compare the two common stretching techniques.[30] Improved flexibility is key to increasing performance ability, however, it appears that no significant difference can be made in the short term with a specific stretching method.

Strength can influence a warm up protocol, specifically by the stretching techniques utilized. Strength measures of the vastus lateralis and rectus femoris decreased after both PNF and static stretching.[35] For practical application, implementing PNF or static stretching for strength gain may not be feasible.[35] Papadoupolos[28] also found knee extensor and flexor muscles showed a significant decrease in isokinetic torque performance, measuring strength, after static stretching exercises, compared to dynamic stretching. The study supports using other stretching techniques besides static stretching in order to reach optimal strength production.[29]

Sprinting and general speed is an advantage in athletic competitions. In teenage athletes, after dynamic and combination stretching warm-ups, 10-yard sprint performance significantly improved.[28] Two variables, the 10-meter speed acceleration and 20-meter flying sprint, increased with dynamic compared to no stretching, in a study specifically involving soccer players.[37] Fletcher et al[31] examined a 20-meter sprint performance, with trained rugby players, after four stretch protocols, (1) passive static stretch, (2) active dynamic stretch, (3) active static stretch, and (4) passive dynamic stretch. Both stretching methods that included static stretching, increased sprint time, which is a decrease in performance level. The active dynamic stretch group significantly improved by having lower sprint times. Short sprint performance may be decreased by static stretching being included in a warm up with potential negative effects.[31]

Power is one of the most important components for optimal performance. A high level of power means increased amount of force moved quickly, combining strength and speed.[43] Leg extension power significantly improved after dynamic stretching as opposed to nonstretching or static stretching. Conclusions suggest since static stretching for 30 second periods does not hinder or increase performance,

and dynamic stretching enhances performance, it should be utilized.[38] Indirect power measures are common assessment techniques when comparing static and dynamic stretching, as a part of a warm up routine. When throwing a weighted medicine ball as an indirect power measurement, dynamic stretching in consistently increasing power performance compared to static stretching.[28,39]

Jumping ability, either vertical jump or long jump can be used as a tool for assessing power indirectly. When static stretching techniques are tested, dynamic stretching and combination of static and dynamic methods have increased vertical jump performance, in children and teenager athletes.[27,28] Further, in children, static stretching showed a decrease vertical jump performance.[27] There has also been research showing static and ballistic stretching creates no difference in jumping ability, and might not decrease performance ability.[26] Static stretching does not necessarily decrease performance, including power ability, but dynamic stretching should be used to most effectively prepare individuals for high-speed performance, for sports such as soccer.[37]

In athletics, agility is a combination of speed and power being used to change directions quickly.[25] Children have shown decreased shuttle run speed, as a measure of

agility, after static stretching.[27] In a study specifically involving soccer players, stretching methods were combined with jogging, sidestepping, back jogging and intermittent sprint and agility runs to prepare the athletes for performance tests. In assessing agility using a zig-zag test, dynamic stretching was better than both static and no stretching for decreasing time, and therefore improving agility.[37]

Stretching methods utilized within a warm up can be a determining factor in a successful warm up that facilitates improving performance. In analyzing performance components, Stretching methods used within a warm up protocol have not shown a difference on muscle activation[36] and flexibility,[27,29] unless the warm up was implemented for an extended period of time.[30] Performance components including strength, speed, power, and agility showed improvements with dynamic stretching methods incorporated in warm up protocols compared to static or no stretch methods.[27-29,31,37-39] Static stretching decreased strength ability.[29,31,35] Concluding, dynamic stretching techniques should be incorporated as a component in a warm up protocol before activity in order to obtain optimal performance.

Functional Assessment

Before an athlete is able to properly progress through rehabilitation or return to participation, the clinician should have him or her perform certain tasks to isolate specific areas of weakness.[43] By using specific functional tests, the clinician can objectively measure an athlete's progress, set specific goals, and return to play criteria.[43] In a textbook by National Academy of Sport Medicine (NASM) for Essentials of Sports Performance Training, the editors outline clearly what needs to be covered in a sports performance assessment prior to activity and further building with a training program.[37] Performance areas that need to be objectively assessed include posture, balance and stability, strength, power, speed, agility, quickness and conditioning.[25]

Posture and movement assessment is an important aspect to assess structural alignment and integrity of the human movement system. The NASM categorizes postural assessment into alignment (static posture) and function (transitional or dynamic posture) assessment sections.[25] Prentice defines these groups as static, semidynamic and dynamic balance.[43] The purposes of assessing individuals and working to improve balance and stability are to identify weak or

abnormal areas, isolate the weak areas, develop measurable progress to assist in return to play criteria and goal setting, and train individuals in proper techniques.[43] As defined by NASM, posture evaluation starts with static posture looking at alignments and structural integrity from the front, side and back. The next step is to look at transitional and dynamic posture using basic functions such as squatting, pushing, pulling, jumping and balancing. These assessment exercises include specific positions and movements to evaluate compensations from probable overactive and underactive muscles that can be addressed in a training program.[25]

To objectively assess balance, trained evaluators can use computerized-interface forceplate technology, such as, Chattecx Balance System, NeuroCom EquiTest, Pro Balance Master or Smart Balance Master.[43] Subjective assessments can be beneficial for on-field evaluations and when the computer programs are not available. The Romberg test and The Balance Error Scoring System (BESS) both look at an individual's balance ability subjectively.[43,44] The standard Romberg test is considered positive if the person sways or falls when standing with feet together, hands on iliac crests and eyes closed. The BESS test is completed in three positions (singe-leg, double-leg and tandom) on both firm

and foam surface with eyes closed, 20 seconds each position. Errors are tallied during the six trials, such as hands moving off iliac crest, opening eyes, step, stumble, fall, lifting forefoot or heel, or remaining out of position for more than 5 seconds. A total BESS score is calculated and can be used in combination with a previously measured baseline. Posture and movement assessment include a wide variety of evaluation including, static posture, transitional or dynamic posture, and balance.[43,44]

