THE EFFECTS OF CRYOTHERAPY OVER THE LATERAL ANKLE
ON STATIC
AND DYNAMIC BALANCE

A THESIS

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by
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THESIS APPROVAL

Graduate Athletic Training Education

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INTRODUCTION

Cryotherapy is one of the most commonly used modalities in athletic training today. This modality is used on a daily basis around the country in various athletic training rooms.\(^1\)-\(^{12}\) Many studies have shown the effectiveness of cryotherapy on pain relief, decreasing inflammation, preventing hypoxic injury, and decreasing muscle spasms.\(^1\)-\(^{14}\) Fewer studies have examined the effect of cryotherapy on performance measures such as balance.

Balance is an intrinsic part of athletic ability and being able to balance while performing is highly important from both the standpoint of performance and injury prevention. Many athletes use a form of cryotherapy prior to participating in sports and during breaks from playing. There have been many conflicting reports about whether there is a decrease in balance, which leads to a decrease in performance from the application of cryotherapy prior to participating in sports.\(^{15}\)-\(^{18}\)

Cryotherapy is defined as the application of a cold modality to an area of the body.\(^3\) The skin, subcutaneous tissues, and muscles are cooled through cryotherapy via
conduction and/or convection.\textsuperscript{1} That is how the skin and underlying tissues and structures loses heat and how cryotherapy modalities work. The effects that cryotherapy has on the body are many and include alteration of sensation, temperature, metabolism, and nerve function and conduction.\textsuperscript{1-14}

Balance can be defined as the ability to maintain an upright stance and maintain equilibrium without falling.\textsuperscript{15} Balance is an intrinsic part of everyday activity and highly important in athletics. If an athlete does not have good balance then they cannot perform at their highest level. Balance is a combination of center of balance, postural control, and center of pressure and base of support. Maintaining balance also includes both sensory and motor components both of which have the potential to be affected by cryotherapy.\textsuperscript{15}

Proprioception can be described as being able to detect changes in specific joint position and being able to adapt to that change.\textsuperscript{16} It can be considered an intrinsic part of balance. It is a combination of input from mechanoreceptors that are contained within the joint, ligaments, tendons and the skin which work together to give the sense of change in joint position. Proprioception has been shown in studies to improve after balance training...
activities, which can lead to better performance and decreased risk of injuries.\textsuperscript{16-20,22}

There are two types of balance that are used every day, static and dynamic. Static balance is used when a person is remaining in a position for period of time and is maintaining balance. To maintain static balance the goal is to minimize the amount of movement in the subjects’ center of balance. Static balance can be observed on a stable and unstable surface to determine an athlete’s static balance ability. Dynamic balance is being able to maintain postural stability while moving. This type of balance is used most often in athletics, and is the most important one to be able to have. If an athlete cannot be balanced and run then they will not be able to perform at their highest ability.\textsuperscript{16-22}

There are many reliable ways to test both static and dynamic balance; two of the most common are the Balance Error Scoring System (BESS) and the Star Excursion Balance Test (SEBT). The BESS test is considered a reliable assessment tool to obtain static balance results.\textsuperscript{16,18,20} This test used 3 stances in two different surfaces. Mistakes are counted as scores. The SEBT is often used to assess dynamic balance in athletes. This test consists of having a star-grid laid out on the floor in eight directions. The test
foot is placed directly in the middle of the star while the other foot reaches out as far as possible and touches the farthest point with their toes.\textsuperscript{16,18,20,24} The SEBT has been proven to be a reliably method of determining dynamic balance in numerous studies.\textsuperscript{27}

Nerve function plays an important role in how cryotherapy may affect balance. The nerves that are affected first by cryotherapy would be the cold and pain nerve receptors, since the first sensations felt are cold and pain. Mechanoreceptors respond to different stimulus. They are a type of superficial receptors that respond to touch and pressure and responds rapidly to changes in stimulus. Thermo receptors are also a type of superficial receptor that responds quickly to changes in temperature. Deep receptors include Golgi tendon organs (GTO) and muscle spindles. GTO help with proprioception and detect changes in muscle length and tension along with the muscle spindles. All of these nerves and receptors are affected by applications of cryotherapy so therefore skin touch, temperature, and pain are all decreased and proprioception is decreased via the deep receptors.\textsuperscript{13}

There have been numerous studies that have shown conflicting results on whether cryotherapy has an effect on static and dynamic balance. A study performed by Wassinger
et al., examined proprioception and throwing accuracy in baseball players after applying cryotherapy. The results of this study demonstrated a decrease in shoulder proprioception and accuracy after applying cryotherapy to the shoulder.\textsuperscript{27} In a study performed by Richendollar et al., the researchers examined the effect of cryotherapy on three different functional performance exercises and on active warm-ups following cryotherapy treatments. The results of this study showed that ice bag application had decreased maximal performance in all three of the tests.\textsuperscript{27} Another study done by Cross et al. examined functional performance after ice immersion. The three functional tests that were performed were the shuttle run, the hop test, and the single-leg hop test. The results of this test showed that ice immersion does have an impact on functional performance.\textsuperscript{16}

Miniello et al. examined lower leg immersion and whether it affected dynamic balance in females. The results of this study showed that lower leg immersion does not affect dynamic stability.\textsuperscript{28} A study conducted by Berg et al. explored peroneal reaction time in subjects following a cryotherapy treatment. The results of this study showed that there was no significant change in peroneal reaction time after treatment at any time.\textsuperscript{28}
In a study that was performed by Evans et al., the researchers were examining agility after applying cryotherapy. The results of this study showed that ice immersion of the foot and ankle did not alter agility to a significant degree.  

Balance is major component of athletic ability and if it is decreased from cryotherapy then professionals who use this common modality on regular bases needs to be aware of the possible effect on athletic performance. Therefore, the purpose of this research is to determine whether cryotherapy decreases an athlete’s static and dynamic balance, which in turn could impact the player’s athletic ability and injury risk.
METHODS

The purpose of this study was to examine the effects of cryotherapy on both static and dynamic balance. 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 research was a quasi-experimental, within subjects, repeated measures design. The independent variable in this study was cryotherapy condition with two levels. The first level was with cryotherapy and the other will be without cryotherapy. The dependent variables were the scores of the BESS and of the SEBT. The BESS test measured static balance while the SEBT test will measure dynamic balance.

Subjects

The subjects that participated in this study were 20 healthy volunteers. They were physically active individuals
from California University of Pennsylvania over the age of 18. Physically active can be defined as participating in moderate to intense exercise at least 3 days a week. The subjects were screened to make sure they have had no previous head injury or lower extremity injury within six months, or any neurovascular condition. There was also a checklist on the information sheet to rule out any contraindications such as Raynauds, cold allergy, etc. There was a mix of both males and females.

