THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF KINESIOLOGY

# COMPARATIVE IMMEDIATE LOWER EXTREMITY PERFORMANCE OUTCOMES AMONG CRYOTHERAPEUTIC INTERVENTIONS AT THE ANKLE

EMILY E WILLIAMS
Spring 2012

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Athletic Training
with honors in Kinesiology

Reviewed and approved* by the following:

Sayers John Miller III
Assistant Professor of Kinesiology
Thesis Supervisor

Jinger Gottschall
Assistant Professor of Kinesiology
Honors Adviser

Giampietro "John" Vairo
Instructor of Kinesiology
Coordinator, Athletic Training Research Laboratory
Co-Thesis Supervisor

Lauren Kramer
Instructor of Kinesiology
Thesis Reader

Stephen Piazza
Associate Professor of Kinesiology
Honors Adviser

* Signatures are on file in the Schreyer Honors College

# ABSTRACT

COMPARATIVE IMMEDIATE LOWER EXTREMITY PERFORMANCE OUTCOMES AMONG CRYOTHERAPEUTIC INTERVENTIONS AT THE ANKLE

Williams EE*, Vairo GL*, Miller SJ*, Kramer LC*, Sebastianelli WJ†: Athletic Training and Sports Medicine Research Laboratory, *Department of Kinesiology, The Pennsylvania State University, University Park, PA; †Penn State Hershey Orthopaedics and Sports Medicine – State College, PA

**Objective:** To primarily investigate the immediate effects of cryotherapeutic modes to the ankle joint on lower extremity functional performance measures and in a physically active population. We hypothesized that cryotherapy would decrease performance when compared to the control and that concomitant compression would further hinder outcomes. **Design and Settings:** A crossover study was conducted in a controlled laboratory. The independent variable was treatment mode; no ice, ice without compression and ice with compression. Dependent variables included center of pressure (COP) excursions, dynamic balance and vertical jump height for the dominant leg. Participants underwent three separate testing sessions separated by 72-hour rest periods. The order of treatment and performance measures was randomized to prevent order effects. **Subjects:** Thirty (9 men, 21 women) healthy, physically active participants (20.6 ± 1.0 years, 1.7 ± 0.1 m, 67.5 ± 11.7 kg) were enrolled. **Measurements:** Normalized dynamic balance reach distances were assessed using the reliable modified Star Excursion Balance Test (SEBT). Center of pressure path length and average velocity were assessed via a force platform during a reliable static balance task under eyes-open and eyes-closed conditions. Relative vertical jump height was assessed using a reliable single-leg vertical hop test. Group means and standard deviations were calculated by treatment mode. One-way analyses of variance with Tukey's post hoc test calculated differences among treatment modes. $P < 0.05$ denoted statistical significance. **Results:** No statistically significant differences existed for all the performance measures among treatment modes {SEBT (%LL): anterior [no ice|75.1 ± 6.6; ice|77.0 ± 6.6, ice-compression|75.1 ± 6.6, $P = 0.568$]; posteromedial [no ice|103.2 ± 9.4, ice|104.1 ± 12.4, ice-compression|103.2 ± 9.4, $P = 0.849$]; posterolateral [no ice|94.8 ± 11.5, ice|98.3 ± 10.1, ice-compression|94.8 ± 11.5, $P = 0.499$]; COP path length (cm): eyes-open [no ice|36.3 ± 10.2, ice|34.3 ± 10.7, ice-compression|35.6 ± 10.6, $P = 0.835$], eyes-closed [no ice|76.6 ± 18.7, ice|75.9 ± 24.2, ice-compression|72.2 ± 22.9, $P = 0.713$]; COP average velocity (cm/s): eyes-open - [no ice|3.6 ± 1.0, ice|3.5 ± 1.1, ice-compression|3.6 ± 1.1, $P = 0.844$), eyes-closed - [no ice|7.5 ± 1.7, ice|7.6 ± 2.3, ice-compression|7.2 ± 2.3, $P = 0.800$];vertical jump height (cm): [no ice|24.8 ± 7.6; ice|22.9 ± 8.1, ice-compression|24.1 ± 7.0, $P$=0.610]}. **Conclusions:** Our findings suggest no immediate significant differences exist for lower extremity performance outcomes among the respective treatment modes to the ankle in a physically active population. Additional investigation is warranted to study the related delayed effects. **Word Count:** 400.