Strength and power are essential components in any training program and therefore also needs to be assessed regularly. Specific goals and areas being evaluated determine the assessment technique that will be utilized to evaluate strength and power, due to the wide range of techniques available. For upper or lower extremity strength evaluation, objectively an isokinetic dynamometer can be used, such as, a Cybex, Kin-Com, or Biodex.[43] Isokinetic machines can work maximally through a range of motion and can work at various set velocities to simulate functional activity. Variables can be set for speed of testing and joint position of the athlete.[43] Other strength and power measures can be evaluated less objectively with one-max bench press and maximum pull-ups or push-ups.[25]

Power is a crucial element in training. Power consists of a large amount of force generated quickly, and the combination of strength and speed. Without the ability to create powerful movements, it will limit an athlete's ability to perform optimally.[43] Assessment of power is more indirect. Power movements are assessed by measurements with an objective number, such as distance of a throw using a weighted medicine ball and height of a jump are common techniques.[25] Examples of power assessments include rotation medicine ball throw, overhead medicine ball throw, standing soccer throw, double-leg and single-leg vertical jumps, double- and single-leg horizontal jumps.[25] Most movements in sports are explosive, and therefore, training needs to include assessing and improving the ability to perform powerful movements.[43]

Speed, agility and quickness are all generally correlated with athleticism. In competitive sports it is essential to be able to change directions quickly without losing speed.[25] Linear speed can be measured with simple sprint distance.[25] Multidirectional speed, or agility, can be measured objectively by timing drills, such as, the T-test, the box, 5-10-5 test and other agility drills. The T-test has been researched specifically to examine its effectiveness of measuring agility, leg power, and leg

speed in college-aged men and women. A total of 304 subjects performed four sports tests, (a) 40-yd dash (leg speed), (b), counter-movement vertical jump (leg power), (c) hexagon test (agility) and (d) T-test. The reliability across all three variables was a 0.98 for the T-test, indicating that it is a highly reliable test to assess agility, leg power, and leg speed.[45]

All of these measurements of function will help clinicians evaluate areas of weakness to progress through rehabilitation and return to play programs. In order to progress returning an athlete to play or meeting specific goals that have been set, clinicians need to know what factors can influence functional movements in all areas of posture, balance strength, power, speed, agility and quickness.

Effects of Cryotherapy on Function

In order to use cryotherapy, an understanding of how the treatment will affect function and performance must be addressed. Cold treatments can causes changes in sensory perception, joint position sense and proprioception during and after application.[18,46-49] Other components of function that can potentially be compromised after cryotherapy

treatment include, muscular activation, strength, and various performance tests, such as, agility, flexibility, speed and power.[15-17,19,20,50-53]

Sensory Effects

Many times cold and hot treatments are followed by exercise as rehabilitation measures. Sensory perception,[46] joint position sense[18,47-49] and proprioception[47] could be effected due to the temperature changes and therefore potentially effect performance ability. The concern is if performance ability is compromised, then it could also increase risk of injury after cryotherapy treatment.[18,46-49] Previous research has examined the effects of cryotherapy on sensory perception, joint position sense, and proprioception.[18,46-49]

Sensory perception examined in the foot and ankle after heat and cold therapy treatments was investigated by Ingersoll et al.[46] Twenty-one subjects immersed their right foot in water for treatments at temperatures 1°C and 40°C. After each treatment dependent variables were measured for topagnosis (loss of ability to localize the site of tactile sensations)[54], two-point discrimination and postural balance. In evaluating the data, there was no significant difference between any of the treatments. In conclusion,

Ingersoll stated that hot and cold therapeutic treatments can be combined with therapeutic exercises without interfering with sensory perception in the foot. A limitation by only immerging the foot up to the ankle malleolus, leaves room for further research pertaining to sensory perception after heat and cold therapy treatments.[46]

Ankle joint position sense was measured after ice immersion for 0, 5, and 20 minute treatments, by LaRiviere and Osternig.[47] Thirty-one subjects were treated and then tested on an electrogoniometer for joint angle replication. There was no statistical difference between conditions, trials or angles. The authors conclude by stating that it is possible that the joint position receptors are not affected by ice immersion.[47]

Two studies examined proprioception after cryotherapy.[18,48] Theime et al[48] investigated knee proprioception after a 20-minute application of ice over their left leg with two ice packs. Proprioception was measured by blindfolding the subjects and testing three sections of knee ROM: 90° to 60°, 60° to 30° and 30° to full extension. There was no significant difference between ice treatment and control trials on proprioception ability. There was a statistical difference between the times of the ROM sectors. In the discussion, the authors discuss the

possibilities for the time differences because (1) the type of receptors at different points in the ROM, (2), difference in the muscle receptors, and (3), gravity assisting sectors 60° to 30° and 30° to full extension. Similar to research testing with ice treatment on the ankle in regards to joint position sense by LaRiviere et al[47], Theieme et al's follow the same findings related to the knee. In conclusion, this study supports using cooling to facilitate exercise for rehabilitation of injuries.[48]