Each subject performed three separate sessions on three days for approximately an hour each day. The study was approved by the Institutional Review Board at California University of PA (Appendix C2). All subjects in the study signed an Informed Consent Form (Appendix C1) prior to participation in the study. Each participant’s identity remained confidential and will not be included in the study.

Preliminary Research

A pilot study was performed on 3 subjects so the researcher could become familiar with the conducting the BESS and SEBT and determine the amount of time needed to take to perform the treatments and the two tests. The
results of the pilot study showed that no changes needed to be made to the methods.

Instruments

The instruments that were used were a demographic sheet (Appendix C5), an ice bag, the BESS test and the SEBT. Information that was gathered in the demographic sheet was age, sport played, gender, last head injury (if any), last lower extremity injury, a checklist of contraindications and any neurovascular disorders that may interfere with balance.

The BESS test consisted of 3 different stances on two different surfaces to test static balance (Picture can be shown of three stances in Appendix C4). The two surfaces are a flat surface and an unstable surface, which was being tested using a foam pad. The three stances are: double leg, single leg, and tandem. The area to stand is about shoulder width apart and marked off by a square. The subject held each stance for 30 seconds with their hands on their iliac crest and maintains the posture as stable as they were able. Mistakes were counted and added as a point. Mistakes include taking hands off the iliac crest, heels off the ground, moving out of the box, jumping around, and heel
touching the ground in the single leg stance.\textsuperscript{15,17,19,21,26}

Intratest reliability has been shown for this test to be from .78 to .96.\textsuperscript{17}

The SEBT is a way to test a subject’s dynamic balance (Picture can be shown of set-up in Appendix C4). The setup for this test consisted of laying out a star shaped marked area in 8 directions. The directions were anterior, posterior, medial, lateral, anterior medial, anterior lateral, posterior medial, and posterior lateral. The subject stood in the middle of the star with their dominant leg and reached out as far as possible in each direction. The researcher then measured the distance reached; this can be repeated and averaged. Reliability of this test has been shown to be from .67 to .87.\textsuperscript{26}

Procedures

The subjects reported on day one to complete paperwork and sign consent forms. Day one also consisted of a practice day. The subjects learned how to perform both the BESS test and the SEBT. The researcher explained the study and the tests. Each subject got one trial for both the BESS and the SEBT. The results were recorded.
Day two, subjects came in and participated in either the cryotherapy condition or the no cryotherapy condition. At the beginning of each test session prior to either the cryotherapy condition or the no cryotherapy the subjects participated in a pre-trial testing to get their baseline measurement for that day. The subjects with the cryotherapy condition sat for 20 minutes with an ice bag over the ankle and foot with a compression wrap. The subjects were sitting up in a supine position with their legs straight out in front of them. The compression wrap has been shown to cause a greater decrease in temperature than just ice bag alone and many athletic trainers use wraps to hold the ice bag in place over the ankle joint. The subjects sat with the ice bag applied for 20 minutes. The subjects without the cryotherapy condition also sat for 20 minutes prior to beginning the tests also with a compression wrap applied and will also sit up in a supine position with their legs out in front of them. Immediately following the application of cryotherapy or no cryotherapy the subjects performed either the BESS test or the SEBT. Whichever one was performed first, the other immediately followed. After these two tests the subject sat for 10 minutes to allow rewarming to occur, to see if there are any changes. They were in the same position supine with their legs straight
in front of them. Then the subject performed the two tests again in reverse order.

Day three consisted of the same routine as day two with the subjects performing the opposite treatment condition. The order of the tests remained the same to eliminate confusion and to create an easier research environment.

Hypotheses

The following are the hypotheses suggested by the researcher prior to performing the study.

1. Cryotherapy will have a negative effect on static balance doing the ground stances as measured by the BESS test.
2. Cryotherapy will have a negative balance on static balance during the unstable stances as measured by the BESS test.
3. Cryotherapy will have a negative effect on dynamic balance as measured by the Star Excursion Balance Test.
Data Analysis

All data was analyzed by SPSS version 16.0 for Windows. The data was analyzed to determine if cryotherapy had an effect on static or dynamic balance. The research hypothesis was analyzed using repeated measures Multivariate Analysis of Variance. The analysis was examined to determine if the application of cryotherapy had a negative effect on static balance in both the stable and foam surface and dynamic balance. An alpha level of 0.05 was utilized to determine statistical significance.
RESULTS

The purpose of this study was to examine whether cryotherapy applied over the lateral ankle had an effect on static and dynamic balance. Static balance was tested by the BESS on two different surfaces and dynamic balance was tested via the SEBT. The following section includes: demographic information, hypothesis testing, and additional information.

Demographic Information

Twenty physically active college students' from California University of Pennsylvania with a mean age of 21.7± 2 years acted as subjects in this study. The subjects volunteered to participate and included 10 males and 10 females. Subjects completed a demographic sheet containing information such as age, previous lower extremity injury, previous head injury, previous cryotherapy use, and cryotherapy contraindications (Appendix C5). The demographic sheet was completed voluntarily with the researcher present before each study was started. Subjects also completed the IRB approved consent form at this time.
Hypothesis Testing

The following three hypotheses were tested in this study. All hypotheses were tested with the level of significance at the ≤.05 level.

Hypothesis 1: Cryotherapy will have a negative effect on static balance as measured by the BESS test on the firm condition.

A 2x3 repeated measures ANOVA was used to examine the effects of the condition (ice and no ice) and time (pretest, posttest, 10 minutes posttest) on BESS firm surface scores. The mean test scores under each condition can be found in Table 1. A significant effect was found for the interaction between time and condition (F(2,38)=14.53, p<.001)). The interactive effect showed that subjects had decreased performance on the BESS test during the testing immediately following ice application scores improved after the rewarming period.

Conclusion: Hypothesis 1 was supported. Balance was negatively affected in the firm condition of the BESS test immediately following application of cryotherapy.
Table 1: Mean number of errors during BESS on firm surface

<table>
<thead>
<tr>
<th>Time</th>
<th>Ice</th>
<th>No ice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(SD)</td>
</tr>
<tr>
<td>Pre</td>
<td>5.0</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>(2.39)</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Post</td>
<td>7.2</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>(2.2)</td>
<td>(1.5)</td>
</tr>
<tr>
<td>10 post</td>
<td>5.7</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>(2.3)</td>
<td>(1.9)</td>
</tr>
</tbody>
</table>

- Test time x condition p<.001

Hypothesis 2: Cryotherapy will have a negative effect on static balance as measured by the BESS test on a foam surface.

A 2x3 repeated measures ANOVA was used to examine the effects of the condition (ice and no ice) and time (pretest, posttest, 10 minutes posttest) on BESS foam surface scores. The mean test scores under each condition can be found in Table 2. A significant effect was found for the interaction between time and condition (F(2,38)=26.27,p<.001 ). The interactive effect showed that subjects had decreased performance on the BESS test during the testing immediately following ice application scores improved after the rewarming period.