This study was funded by the Penn State Schreyer Honors College Summer Research Grant Program

# Table of Contents

## LIST OF FIGURES

## LIST OF TABLES

## ACKNOWLEDGEMENTS

There are many people who have made this research experience possible. I would like to thank all of the volunteers who participated in this study. I would also like to extend my sincere appreciation to the Athletic Training and Sports Medicine Research Laboratory assistants, Sam Debias, Itsuko Yamaguchi, and Jackie Harrigan. You made data collection seem so effortless. I would like to thank my lab partner and co-researcher, Erin Stokes for her friendship, assistance, expertise, and moral support. A big "thank you" to JV, for sharing his wealth of knowledge of research techniques, clinical skills, among many other valuable life skills. By example, he was a constant source of inspiration for me to become a better researcher, clinician, and person. Thank you to Dr. John Miller for his guidance, expertise, and extensive knowledge base. Collaborating with you has taught me so much that will be essential in the next level of my education. I would also like to thank Jinger for her continuing support and encouragement throughout this process.

I would like to thank my family and friends for their unconditional love and support. I feel blessed to have such a strong network of people who really care and show an interest in anything I am doing. It hasn't mattered if I am playing a sport or doing research or working in the training room, my family and friends have been an ear to listen, a shoulder to cry on, or even an extra ankle to tape.

Lastly, I would like to thank the Schreyer Honors College for their funding for this research project through the "Schreyer Honors College Summer Research Grant".

## CHAPTER 1: INTRODUCTION

Cryotherapy is one of the most commonly used therapeutic modalities in clinical physical rehabilitation settings. Eliciting anesthesia via cryotherapy is a goal often targeted by clinicians in treating patients suffering from musculoskeletal injury.[1] The analgesic response associated with cryotherapy is directly related to decreasing nerve conduction velocity of the nociceptor afferents, which is heighted as depth of cold penetration increases.[2] Cryotherapy has been estimated to reach to depths of approximately 2-4 cm in studies on the lower extremity.[3] However, the addition of compression via an elastic wrap is a common clinical practice that is suggested to increase the depth of cold penetration.[4] Through this mechanism, cryotherapy also reduces nerve conduction velocity of mechanoreceptor afferents and muscle spindle sensitivity.[3] This results in a decrease in the amount of afferent sensory information reaching the central nervous system potentially impairing neuromuscular control and subsequent functional performance deficits.[5-7] Such findings question the rationale for the clinical practice of applying cryotherapy prior to physical activity.[8]

A lack of evidence currently exists detailing the immediate effects of different cryotherapy interventions at lower extremity joints, such as the ankle, on performance outcomes. Thus, the purpose of this research study was to investigate the immediate effects of cryotherapy in the form of an ice pack, with and without compression, to the ankle on objective performance measures, including postural control and vertical jump height. Based on previous findings [2,5-7], we hypothesized that cryotherapy would decrease performance measures when compared to a control condition of no ice. Additionally, we hypothesized that ice with compression would elicit a greater decrease in performance when compared to ice without compression and a control condition of no ice.[2,4,9,10]

## CHAPTER 2: MATERIALS AND METHODS

### Experimental Design and Participant Demographics

A crossover experimental design was utilized for this research study. Healthy, physically active participants (**Table 2.1**) reported to the Athletic Training and Sports Medicine Research Laboratory for a total of three testing sessions lasting approximately one hour each session over the course of approximately two weeks. Before participating in the study, all participants gave written informed consent per Institutional Review Board guidelines. Sessions were separated by a 72-hour rest interval. Participants completed the testing sessions under three different conditions to the dominant leg: ice bag with compression applied to the ankle (**Figure 2.1)**, ice bag without compression applied to the ankle (**Figure 2.2**) and no ice or compression applied to the ankle. The cryotherapy sessions lasted exactly 20 minutes. The sequence in which participants progressed through different conditions was randomized via the generation of random permutations using a statistical software package (Minitab 16, Minitab Inc., State College, PA) to prevent order effects.