Proprioception was also researched in the upper extremity by Wassinger et al.[18] The study explored cryotherapy effects on the shoulder proprioception and throwing accuracy. Subjects were physically active college students and were all evaluated for active joint position replication, path of joint motion replication and throwing accuracy. Proprioception measurements and functional measurements were assessed on separate days. Each measurement was assessed three times, 2 trials before and 1 after ice treatment. The two pretests were used for learning controls. Main findings did not show any difference after cryotherapy treatment for active joint position replication. However, there was a decreasing difference in functional throwing performance after cryotherapy application. The authors conclude by stating

this information can be used when assessing an athlete to return to play after treatment. Wassinger et al's study is influential to clinical practice because it shows specific elements of rehabilitation that can be effected by cryotherapy treatment.[23] The findings on functional ability follow prior research findings as well, when it was found that cryotherapy effected functional ability.[15-19]

In a review of literature by Costello and Donnelly[49], the authors examined literature that has produced original research concerning joint position sense (JPS) after cryotherapy treatment. The intention was to be able to give recommendations about returning athletes to play after cryotherapy. The review used 7 articles pertaining to the topic and the outcome measures and numbers, ages, sexes of subjects were extracted. Studies includes were evaluated using the PEDro scale, which averaged a 5.4 out of 10, ranging from 5 to 6. Three joints were used in assessments: 2 ankle, 3 knee and 2 shoulder. The modality used for evaluating JPS was mostly unilateral active joint repositioning. As an active test, active joint repositioning is thought to be more functional that passive testing. Cryotherapy had a negative effect on JPS in 3 of the studies, and 4 of the studies had no effect. All analyzed studies used pre-test and post-test study design

method with a cryotherapy application. Of the studies that reported no change, they all used superficial cubes ice bags and two were done on the shoulder. In conclusion, the authors reported there is limited evidence that address the effect of cryotherapy on joint position sense. Costello et al advise clinicians to use caution with returning patients to activity immediately after cryotherapy until further research is done.[49]

There has been research aimed to evaluate the effect of cryotherapy on sensory perception, joint position sense and proprioception. Measurements of sensory perception has not shown a decrease after hot or cold therapeutic treatments.[46] Further, joint position sense has also not shown to decrease in the ankle, knee, or shoulder after cryotherapy treatment, supporting using cooling to facilitate exercise for rehabilitation of injuries.[23,47,48] Shoulder proprioception showed decrease in throwing accuracy after cryotherapy treatment.[23] In reviewing the literature, authors suggest joint position sense after cryotherapy has showed limited amount of evidence supporting effects on sensory effects. Although various rehabilitation components have decreased function after cooling[23], clinicians can use caution when returning

patients to activity immediately after cryotherapy treatment.[49]

Effects on Strength and Muscular Ability

Understanding an effect on muscular strength and ability after a cryotherapy treatment is necessary before implementing treatment with patients. Several studies examined the muscular effects with cryotherapy treatment on muscular activity[50], concentric and eccentric strength[16], motor recruitment[51] and after simulated injuries.[52]

To investigate muscle activity, Berg et al[50] researched reactions of the ankle to sudden inversion after a cryotherapy treatment. Participants' peroneal muscles were measured for the amplitude of EMG activity over time with sudden inversion on the platform. Main findings supported conclusions that cryotherapy does not affect peroneal muscle reaction after sudden inversion.[50]

Further examination by Ruiz et al[16] researched the effect from cryotherapy on concentric and eccentric strength of the quadriceps. Strength measurements were taken using a kinetic communicator (Kin-Com) after four different 2-set cryotherapy treatments, including, ice and exercise, ice and rest, no ice and exercise and no ice and rest. The main findings showed a significant decrease in

strength immediately post-treatment. In conclusion, Ruiz et al make a point to mention the risk cryotherapy may cause an athlete to return to play immediately after a cryotherapy treatment. The authors also noted the strength reduction may only be short-term. In addition, exercise post-treatment may also help with recovery of concentric strength.[16]

Hopkins[51] analyzed changes in motor recruitment during functional lower chain kinetic movement after joint effusion and cryotherapy treatment. Participants were divided into three treatment groups, including, normative, effusion/control and effusion/cryotherapy. Each subject was evaluated using an Omnikinetic device to measure kinetic data during a semirecumbent stepping motion against a set resistance. After data was analyzed, results showed decreases in peak torque and peak power after effusion. With the cryotherapy and normative groups, there was no decrease of peak torque and peak power over time. In conclusion, Hopkins' results support using cryokinetics in a rehabilitation program to restore motor deficiencies.[51]

Another study, Isabel et al[52], looked at perceived pain, ROM, strength, and serum CK levels after cryotherapy and exercise treatment for delayed onset muscle soreness (DOMS) in the upper arm. Methods of treatment included ice

massage alone, ice massage with exercise and exercise alone. Main results showed no significant difference between mode of treatment on any of the dependent variables.[52]

With conflicting results showing significant decrease in strength ability immediately post-cryotherapy treatment[16], but also studies with no changes in muscular activity[50], motor recruitement[51], returning an athlete to competition or progressing rehabilitation exercises need to proceeded with caution.