Conclusion: Hypothesis 2 was supported. Balance was negatively affected in the foam condition of the BESS test from the application of cryotherapy.
Hypothesis 3: Cryotherapy will have a negative effect on dynamic balance as measured by the SEBT.

A 2x3 repeated measures ANOVA was used to examine the effects of the condition (ice and no ice) and time (pretest, posttest, 10 minutes posttest) on SEBT distances reached. The mean test scores under each condition can be found in Table 3. A significant effect was found for the interaction between time and condition (F(2,38)=218.76, p<.001). The interactive effect showed that subjects had decreased performance on the SEBT during the testing immediately following ice application and scores improved after the rewarming period (Table 3).

Conclusion: Hypothesis 3 was supported. Balance was negatively affected in the SEBT test from the application of cryotherapy.
**Table 3:** Reaching distance during SEBT (cm)

<table>
<thead>
<tr>
<th>Time</th>
<th>Ice Mean</th>
<th>Ice SD</th>
<th>No Ice Mean</th>
<th>No Ice SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>572.7</td>
<td>(66.3)</td>
<td>588</td>
<td>(68)</td>
</tr>
<tr>
<td>Post</td>
<td>559.1</td>
<td>(72.6)</td>
<td>593.9</td>
<td>(73.2)</td>
</tr>
<tr>
<td>10</td>
<td>577.9</td>
<td>(72.4)</td>
<td>591.2</td>
<td>(68.1)</td>
</tr>
</tbody>
</table>

*Test time x condition p<.001*
DISCUSSION

The following section is divided into these subsections: Discussion of Results, Conclusions, and Recommendations.

Discussion of Results

The purpose of this study was to examine the effect of cryotherapy applied over the lateral ankle on static and dynamic balance. Static balance was measured by the BESS test on two different surfaces while dynamic balance was measured by the SEBT. Physically active college students voluntarily participated in this study. This topic was chosen because the researcher has been interested in cryotherapy and balance and there have been many conflicting reports whether cryotherapy may cause a change in balance. This study demonstrated that there is a significant effect of cryotherapy on balance comparing the times and conditions from the ground and foam stances in the BESS test and from the SEBT test.

The researcher’s first hypothesis was that there would be a negative effect on balance after applied to the
lateral ankle on static balance on the firm surface in the BESS test. The results supported the hypothesis. The data analysis found a significant difference between the time and condition with the firm stances on the BESS test. The mean for the ice application pre-test was 4.95 (in number of mistakes) and the post-test mean was 7.15 and 10 minutes after the post test was 5.65. (Figure 1) There was a significant difference between the pre and post test scores. This shows that the application of cryotherapy over the lateral ankle caused a decrease in the athlete’s balance for a short duration. The average mean for the no ice condition for the pre test was 3.75, the post-test was 3.55 and the 10 minutes post test was 3.6. (Figure 1). Comparing the no ice condition to the ice condition the results show that there is a difference between the two. The subjects’ scores were lower in the ice condition from the pre to the post test. This indicates a decrease in performance. They improved from the post test to the 10 minutes post test but still did not return to baseline measurements. The no ice condition the scores remained approximately the same with slight improvements throughout the three tests. If there would be no effect, the effects would be approximately the same with both the ice and no ice condition, they would both get slightly better during
the course of the three tests but the opposite occurs during the ice trial. This demonstrated ice application caused a significant decrease in balance from immediately post after and is still affecting the subject 10 minutes past the post-trial.

![BESS Test Ground Ice and No Ice](image)

**Figure 1.** BESS Test Ground Ice and No Ice

The researcher’s second hypothesis was that there would be a negative effect on balance in the foam stances from the BESS test. The 2x3 repeated ANOVA showed a significant difference between time and condition with the foam surface using the BESS test. The average means for mistakes in the ice condition in the pre test was 6.9, and
the post test after the ice application was 10.2 and the 10 minutes after the post test was 8.05 (Figure 2). The mean for the no ice condition for the pre-test was 6.55 and for the post-test was 6.05 and the 10 minute after the post test was 5.55 (Figure 2). The foam condition was considered to be harder to most subjects so the initial mistakes were higher and the mistakes made after icing were greater. The pre-test and the post-test mistakes on the foam test averaged about 3 mistakes higher and the 10 minute post-test mistakes decline from the immediate post after testing but still did not return to baseline pre-test measurements. The number of mistakes made for the no ice condition remained about the same for the foam condition with no significant fluctuations. This implies that if ice had no effect then the same would have been expected to happen with the ice condition, for mistakes to either stay the same or decrease. These results showed that ice applied to the lateral ankle caused a decrease in balance on the foam surface.
The researcher’s third hypothesis was that there would be a negative effect on dynamic balance from cryotherapy as tested by the SEBT. The 2x3 repeated ANOVA showed a significant difference between time and condition with the SEBT test. The average distance reached in centimeters for the ice condition for the pre-test was 572.7, the post-test was 559.1, and the 10 minute test was 577.9. (Figure 3). The average distance reached for the no ice condition for the pre-test was 588, the post test was 593.9 and 10 minutes after was 591.2(Figure 3). For the ice condition
the distance dropped significantly from the pre test to the
post test. The 10 minute post test, the average distance
went back to up higher then baseline pre-testing. The
average distance reached (centimeters) for the no ice
condition for the pre-test was 588, the post test was
593.9, and the 10 minute post test was 591.2(Figure 6). The
distance reached in the three trials of the no ice
condition remained relatively stable with no significant
differences. The results of this analysis also showed that
ice applied to the lateral ankle caused a significant
decrease in dynamic balance using the SEBT test, and that
it takes longer than 10 minutes for the effects of ice to
completely wear off.
The results of this study were different to the results of some other studies that showed no decrease in performance from the application of cryotherapy\textsuperscript{1-4,6,15,16,20,26}. There are many reasons why the results of this study could have been different. One of these reasons is that other studies mostly examined functional performances as a whole and not static and dynamic balance separately. Another reason is that the application of cryotherapy was applied to different areas of the body such as the peroneals or the quadriceps muscle. Some of the other studies looked at certain muscle groups and their reaction not the whole body.
responding to balance.\textsuperscript{1-6,9,10,12,18} There were also studies that found similar results as this study. Some of them looked at different functional performances following the application of cryotherapy. These studies mostly examined different functional activates and not just balance alone but still found a decrease in performance.\textsuperscript{4-6,15,16,20,26}

Conclusions

The significance of these results is that professionals that use cryotherapy on a daily basis may need to re-think how they apply cryotherapy to their athletes prior to practice or games. The results have shown that cryotherapy has a negative effect on both static and dynamic balance immediately post application and 10 minutes after the post-test. The amount of mistakes made for static balance were increasing and distance reached for dynamic balance was decreasing from the immediate post test but still have not quite returned to normal.