The necessary anthropometric measurements were initially taken. These included height, mass, and bilateral leg length measures. Body mass index was calculated from height and mass data. Leg length was measured from the inferior most border of the anterior superior iliac spine to the apex of the medial malleolus with the participant in a supine position. Immediately following the treatment condition as well as 10 and 20 minutes afterwards, participants completed a visual analog scale (VAS) as a means to offer subjective feedback regarding perception of pain or discomfort associated with the treatment conditions. Subsequent to the assigned treatment, participants' postural control and functional performance were measured via dynamic and static balance tasks, and a vertical hop task respectively. The order of executed tasks was randomized in a similar manner as previously described to prevent order effects.

**Table 2.1: Participant Demographics and Anthropometrics**

| | **M ± SD** |
|---|---|
| Participants | 30 |
| Sex (Men/Women) | 9/21 |
| Age (years) | 20.6 ± 1.0 |
| Height (m) | 1.70 ± 0.1 |
| Mass (kg) | 67.5 ± 11.7 |
| BMI ($kg/m^2$) | 23.7 ± 4.7 |

Values are Mean ± Standard Deviation

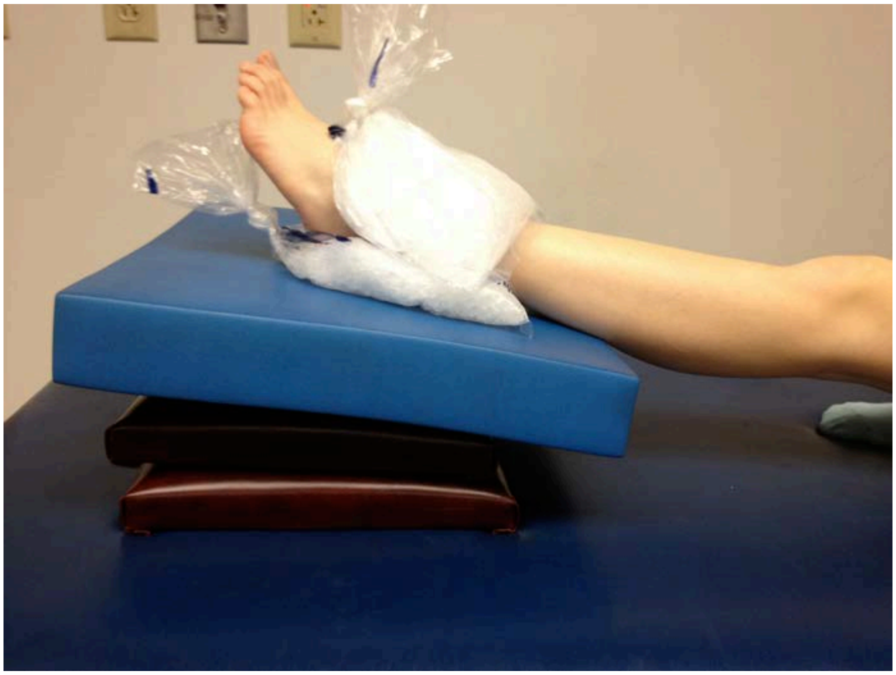


**Figure 2.1: Ice without compression**

**Figure 2.2: Ice with compression**

**Laboratory Techniques**

Objective Analyses

Dynamic Balance Measure: *Star Excursion Balance Test*

The goal of the Star Excursion Balance Test (SEBT) is to reach as far as possible with one leg in each of the three directions while maintaining balance upon the opposite leg. Sufficient ankle, knee, and hip ranges of motion are required to complete the task as well as adequate strength, proprioception and neuromuscular control. The SEBT is a functional screening tool that measures lower extremity reach while challenging the associated limitations of joint stability. Reliability of the SEBT has been investigated and reported in precious research studies.[11,12]