Effects on Performance Tests

There have been many studies performed addressing how cryotherapy affects various performance tests. Results have shown significant decreases[15,17,19] in performance, but also shown no significant differences[17,20,53] after cryotherapy treatments. Components of performance ability that have been investigated include agility, stability, vertical jump, sprint, power, and flexibility.[15,17,19,20,53]

Two studies have shown no significant decrease in function after cold immersion.[20,53] Using three agility tests, no statistical difference was shown in any of the tests post cold immersion treatment. These results could be because the cold therapy treatments consisted of ice

immersion to the level about 8 cm above the lateral malleolus, which only submerged the foot and ankle.[20] Stabilization was also assessed after cold immersion treatment, finding no decrease in muscle activity or time to stabilize.[53] Both groups of authors suggest cryotherapy should continue to used for treating musculoskeletal injuries.[20,53]

Cross et al[17] also used a Pre-activity ice immersion treatment on the lower extremity, but received varying results when performing numerous functional tests. Participants were from Division III soccer and football athletic teams. Main results showed decrease ability to perform the shuttle run and single-leg vertical jump test, but no difference when performing the 6-meter hop test. Within the same study, following the same treatment protocols before functional tests shows that maybe the effect of cryotherapy has to do with which skills was being measured.[17]

There is supporting evidence that when measuring impaired functional performance, due to a cold whirlpool treatment, performance ability will regain baseline levels gradually. Patterson et al[19] utilized examining functional performance before and after cold whirlpool treatment immersing bilateral lower legs to the fibular head. The

functional testing included a counter movement vertical jump, T-test, 40-yard dash and active ROM. Results showed significant decreases immediately following treatment in all of the functional tests, including, the vertical jump, T-test and 40-yard dash. All of the decreased performances were below normal for significant amount of time. Authors suggest since the functional performance increased over time, the timing of returning athletes to play should be carefully considered after cold whirlpool treatments.[19]

Increasing performance ability after cryotherapy conditions can be accelerated by adding a warm-up. Richendollar et al[15] investigated four ice treatment conditions on the ability to perform functional fitness tests: single leg vertical jump, shuttle run and 40-yard sprint. The cryotherapy conditions were no ice/no warm-up, ice/no warm-up, no ice/warm-up and ice/warm-up. A warm-up consisted of a 3-minute jog, 3-minute stretch, and 10 2-legged vertical jumps. Treatment with ice bag, on the anterior thigh, decreased performance in all three performance tests. Also, adding the warm-up statistically increased performance on three tests. However, the warm-up used did not return participants to the pre-ice level of performance. Richendollar et al expressed that a warm-up after ice bag application was detrimental on the effects of

icing on functional performance.[15] Richendollar et al's study shows, with the warm-up lasting 6.5 minutes, even though the subject is not able to return to maximal performance level, there is a decrease of injury risk because an athlete is better able to perform than without a warm-up.[15]

These studies have all evaluated performance ability on the lower extremity after cryotherapy treatment, but have shown different results.[15,17,19,20,53] Cryotherapy has shown a decreased function with a variety of the size of the treatment area covered, the mode of application and the task required to perform post-treatment.[15,17,19] Without specific guidelines to the effects of cryotherapy before performance assessments, decreased function is still a unfavorable possibility. Even with supporting evidence that adding a warm-up can counter the detrimental cryotherapy effects,[15] research has not been conducted to determine post-cryotherapy warm-up guidelines to return to full performance ability.

Summary

Cryotherapy is a commonly used modality by athletic trainers during competitions. Many studies have shown the

physiological responses that are beneficial for rehabilitation after an injury.[1-14] By undergoing certain physical property changes, treatment sessions can be more effectively used.[1-4] Cryotherapy effectiveness can be increased by utilizing certain methods of cold therapy, the type of ice, and the amount of ice and compression.[1,2,5-14]

Utilizing a pre-activity warm up is also a common practice for before athletic competitions and practices. A warm up that will successfully enhance performance and decrease risk of injuries can have many influencing variables. The type of warm-up, intensity, duration, recovery periods, and stretching techniques can all factor into formulating a proper pre-activity warm up. Looking at the effect of stretching techniques on performance, generally, research has supporting using a dynamic stretching component incorporated in a warm up protocol.[27-29,31,37-39]

Functional ability is a major area for assessing athletes' ability to participate in activity or competition when rehabilitating an injury.[43] By being able to objectively assess posture, balance, stability, strength, power, speed, agility and quickness, a clinician can set specific goals and return to play criteria.[25,43] The difficulty arises when an athlete wants to immediately

return to play after a cryotherapy. Clinicians cannot ignore the effects of cryotherapy that have shown to decreased ability to perform optimally and therefore leaves risk of injury possible for athletes.[15,17,19] One study showed a short warm-up (6.5 minutes) after cryotherapy treatment significantly improved performance ability. However, the participants did not return to pre-ice performance with only 6.5 minutes of warming up.[15] Therefore, more research is needed to gain conclusive data on what is necessary in a warm-up to be able to return an athlete to play after a cryotherapy treatment.

APPENDIX B

The Problem

THE PROBLEM

Statement of the Problem

Cryotherapy is one of the most commonly used modalities in sports medicine even though it has the potential to negatively impact performance. There has been conflicting evidence on the effect cryotherapy has on effecting performance.[15-20,50-53] Specifically, when testing agility, two other studies have shown cryotherapy to decrease agility performance using a large lower extremity treatment area for cold whirlpool[17,19] and an ice bag on the anterior thigh.[15] There has also been varying research to support the most effective warm-up protocols before high performance activities.[22,25-41] It is known that dynamic warm-ups are successful at increasing performance in areas of strength, speed, power and agility compared to warm up incorporating only static stretching or no stretching warm ups.[27-29,31,37-39]

The purpose of the present study was to investigate the effect of re-warming on functional agility performance after cryotherapy treatment. It is important to examine the relationship between varying warm-up protocols on agility performance after cryotherapy treatment to help guide clinical practice. Additionally it will be beneficial for

clinicians to know what type of warm-up protocol will help return athletes to be able to maximally perform after cryotherapy.