There have been studies that have shown that poor balance can be an indicator of injury. Therefore applying cryotherapy to an athlete and sending them right back to play could possibly lead to further injury. Even after 20
minutes after removing cryotherapy the results have not quite returned to baseline measurements.

Recommendations

The results of this study demonstrate that cryotherapy application to the lateral ankle caused a significant decrease in both static and dynamic balance. Even in the 10 minute post trial testing of both static and dynamic balance showed a deficit, the scores were recovering from the immediate post trial but still did not return to baseline. Certified Athletic Trainers or other professionals who are applying cryotherapy to a subject prior to participating in sports or recreational activities should make sure to not put them in immediately after using cryotherapy. A suitable warm-up of at least 10 minutes should be implemented; they may not be fully recovered from the cryotherapy but well on their way back to baseline.

Further research that could be done would be to see how long it takes for results to return to baseline following the application of cryotherapy. Also, one other area that could be examined would be what time of warm-up could be used to decrease the detrimental effects of cryotherapy on balance. Another area of future research
could include looking at healthy subjects and injured subjects to see if there are similar results or if one is worse than the other. Finally, a future study could look at different time applications of cryotherapy to see if shorter time application still causes a negative effect on balance or less of a decrease on balance.
REFERENCES


APPENDICES
APPENDIX A

Review of Literature
Cryotherapy is one of the most commonly used modalities in athletic training. Cryotherapy has been shown to have multiple effects on the body, both externally and internally. Athletic participation requires many abilities to perform at a high level, including speed and balance. These two components are critical in athletes who wish to perform at their best.

Many athletes prior to participating in sports use some form of cryotherapy to help them participate fully without pain. The research is unclear as to whether this treatment will decrease overall athletic performance. The purpose of the literature review is to examine cryotherapy, balance and the effect that cryotherapy has on static and dynamic balance. This review will be discussed in the following sections: (1) Cryotherapy, (2) Balance, (3) The Effects of Cryotherapy on Performance, and (5) a Summary.
Cryotherapy

Cryotherapy is defined as “the use of ice or cold in a therapeutic setting.” Cryotherapy is one of most commonly used modalities in athletics today. Athletic trainers use some form of cryotherapy daily for athletes before and after participating in their respective sports. The main purposes of using cryotherapy on injuries are to decrease pain, decrease muscle spasm, and to decrease farther harm from acute injuries.

The skin, subcutaneous tissues, and muscles are cooled through cryotherapy via conduction and/or convection. Heat goes from areas of high heat to areas of low heat. This means that heat from the skin, which is warmer than the cold modality, gets absorbed into the cold modality. The deeper tissues lose their heat by giving their heat to the superficial layers which continues to give heat to the cold modality. That is how the skin and underlying tissues and structures looses heat and how cryotherapy modalities work. The effects that cryotherapy has on the body are many and include alteration of sensation, temperature, metabolism, and nerve function and conduction.
Tissues Affected by Cryotherapy

The main external structures that cryotherapy has an effect on is the skin, subcutaneous tissues, and muscles.\textsuperscript{2-5, 7-9, 11-13} A study performed by Merrick et al. compared different modes of cryotherapy on surface temperature, 1 cm and 2 cm below the subject's skin. Using four different cold modalities, the researchers found that using an ice bag and Wet-Ice, which is a reusable ice pack that adds compression via elastic bands, caused the greatest decrease in both surface and sub adipose tissue levels. The surface temperature for all the trials was approximately 31 degrees Celsius. The average post-test temperature for both the ice bag and wet-ice was 6.35 degrees Celsius at the surface temperature. At the 1 cm sub adipose level the baseline temperature was about 35 degrees and after treatment the temperate dropped to around 27 degree. At the 2-cm sub adipose level the baseline temperature was around 36 degrees and the temperature dropped to an average of 31.5 degrees. Skin temperature was shown to drop the fastest and by the most degrees when compared to the sub adipose levels.\textsuperscript{2}

This data is supported by a study performed by Palmer et al., which studied skin temperature changes after multiple applications of cryotherapy. This study
demonstrated that skin temperature dropped very fast and as soon as the ice bag was applied and that temperature changes were greater after having ice on for 40 minutes compared to only 20 minutes.\textsuperscript{5} After removing the ice there is an initial temperature rise followed by a slow return to baseline temperature.\textsuperscript{13} The superficial muscles, and sub adipose tissues return to baseline measurements approximately 20 minutes prior to deeper tissues.\textsuperscript{2,5,8}

Cryotherapy has also been shown to decrease muscle spasms.\textsuperscript{1,2,6,8,9,11,13} Cryotherapy has shown to decrease these spasms through reflex mechanisms, which make the muscle spindles not as sensitive allowing them to relax and therefore relieve the spasm.\textsuperscript{13}

Internal structures that are affected by applying cryotherapy include: blood vessels, nerves, and mechanoreceptors. Alteration of the function of mechanoreceptors will potentially affect sensation. As a tissue cools, there are usually four sensations that are felt while applying Cryotherapy. This altered sensation starts out as extreme cold, and then changes to an aching pain, followed by a pins and needles sensation and then eventually it becomes numb.\textsuperscript{13}

Different nerve types also are affected by cooling. The nerves that are affected first would be the cold and
pain nerve receptors, since the first sensations felt are cold and pain. As heat is taken away from the skin, muscles, and nerves, the nerve impulses are slowed down which causes a decrease in sensation. Sensation can be divided into superficial and deep sensation. Superficial involves touch, temperature, and pain from the skin, which are from superficial receptors, which transmit these signals to the brain. Mechanoreceptors are responses to different stimulus as well. They are a type of superficial receptors that respond to touch and pressure and responds rapidly to changes in stimulus. Thermo receptors are also a type of superficial receptor that responds quickly to changes in temperature. Deep sensation involves joint and muscle positions, pressure, and proprioception from muscles, joint capsules, and ligaments. Deep receptors include Golgi tendon organs (GTO) and muscle spindles. GTO help with proprioception and detect changes in muscle length and tension along with the muscle spindles. All of these nerves and receptors are affected by applications of cryotherapy so therefore skin touch, temperature, and pain are all decreased and proprioception is decreased via the deep receptors.