The SEBT was performed with the participant standing at the center of an outlined floor grid with eight lines extending at 45° angles from the center of the grid. The lines positioned on the grid were labeled according to the direction of excursion relative to the stance leg. The grid was constructed in an area using a protractor and 3 in (7.62 cm)-wide adhesive tape enclosed in a 182.9 cm by 182.9 cm square on a hard bare floor. Only three of the directions were used for this study, anterior, posterior medial, and posterior lateral, because these have been shown to the most effective in detecting chronic ankle instability.[13] Participants were given verbal instructions and a visual demonstration. To become familiar with the task Robinson & Gribble[14] recommended each participant perform four practice trials in each of the three directions for each leg. To perform the SEBT the participant maintained a single-leg stance while reaching with the opposite leg as far as possible along the appropriate direction. The participant contacted the furthest point possible on the line with a toe-touch using minimal pressure in order to ensure that stability is achieved through balance. An investigator manually measured the distance from the center of the grid to the touch point with a tape measure in centimeters. The same investigator took all reach measurements. Reach distance was marked and measured from the crosshair at the center of the star to the mark within 1 mm of precision. Three reaches in each direction (anterior, posteromedial, posterolateral) were recorded and normalized to participant leg length. The average of the three reaches for each leg in each of the three directions was calculated. Participants were given a 15 second rest interval between reach trials, a one- minute rest interval between practice trials and data collection trials as well as a two-minute rest interval between changes in reach direction. Order of excursions performed was randomized to control for learning as well as order effects. All trials were then performed in sequential manner per randomized order (**Figure 2.3**). Reach distance were normalized to leg length of the non-stance leg.

Trials were discarded and repeated if a participant did not touch the line with the reach leg while maintaining weight bearing on the stance leg, lost balance at any point in the trial or did not maintain initial and return positions for one full second. The trial was also discarded and repeated, if a participant touched down with the reach leg in a way that caused the reach leg to considerably support the body. The base of support was the stance foot for the entire trial with the fraction of a second in which the reach foot very lightly touched the ground. Participants performed the task with hands upon hips. At no time were verbal cues or communication of encouragement directed to participants performing this testing. The SEBT has been shown to be a valid measure of chronic ankle instability.[12,15]

**Figure 2.3: Anterior balance reach task**

Static Balance Measure: *Quiet single-leg balance task*

The goal of the quiet stance single-leg balance task is to stand barefoot on one leg while maintaining balance for a 10-second period. Trials were conducted with eyes open and eyes closed. During the eyes open condition, participants were instructed to stare at a black dot placed on the wall approximately 10-feet from the force-plate. The stance foot was placed in the same position for each trial and was precisely positioned on the Accusway force platform (AMTI Corp., Watertwon, MA).[16] The participant was instructed to stand as still as possible with their hands on their hips while keeping the non-stance leg bent at a 45° angle and at the side (**Figure 2.4**).[16-18] If the participant touched the ground with the non-stance foot during the trial or if their hands were lifted off of the hips, the trial was thrown out and repeated. At no time were verbal cues or communication of encouragement directed to participants performing this testing. Center of pressure excursion measures, specifically path length (cm) and average velocity (cm/s), were established through use of Balance Clinic computer software (AMTI Corp., Watertwon, MA). Center of pressure data has been commonly used in prior studies of chronic ankle instability.[16-18] These measures have been reliable in assessing static stability in comparison with the commonly used Rhomberg Test[19,20].