Definition of Terms

The following definitions of terms were defined for this study:

1. Cryotherapy- the application of cold therapy.[1,2]
2. Wetted Ice- ice and water added together in an ice bag and used with a dry interface.[9]
3. Functional Agility- the ability to change direction or orientation of the body based on internal or external information quickly and accurately without significant loss of speed.[25] Agility is a measurable component of functional performance and is crucial for optimal performance.[20,25,43,45]
4. T-test- a reliable and valid measure of agility, leg power, and leg speed.[45]
5. Re-warming- a second warm up period prior to returning to competition, after which they have already participated in competition and had a period of cooling, by either inactivity or cryotherapy treatment.

6. Dynamic Stretching- utilizes full range of motion movements with the body's own weight and force production.[22] Fletcher[31] defines dynamic warm-up as a controlled movement through the active range of motion for each joint.[31]
7. Static Stretching- when the muscle is stretched to a point of discomfort and then held at that point for an extended period of time.[22,26]
8. Collegiate Athlete- individuals that are identified by the NCAA as an athlete that have completed at least one full season.

Basic Assumptions

The following are basic assumptions of this study:

1. The subjects will be honest when they complete their demographic sheets.
2. All subjects are volunteers without any obligation by coaches or faculty.
3. The subjects will fully understand the directions and perform to the best of their ability during testing sessions.
4. The subjects will follow the instructions for the process during each portion of the testing sessions.
5. The T-test is reliable and valid to test agility.

6. The equipment will be calibrated and set up identically each testing session and time will be measured accurately.

Limitations of the Study

The following are possible limitations of the study:

1. The subjects were volunteers and limited to the soccer teams from California University of Pennsylvania.
2. Results of this study are limited to non-injured athletes.

Delimitation of the Study

The following statement reflects the delimitations of the study:

1. The study is limited by completing agility assessment on hardwood, gymnasium floors, which potentially, is not familiar for the soccer athletes.
2. The research study is limited to the effects of ice bag treatment placed on the anterior thigh and testing agility performance.

Significance of the Study

The scope of this study is to investigate the length of re-warming exercise on agility performance after cryotherapy treatment. With the effect of cryotherapy, lengths of warm-up to prepare to return to play needs to be determined in order for the athlete to be able to return to play without a decrease in performance and increase risk of injury. When athletes suffer an injury, they are commonly treated with ice bags. Previous research has found that cryotherapy can be detrimental to performance ability.[15-19] When performance ability is compromised due to cold therapy, it can increase risk of injury.[22] Warming up before activity can improve performance ability mostly from temperature-related physiological responses, including increasing core temperature, blood flow, and preparing the body for exercise.[22] Research also demonstrates that warming up can counter the cryotherapy response which inhibits factors of performance ability.[15] Agility is a measurable component of functional performance and is crucial for optimal athletic performance.[20,25,43,45] It is essential for clinicians to know the amount of time re-warming exercise should be conducted to return an athlete to full functional agility performance level in order for them to return to competition.

APPENDIX C

Additional Methods

APPENDIX C1

Informed Consent Form

Informed Consent Form

1. Colleen J Frickie, ATC has requested my participation in a research study at California University of Pennsylvania. The title of the research is "Effect of Re-warming on Functional Agility in Collegiate Athletes After Cryotherapy Treatment".

2. I have been informed that the purpose of the research is to investigate the effect of re-warming on functional agility performance after cryotherapy treatment.

3. My participation will involve a light warm-up, performing the T-test, completing a cryotherapy treatment (ice application) and completing several warm-up protocols before performing a follow up T-test. The pre warm-up is light exercise allowing me to get prepared to perform the baseline T-test. The T-test is used to measure functional agility, in which I will sprint, lateral shuffle and run backward in a T-shape, as directed by the researcher. The cryotherapy treatment will involve an ice bag being wrapped to my anterior thigh for 30 minutes. The warm-up protocols will involve jogging, static stretching, dynamic stretching, and agility exercises. All testing, treatment and warm-ups will take place in the gymnasium of Hamer Hall on three separate days for approximately one hour each day, with at least 48 hours between testing sessions, for all subjects.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. The possible risk of falling during the T-test or during the warm-ups will be minimized by the researcher. The risk is no more than normal physical activity that normal collegiate athletes would experience during practice or competition. I would not be included in the study if I had any known contraindications to cold therapy or cold allergy.

5. Any injuries or prolonged soreness that may occur during testing can be treated at the athletic training room at Hamer Hall provided by the researcher, Colleen J Frickie, ATC, or another Certified Athletic Trainer, either of whom can administer emergency and rehabilitative care.

7. I understand that there are no feasible alternative procedures available for this study.

8. I understand that the possible benefits of my participation in the research are contributions to existing research and may aid in identifying what level of a warm-up protocol will help return athletes to maximal performance ability after ice application.

9. I understand that the results of the research study may be published but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Colleen J Frickie, will maintain all documents in a secure location in which only the researcher and research advisor can access them.

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

11. 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:

Colleen J Frickie, ATC
947 Cross St Apt #1
California, PA 15419
703.795.6416
Fri0405@calu.edu

Rebecca Hess, PhD
B6 Hamer Hall
California University of Pennsylvania
California, PA 15419
724.938.4359
Hess_ra@calu.edu

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

13. I have read the above information. 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.

Subjects signature _____ Date _____
Other signature (if appropriate)_____ Date _____

14. I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

15. I have provided the subject/participant a copy of this signed consent document if requested.

Investigator's signature _____ Date _____

Approved by the California University of Pennsylvania IRB:
Start date: 2/15/11, End date: 2/14/12.