Blood vessels are affected through cryotherapy because decreasing the temperature causes a decrease in the
metabolic rate of the tissue and the need for oxygen. Therefore since the need for oxygen is considerably less, blood vessels constrict so not as much oxygenated blood goes to the area.\textsuperscript{1-13}

Methods of applying cryotherapy

There are many methods of applying cryotherapy. Some of the most common example includes: ice bags, ice packs, gel packs, cold whirlpool and compression units. In a study performed by Merrick et al., the researchers compared 3 types of cryotherapy to examine which had the deepest surface and deep cooling temperatures. The researchers used an ice bag, Wet-Ice, and Flexi-Cold. Wet-Ice is a type of compression unit that ice is applied in and then applied to the skin with its elastic wraps. Flexi-Cold is a type of gel pack just applied to the skin. In this study the results showed that using ice bags and Wet-Ice, produced similar results and had the most rapid temperature loss and the coldest temperature.\textsuperscript{2}

Another study, performed by Kennett et al., examined four commonly used cryotherapy modalities and how well they cooled. The four modalities used were: crushed ice, gel pack, frozen peas, and ice water immersion. The results of this study showed that using crush iced produced the lowest
temperature followed by ice immersion. The results of these two studies show that ice bags are the best available form of cryotherapy if you want the quickest and coolest drop in temperature. Ice bags are also the cheapest and easiest forms of cryotherapy to use and can be conformed to almost any area of the body.

Cryotherapy is the most commonly modality in sports medicine today and has been shown to be effective in treating soft tissue injuries. There are a wide variety of applications, such as ice bags, compression units, cold whirlpools, and gel packs. Each type has different temperature penetrations with ice bags with compression allowing the deepest and the coolest temperature.

Balance

Balance can be defined as “the state of bodily equilibrium or the ability to maintain the center of body mass over the base of support.” Balance is an intrinsic part of everyday activity and highly important in athletics. If an athlete does not have good balance then they cannot perform at their highest level. Balance is a combination of center of balance, postural control, center
of pressure and base of support. Maintaining balance also includes both sensory and motor components.

**Sensory Components of Balance**

Postural stability is controlled through a combination of visual, vestibular, and proprioceptive neural input, which comes from the central nervous system. Information is gathered from these three inputs and is processed to establish the motor controls to follow. After deciding on the appropriate motor control it is followed through via muscles activity. 

Postural stability is dependent on the athlete’s base of support, the larger the base of supports the better the balance. Base of support can be defined as the area of the body that is making contact with the ground or environment. In many sports athletes are rarely on two feet for long period of time, making their base of support very small. Therefore the inputs from visual, vestibular, and proprioceptive sources must be interpreted and acted on quickly so that motor commands can maintain equilibrium in the body. 

Proprioception can be described as being able to detect changes in specific joint position and being able to adapt to that change. It is a combination of input from
mechanoreceptors that are contained within the joint, ligaments, tendons and the skin which work together to give the sense of change in joint position. Proprioception has been shown in studies to improve after balance training activities, which can lead to better performance and decreased risk of injuries.\textsuperscript{15-17,19,21,25}

Visual input is an important part of balance. Information is gained through vision and goes to the brain to be analyzed and put into motor commands. Visual input is important but not necessary in healthy individuals. In healthy subjects, with their eyes closed, subjects can still maintain balance with little change in movement. In subjects that have lower extremity injuries or instability vision plays an important part in maintaining balance. Paying attention while focusing on the visual inputs is another aspect of vision integration. While focusing on solely balancing subjects have been shown to balance more effectively than when there are distractions surrounding the subject.\textsuperscript{21}

The vestibular sensory component also plays an essential role in balance. It is a part of the hearing system and contributes to equilibrium and movement. Signals from the vestibular system send outputs to the eyes and to
muscles. The signals to the muscles help keep correct
posture to maintain balance.\textsuperscript{16,18}

**Components of Balance**

There are two types of balance that are used everyday, static and dynamic. Static balance is used when a person is remaining in a position for period of time and is maintaining balance. To maintain static balance the goal is to minimize the amount of movement in the subjects' center of balance. Static balance can be observed on a stable and unstable surface to determine an athlete's static balance ability. In a study done by Bressel et al., they compared static balance of athletes in three different female sports to see if different sports played a role in static balance. The results of this study showed that gymnastic athletes had a better static balance score than the basketball group but no statistical differences in other comparisons.\textsuperscript{15} Another study performed by Onate et al., determined that static balance can be changed just by changing the environment around the test subject. The study took a sample of baseball athletes and took a controlled baseline measurement using the Balance Error Scoring System (BESS), in the athletic training room. The researchers took another measurement in the sidelines off the baseball field during
practice on a level surface. The results of comparing these two tests showed that there was an increase in the scores from the controlled setting to an uncontrolled setting.\textsuperscript{21}

Dynamic balance is being able to maintain postural stability while moving. This type of balance is used most often in athletics, and is the most important one to be able to have. If an athlete cannot be balanced and run then they will not be able to perform at their highest ability. A study performed by Lee and Lin examined dynamic balance training on ankle instability over a period of twelve weeks. Ankle instability was defined as having at least one severe lateral ankle injury, and feelings of giving away. Center of balance and neuromuscular ability was examined pre and post training. Center of balance is considered the center of the base of support when 25\% of weight is equally in four quadrants.\textsuperscript{23} What was found was that dynamic balance training reduced ankle instability, increased neuromuscular ability and improved center of balance. In a study performed by Gribble et al. the authors examined dynamic balance and the influence on time of day. Testing was performed using the Star Excursion Balance Test (SEBT) over a period of 48-hours using 3 separate times over the two days. The results of this study showed that time of day had an impact on dynamic balance, showing that mornings
produced the best score. Activities that require dynamic activity would best be performed in the morning shortly after waking. Another study examined ankle braces while performing the Star Excursion Balance Test (SEBT), to see if dynamic balance is changed from wearing ankle braces. The results showed that wearing ankle braces had no decrease in dynamic balance performance.

There are many valid and reliable ways that both static and dynamic balance can be tested. Some of these include the BESS, the SEBT, and the Chattecx Balance System and the Biodex Balance System. While the Chattecx Balance System and the Biodex Balance System are both reliable and accurate they are expensive to use and require proper training. The BESS test and the Star Excursion are just as reliable and accurate and require little to no money and are simple to perform.

The BESS test is considered a reliable assessment tool to obtain static balance results. This test used 3 stances in two different surfaces. The three stances used are double-leg stance, single leg and tandem stance both on a firm and foam surface, all with eyes closed. This test can be used as a clinical test after a head injury, assuming there were baseline measurements taken, to see if
balance was affected. Mistakes are measured using this test and counted as the score.