Appendix C2

Individual Data Collection Sheet

Individual Data Collection Sheet

Subject Number: _____

Age : _____ Gender: Female / Male Dominant Leg: R / L

DAY 1	Date: _____
WUP (circle one)	No WUP / SWUP / LWUP
Pre-Warm Up	10-15 min
Baseline T-test	Time: _____
Re-trial 1	Time: _____
Cryotherapy Tx	30min
Re-warming WU	0 min / 6.5 min / 16 min
T-test	Time: _____
Re-trial 1	Time: _____

Observation Notes:

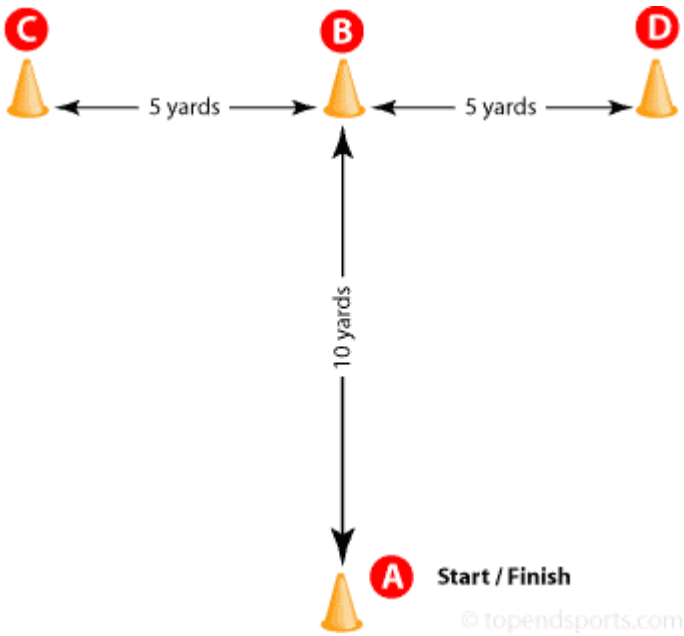
DAY 2	Date: _____
WUP (circle one)	No WUP / SWUP / LWUP
Pre-Warm Up	10-15 min
Baseline T-test	Time: _____
Re-trial 1	Time: _____
Cryotherapy Tx	30min
Re-warming WU	0 min / 6.5 min / 16 min
T-test	Time: _____
Re-trial 1	Time: _____

DAY 3	Date: _____
WUP (circle one)	No WUP / SWUP / LWUP
Pre-Warm Up	10-15 min
Baseline T-test	Time: _____
Re-trial 1	Time: _____
Cryotherapy Tx	30min
Re-warming WU	0 min / 6.5 min / 16 min
T-test	Time: _____
Re-trial 1	Time: _____

APPENDIX C3

Agility T-test Diagram

Agility T-test diagram



This image has been taken from Topend Sports Network website.[55]

Cone A to B = Sprint Forward

Cone B to C = Lateral Shuffle Left

Cone C to D = Lateral Shuffle Right

Cone D to B = Lateral Shuffle Left

Cone B to A = Run backwards

APPENDIX C4

Short Warm-Up Protocol

Short Warm-Up Protocol

Phase 1: Jogging
Each subject will jog at a light, comfortable pace around the gymnasium for 3 minutes.

Phase 2: Static Stretching
Each subject will individually perform each stretch for the allotted amount of time. For each stretch, the subjects are instructed to hold the position at the end of the range of motion without causing any pain.

Phase 3: Dynamic Stretching
Each subject will complete 10 double-leg jump-tucks in place. The subjects will be instructed to complete 10 jumps in a row, with no break in between. The subjects will also be instructed to use both arms for counter movement and jump as high as possible.

A breakdown of each phase and times for each stretch is as follows:

Time		Phase	Position	Time	Reps	Target Areas
3 min	1	LIGHT JOGGING		3 min	x1	
3 min	2	STATIC STRETCHING				
		Butterfly	Seated	30 sec	x1	Adductors
		Figure-4	Seated	15 sec	x2	Hamstring
		Spinal Twist	Seated	15 sec	x2	Lower Back & Gluts
		Foot Grab	Side-lying	30 sec	x2	Quadriceps
		Calf	Push-Up	15 sec	x2	Gastroc & Soleus
30 sec	3	DYNAMIC STRETCHING				
		Double-Leg Jump-Tucks		2 sec	x10	
6.5 min		TOTAL TIME	6.5 min			

The short warm-up protocol has been taken from the active warm-up routine developed by Richendollar et al.[15]

APPENDIX C5

Long Warm-Up Protocol

Long Warm-Up Protocol

Phase 1: Jogging
Each subject will jog at a light, comfortable pace around the gymnasium for 2 minutes total. This will include 45 seconds light jogging, side stepping 15 seconds on each side, back jogging for 15 seconds and another 45 seconds light jogging.

Phase 2: Static Stretching
Each subject will individually perform each stretch for the allotted amount of time. For each stretch, the subjects are instructed to hold the position at the end of the range of motion without causing any pain.

Phase 3: Dynamic Stretching
Each subject will complete five dynamic stretches. Each exercise will be performed in a walking pattern for the allotted time. Each stretch is performed for a total of 1 minute each.

Phase 4: Sprint and Agility
This phase is aimed to include incremental intermittent sprint and agility exercises to prepare the body for agility performance. Following 10 doulbe-leg jump-tucks, each subject will start at three-quarter running pace and increase intensity to be full speed for the final exercise. Time for these is estimated on each exercise, when each exercise is complete the subject will rest for the remaining of the 20 seconds.