Using a similar environment to use this test is important. In a study performed by Onnate et al., the used the BESS test in a controlled clinical site (athletic training room with only the subject and testers) and on the sidelines of the baseball field (with multiple people and practice going on) to see if the results changed. The study found that there was a major statistical increase in the mistakes made on the sidelines compared to the clinical setting. If this test is going to be used, as head injury test baseline measurements should be taken on the field where the athlete most likely will be when a head injury occurs.\textsuperscript{19}

The SEBT is often used to assess dynamic balance in athletes. This test consists of having a star-grid laid out on the floor in eight directions. The lines are 45 degrees away from each other. The test foot is placed directly in the middle of the star while the other foot reaches out as far as possible and touches the farthest point with their toes.\textsuperscript{15,19,24,26} The distance is then recorded used as needed. The Star Excursion Balance test has been proven to be a reliably method of determining dynamic balance in numerous studies.\textsuperscript{27}
The Chattecx Balance System is a force platform connected to a computer and can measure both static and dynamic balance. It can measure both static and dynamic balance in single and double leg stances. The Balance System measures the subject’s center of balance and determines how far away they move from their center of balance during the testing. In the static testing the platform remains flat and still and in the dynamic stance the platform is tilted in various positions. This balance platform is a very reliable way to test static and dynamic balance but it expensive while the BESS and the Star test are equally as reliable and cheap and easy to test.

The Biodex Balance System tests both static and dynamic balance as well. The machine consists of a platform with a safety harness to ensure the subject does not fall. This machine also measures postural sway, center of balance, and postural stability. In the static testing the platform remained still, while the subject maintained balance. The dynamic portion consisted of making the platform shake and tilting the platform anterior and posterior.

Balance is an intrinsic and complicated part of athletics. Input is gained through visual, vestibular and proprioceptive input that is used to determine proper
commands to execute which keeps a person balanced. Balance is a combination of both static and dynamic balance and is critical in everyday activities and more so in athletics. Proprioception, center of balance, and mechanoreceptors are all part of maintaining both static and dynamic balance.

Cryotherapy and Balance

There have been numerous studies examining cryotherapy and cryotherapy’s effect on numerous aspects of performance. There have been many contradicting results from these studies; some results show an impact while some show no difference.¹⁵⁻¹⁷,¹⁹⁻²⁵

In a study performed by Wassinger et al., they examined proprioception and throwing accuracy in baseball players after applying cryotherapy. The subjects that were used were 22 healthy college students, none that were participating in a throwing sport. All the subjects participated in a pre-test, post-test experiment. The independent variable was cryotherapy. The dependent variables were the Active joint position replication (AJPR), and Path of Motion Replication (PJMR), and the Functional Performance index, which is what the researchers
used to determine proprioception and throwing accuracy. The AJPR was determined using an isokinetic dynamometer. Pads were placed on various parts of the body to analyze the movements of the shoulder. Subjects were blindfolded and asked to move into certain position. When they reached that position they were asked to maintain it for 10 seconds, and it was repeated without using the dynamometer. The PJMR also used the dynamometer and moved into position at a certain speed in a specific path. This was also repeated without the dynamometer. The results of this study showed that there was a decrease in shoulder proprioception and accuracy after applying cryotherapy to the shoulder. The conclusions drawn from this study was that if a subject who is participating in a throwing sport that uses cryotherapy to the shoulder should perform a proper warm-up to regain accuracy and proprioception in throwing.

In the study performed by Richendollar et al., the researchers were examining the effect of cryotherapy on three different functional performance exercises and on active warm-ups following cryotherapy treatments. There were 4 different treatment conditions that were tested. They were no ice/no warm-up, ice/no warm-up, no ice/warm-up, and ice/warm-up. They tested the effects of jogging, stretching and vertical jumps in each of these treatment
conditions. The independent variables of this study were ice/no ice and warm-up/no warm-up. The dependent variables were the functional performance, jogging, stretching and vertical jumps. The subjects used in this study were 24 uninjured mean from 18-24 years old. The results of this study showed that ice bag application had decreased maximal performance in all three of the tests. The warm-up protocol following ice application offset the effects of ice application but did not return the subject to no-ice ice and warm-up results. The conclusion is that if ice is applied to the anterior thigh prior to practice than a proper warm-up should be done prior to playing and that no icing and a proper warm-up increases the subjects performance.27

Another study done by Cross et al. examined functional performance after ice immersion. The three functional tests that were performed were the shuttle run, the hop test, and the single-leg hop test. The subjects that participated in this study were 20 Division 3 male college athletes. The subjects were assigned into the control or the experimental group. The independent variable of this study was ice immersion or no ice immersion. The dependent variable was performance on the functional tests. The results of this test showed that the vertical jump, and shuttle run scores
decreased in experiment group but had no effect in the control group. There was no effect in the hop test. The conclusion is that ice immersion does have an impact on functional performance.\textsuperscript{16}

Miniello et al. examined lower leg immersion and whether it affected dynamic balance in females. The subjects were 17 healthy women who all participated in a pre-test, post-test study. The researchers used EMG to analyze activity and stabilization of lower leg muscles after a jump landing. The independent variable was lower leg immersion in cold whirlpool and the dependent variables were dynamic stability. The results of this study showed that lower leg immersion does not affect dynamic stability. The conclusions drawn from this study were that using cold-water immersion in athletes would not have an effect on dynamic stability.\textsuperscript{28}

A study conducted by Berg et al. explored peroneal reaction time in subjects following a cryotherapy treatment. The study done was a repeated measures design using 27 healthy volunteers. The subjects participated in both a control and treatment group. The reaction times were measured at baseline, immediately post treatment, and at 15 and 30 minutes post-treatment. The inversion of the ankle was caused by a trap door mechanism and the peroneal
reaction time was measured. The independent variable was cryotherapy and the dependent variable was peroneal reaction time. The results of this study showed that there was no significant change in peroneal reaction time after treatment at any time. The conclusions was that cryotherapy over the lateral ankle has no affect on the reaction time of the peroneals.$^{18}$

In a study that was performed by Evans et al. the researchers were examining agility after applying cryotherapy. The study performed was a pre-test, post-test design. There were 24 male subjects that participated in the study. Subjects participated in a control and treatment setting. Agility was measured using the concontraction, carioca, and the shuttle run test. The concontraction test is performed by having a rubber tube attached to a belt, which is around the subject’s waist, while the other end is attached to a wall. The subject then performs a semi-circle around the room with the rope taunt. The point of this test is to replicate rotational forces that use stabilization at the ankle. The cryotherapy treatment consisted of foot and ankle ice immersion for 20 minutes. The results of this study showed that ice immersion of the foot and ankle did not alter agility to a significant degree. The conclusions
of this study were that ice immersion of the ankle and foot does not decrease the ability to perform agility movements.\textsuperscript{6}

Many of the studies were performed on lower extremity, mostly lower leg and ankle, except for the shoulder proprioception research study. There are many conflicting results of previous studies done on cryotherapy and performance. Three have shown that there is an effect from using cryotherapy while three have shown that there is no effect. More research needs to be done to have more conclusive evidence whether cryotherapy affects performance.

Summary

Cryotherapy is the most commonly used modality is athletic training today. Many studies have shown it to be an effective way to decrease pain, secondary hypoxic injury, and muscle spasms and to decrease edema.\textsuperscript{1-14} Three studies have shown cryotherapy to have a negative effect and three studies have shown it to have no effect on performance.

Therefore more research needs to be applied to this field to try and obtain conclusive results on whether cryotherapy decreases an athlete’s static and dynamic
balance, which in turn could impact the player’s athletic ability and injury risk.
APPENDIX B

The Problem
THE PROBLEM

The purpose of the study is to examine the effects of cryotherapy on static and dynamic balance. There have been conflicting reports about whether cryotherapy has an effect on static and dynamic balance. Some research has found that cryotherapy decreases balance performance while some has found that there is no difference. This is important to know because if there is an effect on either of these two components performance may be declined.

Definition of Terms

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

1) Cryotherapy – the application of a cold modality

2) Balance- the ability to maintain upright and in a position of equilibrium

3) Static Balance—balance maintained while standing without moving as measured by the BESS test

4) Dynamic Balance—balance maintained while performing as measured by the SEBT.

5) Rewarming— the tissues reaction after a cryotherapeutetic modality is removed, blood flow
increases to the area and the tissues begin to re-warm, may be increased by activity

6) Physically active-participating in moderate to intense exercise at least 3 times per week

Basic Assumptions

The following are basic assumptions of this study:

1) The subjects will honestly complete the demographic sheet about prior injury history.

2) All subjects are volunteers with no coercion by coaches or faculty.

3) The subjects will fully understand the instructions given to them during the study and perform to their best ability.

Limitations of the Study

The following are possible limitations of the study:

1. The subjects are volunteers and are limited to physically active subjects from California University of Pennsylvania and therefore it is not randomized

2. There may be a practice effect while performing the BESS and Star tests.

3) Testing done in the lab is not sport specific tests.
4) There might be a re-warming effect between performing the two tests.

Significance of the Study

This is important to study because many athletic trainers apply a form of cryotherapy to athletes prior to participating in sports and even during halftime at games. Knowing whether cryotherapy causes a detrimental effect on either static or dynamic balance may cause professionals to re-evaluate applying cryotherapy immediately before or during participation in athletics. If there is an effect we can know that there should be some time of warm-up after applying cryotherapy to counteract some of the effects. If there aren’t any effects from cryotherapy then we know that it is safe to put athletes immediately back to play after using cryotherapy.
APPENDIX C

Additional Methods
APPENDIX C1

Informed Consent Form
Informed Consent Form

1. Amber Fisher, who is a Graduate Assistantship Athletic Training Student at California University of Pennsylvania, has requested my participation in a research study at California University of Pennsylvania. The title of the research is *The Effect of Cryotherapy over the Lateral Ankle on Static and Dynamic Balance.*

2. "I have been informed that the purpose of this study is to determine if cryotherapy has an impact on static and dynamic balance in physically active subjects from California University of Pennsylvania. I understand that I have been asked to participate along with 19 other individuals because I have no previous head injury or lower extremity injury within the last 6 months nor do I have any neurovascular disorders which could interfere with balance and because I am physically active, as defined as participating in moderate to intense exercise at least 3 times a week."

3. "My participation will involve applying an ice bag to my lateral ankle for 20 minutes and without applying an ice bag with a compression wrap and then partaking in two balance tests. The two tests are the Balance Error Scoring System and the Star Excursion Balance Test. I will be tested immediately after removing the ice bag and 20 minutes after applying the ice bag. My participation in this study will consist of an orientation meeting with a practice trial of each test and two meeting days for testing."

4. "I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. The possible risks and/or discomforts include possible ice injury and/or injuries do to falling from loss of balance. To minimize these risks the researcher will be asking me questions about prior cryotherapy use and cold allergy. The researcher will also stand by closely during the balance testing in case I need help or begin to fall."

5. "I understand that, in case of injury, I can expect to receive treatment or care in Hamer Hall’s Athletic Training Facility. This treatment will be provided by the researcher, Sonia Masse, under the supervision of another Certified Athletic Trainer, either of whom can administer emergency and rehabilitative care. Additional
services needed for prolonged care past these days will be referred to the attending physician at the Downey Garofola Health Services located on campus.’’

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

7. I understand that the possible benefits of my participation in the research is to help determine the effects of cryotherapy over the lateral ankle on static and dynamic balance. This study can help athletic trainers decide how and when to use cryotherapy and if it causes a decrease in balance after application which could lead to a decrease in performance.

8. I understand that the results of the research study may be published but my name or identity will not be revealed. In order to maintain confidentially of my records, Amber R Fisher will maintain all documents in a secure location in which only the student researcher and research advisor can access. Each subject will be given a specific number to represent his or her name.

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

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

Amber R Fisher
Fis6490@cup.edu
302-228-25874

Thomas F. West, PhD, ATC
west_t@cup.edu
724-809-1321

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

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

13. This study is (will be) approved by the California University of Pennsylvania Institutional Review Board.

14. The IRB approval dates for this project are from: January 2009 to May 2009.

Subject's signature___________________Date:____________

Other signature:______________________Date____________
APPENDIX C2

Institutional Review Board –

California University of Pennsylvania
I. Introduction

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*

II. Project Information

- **Project:** The Effect of Cryotherapy Over the Lateral Ankle on Static and Dynamic Balance
- **Researcher/Project Director:** Amber Fisher
- **Phone #:** 302-228-2584
- **E-mail Address:** fitted490@cup.edu
- **Faculty Sponsor (if required):** Thomas West
- **Department:** Health Science and Sports Studies
- **Project Dates:** January 1, 2009 to May 1, 2009
- **Sponsoring Agent (if applicable):**

III. Location

**Project to be Conducted at:** California University of Pennsylvania

IV. Project Purpose

- Thesis
- Research
- Class Project
- Other

Keep a copy of this form for your records.

V. Required IRB Training

The training requirement can be satisfied by completing the online training session at [http://cme.ncl.nih.gov/](http://cme.ncl.nih.gov/). A copy of your certification of training must be attached to this IRB Protocol. If you have completed the training at an earlier date and have already provided documentation to the California University of Pennsylvania Grants Office, please provide the following:

- **Previous Project Title:**
- **Date of Previous IRB Protocol:**

Draft, April 7, 2005
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 Researchers’ Signature

Kevin A. Kerry

Department Chairperson’s Signature

COB&HR

Supervising Faculty Member’s Signature if required

ACTION OF REVIEW BOARD (IRB use only)

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

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risks 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

02-06-09

Date

Draft, April 7, 2005
Please attach a typed, detailed summary of your project AND complete items 2 through 6.