Long Warm-Up Protocol

Time		Phase	Position	Time	Reps	Target Areas
2 min	1	JOGGING				
		Jogging		45 sec	x1	
		Side Stepping		15 sec	x2	
		Back Jogging		15 sec	x1	
		Jogging		45 sec	x1	
4.5 min	2	STATIC STRETCHING				
		Butterfly	Seated	30 sec	x1	Adductors
		Figure-4	Seated	30 sec	x2	Hamstring
		Foot Grab	Side-Lying	30 sec	x2	Hip Flexor & Quads
		Spinal Twist	Seated	30 sec	x2	Gluteals
		Calf	Push-Up	30 sec	x2	Gastroc
3 min	3	DYNAMIC STRETCHING				
		Open Gates	Alternating	30 sec	x1	Adductors/Gluteals
		Close Gates	Alternating	30 sec	x1	Adductors/Gluteals
		Lateral Lunge	One-Way	15 sec	x2	Adductors
		Forward Walking Lunge	Alternating	30 sec	x1	Gluteals/Quadriceps
		Straight-Leg March	Alternating	30 sec	x1	Hamstrings
		Heel-to-Toe	Alternating	30 sec	x1	Gastroc
2.5 min	4	SPRINT and AGILITY				
		10 Double-Leg Jump-Tuck		20 sec	x1	
		10m Forward + 5m Forward	Alternating	20 sec	x2	3/4 Speed
		10m Forward + 20m Forward		20 sec	x1	3/4 Speed+Full Pace
		30m Forward		20 sec	x1	Full Pace
12 min		TOTAL TIME	12 min			

The long warm-up protocol has been taken from the warm up protocol routines developed by Little et al.[37]

APPENDIX C6

Institutional Review Board –

California University of Pennsylvania

IRB Application

California University of Pennsylvania

Proposal Number
Date Received

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 Re-warming on Functional Agility in Collegiate Athletes After Cryotherapy Treatment*

Researcher/Project Director *Colleen J Frickie*

Phone # *703.795.6416* ***E-mail Address*** *fri0405@calu.edu*

Faculty Sponsor (if required) *Dr. Rebecca Hess*

Department *Health Science*

Project Dates *12/12/10* ***to*** *12/11/11*

Sponsoring Agent (if applicable) _____

Project to be Conducted at *Hamer Hall Gymnasium at California University of Pennsylvania*

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 this study will be to investigate the effect of re-warming on functional agility performance after cryotherapy treatment. Healthy National Collegiate Athletic Association (NCAA) Division II collegiate soccer athletes will be invited to participate in this study (N~20), and told their selection is due to their involvement on the soccer teams of California University of Pennsylvania. It will be beneficial for clinicians to know the length of a warm-up protocol necessary to return athletes to be able to maximally perform after cryotherapy. It is hypothesized that re-warming protocols (short and long warm-up) will cause significant improvements in functional agility (T-test) after cryotherapy (ice application). Additionally, the long warm-up protocol will cause significant improvement in functional agility (T-test) when compared to the short warm-up protocol after cryotherapy (ice application) treatment.

Subjects will be excluded from this study if are currently not participating in practice or competitions due to an injury, or have any contraindications to cold therapy, such as Raynaud's, cold allergy, etc. Each subject will be presented with an informed consent (attached) to sign to explain the involvement in the study, with a full understanding that their participation is voluntary. Each subject will understand they may withdraw from the research at any time without penalty. Each subject will be asked to report to the athletic training facility on three separate days with at least 48 hours between performance sessions. On each test day, the subjects will consist of a pre-warm up, a daily baseline T-test, a standard cryotherapy treatment, one of three warm up conditions (no warm-up, short warm-up, long warm-up), and then perform a maximal T-test to assess agility.

The pre-warm up will be allowed to prepare the subjects to perform the baseline T-test. The pre-warm up will consist of an individual warm up for 10-15 minutes, including 3-5 minutes of light jogging, followed by stretching. These pre-warm up guideline have been taken from the study that evaluated the reliability and validity of the T-test.(1) Following the pre-warm up, the subjects will perform a baseline T-test and proceed to the cryotherapy treatment.

The cryotherapy treatment will be a 30-minute ice bag treatment on the subject's dominant leg on the anterior thigh. Compression will be applied using plastic wrap to increase reduction in tissue temperature, as determined by Tomchuk et al.(2) Compression pressure will be measured at the beginning of the treatment session between 40-45mmHg.(3) Following the cryotherapy treatment, the subject will complete the level of re-warming condition.

The order of the warm-up conditions for each subject will be randomly assigned. The no warm-up condition will only allow for 2 minutes between cryotherapy treatment and maximal T-test performance. The short warm-up (attached) will include selected components from previous research, including a combination of jogging, static and dynamic stretching, totaling 6.5 minutes.(4) The components are aimed to simulate a jog and stretch that an athlete might perform quickly before returning to competition. The long warm up will also include selected components from previous research studies. The long warm up (attached) will include jogging, dynamic stretching, static stretching and intermittent sprint and agility exercises.(5) Both stretching protocols target major lower extremity muscles that are used for the agility test.

Agility will be measured using a standard T-test. The T-test has resulted to have high reliability (r=0.94) and therefore only one trial is necessary in each treatment condition.(1) Before testing, subjects will be allowed to walk through the T-test course to familiarize themselves with the set up and requirements. Testing will take place indoors at a college gymnasium on hardwood floors to eliminate extraneous variables and maintain a consistent surface and climate conditions. The T-test uses four cones (1 foot tall each) placed on the court in a T-shape. The time is an automatic laser timer, Speed Trap II Timer. Start time is initiated by the release of the button from the subject. In using the Speed Trap II Time, which is accurate to $1/100^{th}$ sec,

research error will be eliminated. The method of assessing agility will follow the T-test set up and directions (attached) will as outlined in previous research directly investigating the T-test by Paulo et al.(1) To start, the subject will begin with both feet behind the starting cone A. The subject will sprint forward 9.14m (10 yards) to cone B, lateral shuffle left 4.51m (5 yards) to cone C, lateral shuffle right 9.14m (10 yards) to cone D, lateral shuffle left 4.51m (5 yards) back to cone B, and run backward 9.14m (10 yards) returning to cone A. Time will stop when the athlete crosses the line breaking the laser. Individual times will be recorded in a data sheet to later be analyzed. Decreased time represents improved agility performance.

The data will be analyzed using a within subjects repeated measures ANOVA to determine the differences within subjects on two tests (pre- and post-test) and between three conditions (no re-warming, short warm-up and long warm-up). A post hoc analysis will also be performed to determine the differences among the three levels of re-warming (no re-warming, short warm-up and long warm-up). All data will be analyzed using SPSS version 14.0 at an alpha level of ≤ 0.05.

References:

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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.*

    The possible risks and/or discomforts are very minimal include falling down during the T-test and warm up protocols and/or negative affects due to cryotherapy treatment. The warm up protocols and T-test are no more than normal physical activity of collegiate athletes would be exposed during a regular competition or practice. The warm up protocols will be explained prior to execution to allow full understanding by the subjects in order to decrease chance of injury. Further, the T-test will be fully explained and the subjects will be given the chance to walk through the set up and understand the requirements to complete it safely and successfully. Subjects will be excluded from participating in the study if they have any known contraindications to cold therapy or cold allergies. Further, to ensure no adverse reactions happen during the cryotherapy treatment, the researcher will check after applying the ice during testing sessions. No tests are physically invasive. If any injury was to occur, the research will take care of the subjects, or another certified athletic trainer, in the Athletic Training Room in Hamer Hall at California University of Pennsylvania.

    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.*

All subjects will be volunteers who are eighteen years or older and are NCAA Division II collegiate athletes at California University of Pennsylvania. Prior to the study, an informational meeting will be held with the potential subjects to explain the concept of the study in the absence of the coach. Any athlete will be excluded from this study if they are currently not participating in practice or competitions due to an injury, or have any contraindications to cold therapy, such as Raynaud's, cold allergy, etc.

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.*

An informed consent form (attached) will be complete and signed by all subjects prior to any participation in the study on the first day of testing. Each signed form will be kept by the researcher.

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 data collected will be documented on an individual data collection sheet (attached). Data will be collected during spring semester. All subjects are supposed to come in three different days for testing under the three warm-up conditions (no warm-up, short warm-up and long warm-up). All collected data, which will be identified by subject number, will be maintained by the researcher in a secure location in which the researcher and research advisor can access.

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 Signature if required

Department Chairperson's Signature

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

Approved, September 12, 2005 / (updated 02-09-09)

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

Ms. Frickie,

Please consider this email as official notification that your proposal titled "The Effect of Re-warming on Functional Agility in Collegiate Athletes After Cryotherapy Treatment" (Proposal #10-023) has been approved by the California University of Pennsylvania Institutional Review Board as submitted.

The effective date of the approval is 02-15-2011 and the expiration date is 02-14-2012. 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 02-14-2012 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

APPENDIX C7

Cryotherapy Set Up

Cryotherapy Set Up

Step 1: Ice bag contained wetted ice as defined by Dykstra et al[9] with 2000mL of ice and 300mL of room temperature water.

Step 2: Compression was measured to insure consistency at the beginning of the treatment session between 40-45mmHg using a blood pressure cuff.[13]

Step 3: Plastic wrap was applied to secure the ice bag application, ensuring the compression remained within 40-45mmHg, at the beginning of the treatment.

Step 4: Athlete sat with minimal movement and leg extended for a 30-minute ice bag treatment.

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ABSTRACT

TITLE:	Effect of Re-Warming on Functional Agility in Collegiate Athletes after Cryotherapy Treatment
RESEARCHER:	Colleen Joyce Frickie ATC, NASM-PES
ADVISOR:	Dr. Rebecca Hess
DATE:	May 2011
RESEARCH PROBLEM:	Master Thesis
PURPOSE:	The purpose of the study was to investigate warm-up lengths on functional agility, measured using the T-test, after ice bag application to the anterior thigh.
PROBLEM:	With the detrimental effects of cryotherapy on performance ability, lengths of warm-up in preparation to return to play needs to be determined to decrease the risk of injury and increase athletes' performance.
METHODS:	This study used a quasi-experimental, within-subjects design. Seventeen Division II collegiate soccer athletes completed three testing sessions that included a prewarm-up, baseline (pretest) agility T-test, ice bag application, level of warm-up condition (no warm-up, short warm-up and long warm-up), and maximal performance (posttest) T-test.
FINDINGS:	A repeated measures ANOVA revealed a significant difference among no warm-up, short warm-up and long warm-up ($F(2,32) = 19.316$, $P < .001$). In addition, Paired-Sample T-tests were significant among all three pairs (Control – Short, Control – Long, and Short – Long). The long warm-up demonstrated the best agility time,

shown with a difference average of -.2341 seconds being a faster agility time.

CONCLUSIONS: Re-warming after ice bag application to the anterior thigh will increase agility performance ability in Division II collegiate soccer athletes. Further, after cryotherapy, a 12-minute warm-up will show more improvement in agility performance compared to a 6.5-minute warm-up.