1. Methods: My research is to examine whether cryotherapy has an impact on both static and dynamic balance. I am planning on using the Balance Error Scoring System (BESS) and the Star Excursion Balance Test (SEBT). I plan on having subjects come in on three days. Day one will be a practice session and they will be randomly assigned into either a cryotherapy or no cryotherapy group for day two and will switch conditions for day three. Before beginning any testing, the subjects will fill out a demographic sheet with information about having previously used ice before and any known cold allergy and will fill out an informed consent form. The subjects with the cryotherapy condition will lay supine on the table with an ice bag over their lateral ankle for 20 minutes with a compression wrap to hold on the ice bag. The subjects not under the cryotherapy condition will also lay supine on a table with a compression wrap for 20 minutes. Following the 20 minutes the athletes will perform both the Balance Error Scoring System and the Start Excursion Balance Test. The BESS test consists of the subject performing three stances on both firm ground and a foam pad. The three stances include a double leg, single leg and tandem (heel to toe) stances. They remain in each stance for 30 seconds and any mistakes (i.e. hands coming off hips) that are seen are counted as scores. The SEBT test consists of a star pattern laid out on the ground with tape in 8 different directions at 45-degree angles. The subject then stands on his dominant leg in the middle of the star and reaches out with his/her foot as far as able in each different direction and taps the ground with his/her toe. The researcher then measures the distances reached. After the subject performs these 2 tests, they will wait 10 minutes and perform the tests again to see if any re-warming has occurred and changed their balance. Hypotheses: My hypotheses are: 1. Cryotherapy will have a negative affect on both static and dynamic balance and 2. There will be a difference in balance scores from immediately post-cryotherapy treatment to re-testing after re-warming. Data Analysis: The data will be analyzed using SPSS with a 2x2 repeated measures Multivariate Analysis of Variance.

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.

Draft, April 7, 2005
To insure that any risks are minimized I will have the athlete fill out information about history of using cryotherapy and any known cold allergy. If any athlete has cold allergy they will not participate. I will also check after applying the ice to make sure there are no negative affects happening to the athlete. Also while performing the balance tests they will stand in an open area away from anything they might land on if they fall. Also, the researcher will be close by to prevent them from falling if they lose their balance. The risks are reasonable because cryotherapy is something that is used on a daily basis by very many people to treat injuries and for pain relief and having the subjects balance is something everybody does daily to be able to walk.

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.

i. To make sure my selection is equitable I will be using physically active volunteers from California University of Pennsylvania. Physically active can be defined as participating in moderate exercise at least three times a week. Many people fit into this definition so there should be a wide range of available subjects. To prevent them from feeling coerced they will sign an informed consent agreement prior to participating and are free to drop out of the study at any point.

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.

i. I will obtain informed consent from each subject prior to participating in the study, since they will all be over the age of 18 they can give their own consent. They will come in on day one to sign the papers before the study begins on day 2. I will check and make sure they sign the agreement form prior to allowing them to participate.

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.

i. The data collected will remain private; the only person to see the names of the subjects will be the primary researcher to correspond the names with their subject number. The informed consent agreements with their names
will be kept privately and will only be seen by the researcher. The information will not be left in a public setting, I will take all information and data collected with me and kept private. Subjects' numbers will not be able to related to the subject's name.

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

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

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

5. Is this project part of a grant? ☐ Yes or X 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 X No
   If Yes, explain the debriefing process here.

If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix ___ in the Policies and Procedures Manual.

Draft, April 7, 2005
Appendix C3
Individual Data Collection Sheet
Data Collection Sheet

Subject # ________________________-

Balance Error Scoring System

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<thead>
<tr>
<th>Trial 1 Stances</th>
<th>Firm</th>
<th>Foam</th>
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</thead>
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<td>Double Leg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Leg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tandem</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
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<td></td>
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</tbody>
</table>

<table>
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<th>Foam</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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Star Excursion Balance Test

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<th>Direction</th>
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<th>Distance Trial 2</th>
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<td></td>
</tr>
<tr>
<td>Lateral</td>
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</tr>
<tr>
<td>Posterior Medial</td>
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<tr>
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</tr>
<tr>
<td>Total</td>
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<td></td>
</tr>
</tbody>
</table>
APPENDIX C4

Pictures of the BESS and SEBT Test
Figure 4. BESS Test Double Leg Stance Firm

Figure 5 BESS Test Single Leg Stance

Figure 6 BESS Test Tandem Stance
Figure 7. BESS Test Double Leg Foam

Figure 8. BESS Single Leg Foam
Figure 9. BESS Tandem Foam

Figure 10. Star Excursion Balance Test
Appendix C5

Demographic Information
Demographic Information

Age: __________________________

School year: _________________

Gender: _________________

Sport: _________________

Injury History:
Any history of lower extremity injury, if so, date of last injury, type and severity:

Any history of head injury, if so, date of last injury, type, and severity?

Any neurological disorder that affect balance?

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

Contraindications for application of ice: (yes or no if known condition)

Raynauds phenomenon: yes/no

Cold allergy: yes/no

Poor circulation: yes/no

Diminished sensation: yes/no

Long-lasting/slow healing wounds: yes/no

REFERENCES


ABSTRACT

Title: THE EFFECTS OF CYROTHERAPY OVER THE LATERAL ANKLE ON STATIC AND DYNAMIC BALANCE

Researcher: Amber R Fisher, ATC, PES

Advisor: Dr. Thomas F. West

Date: May 2009

Research Type: Master's Thesis

Context: There has been conflicting results from the effects of cryotherapy on performance. There have been reports that there is no difference on performance following the application of ice and some have shown a difference in performance. Previous studies have not looked at both static and dynamic balance in a physically active population.

Objective: The purpose of this study was to examine the effects of cryotherapy on static and dynamic balance in a physically active population as measured by the Balance Error Scoring System (BESS) and the Star Excursion Balance Test (SEBT).

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

Setting: Controlled laboratory setting.

Participants: 20 physically active college students, who volunteered, with no current injury or cold contraindications.

Interventions: Subject were tested on 3 different days. The first day was a practice trial for the two tests. The second day was either under the ice trial or no ice trial. Each consisted of a pre-trial of both BESS and SEBT. The subjects then sat with ice or no ice for 20 minutes over the lateral ankle and then conducted an immediate post trial, and 10 minutes following the trial they repeated the two tests again. The subject repeated
the opposite trial on the following day following the same format.

Main Outcome Measures: Number of mistakes during the BESS tests in each the firm and firm ground and the total distance reached were gathered for the SEBT.

Results: The results showed that there was a significant difference from the application of cryotherapy comparing time and condition on static balance in both the firm and foam condition and on dynamic balance. The differences remained even after a 10 minute re-warming period, but gradually returning back to baseline measurements.

Conclusions: Professionals using cryotherapy on clients prior to participating in physical activity should not send them to participation immediately after application without a proper warm-up.

Word Count: 311