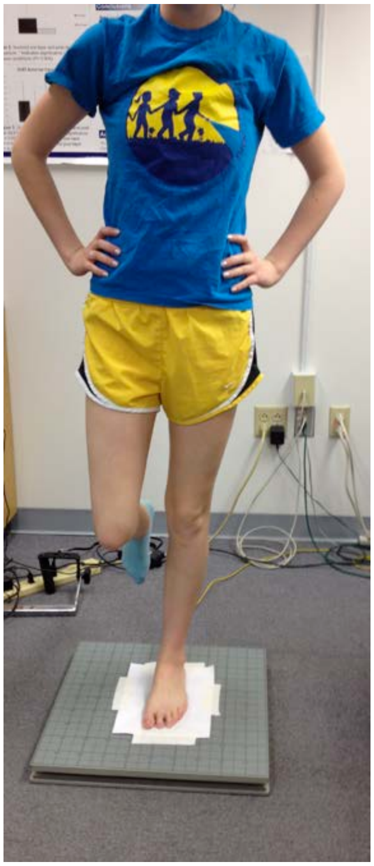


**Figure 2.4: Quiet standing balance**

Functional Performance Measure: *Single-leg vertical hop*

A Vertec unit was used to measure single-leg vertical hop height. Participants stood next to the Vertec on one foot with the arm closest to the Vertec raised overhead and their other arm behind their back.[21] We measured participants' maximal reach and total hop height and subtracted the two values to find maximum hop height. The single-leg vertical hop has been used in a number of other studies examining functional performance post-cryotherapy[6,21,22] and is reported to closely simulate the functional stability that is encountered in sporting activities[21] (**Figure 2.5**).

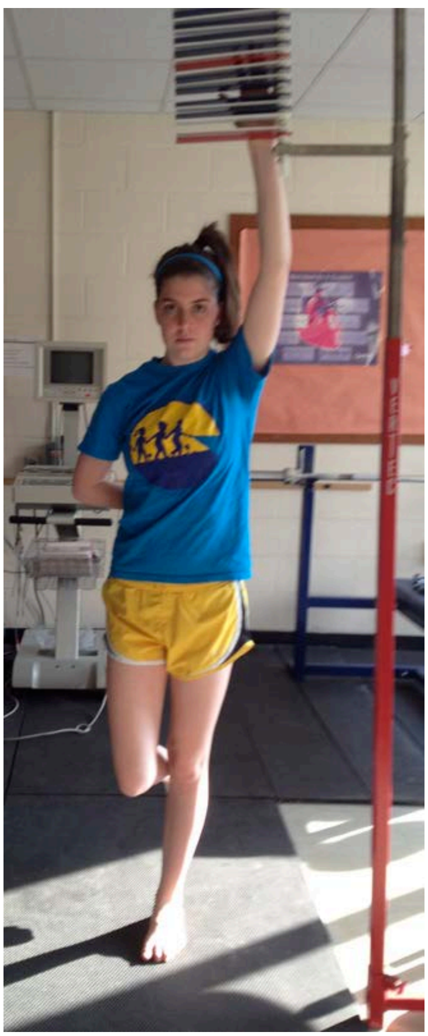


**Figure 2.5: Single-leg vertical hop**

Subjective Analysis

Perception of pain: *Visual Analog Scale*

Upon completion of the icing conditions, a VAS, represented by a 6.75 cm horizontal line, (**Figure 2.6**), was administered to participants in order to subjectively measure perceived pain at specific time points after icing. The time points were 0-minutes, 10-minutes and 20-minutes after icing. Participants were asked to mark a point on the line that best represented where their pain was at the given time. A ruler was used to measure the distance from the left anchor of the line to the related point marked by the participant. The measured value, in centimeters, was then converted to a percentage.

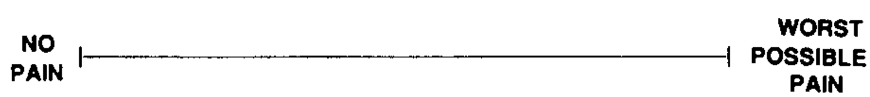



**Figure 2.6: Visual Analog Scale (VAS) for perceived pain**

Statistical Analysis

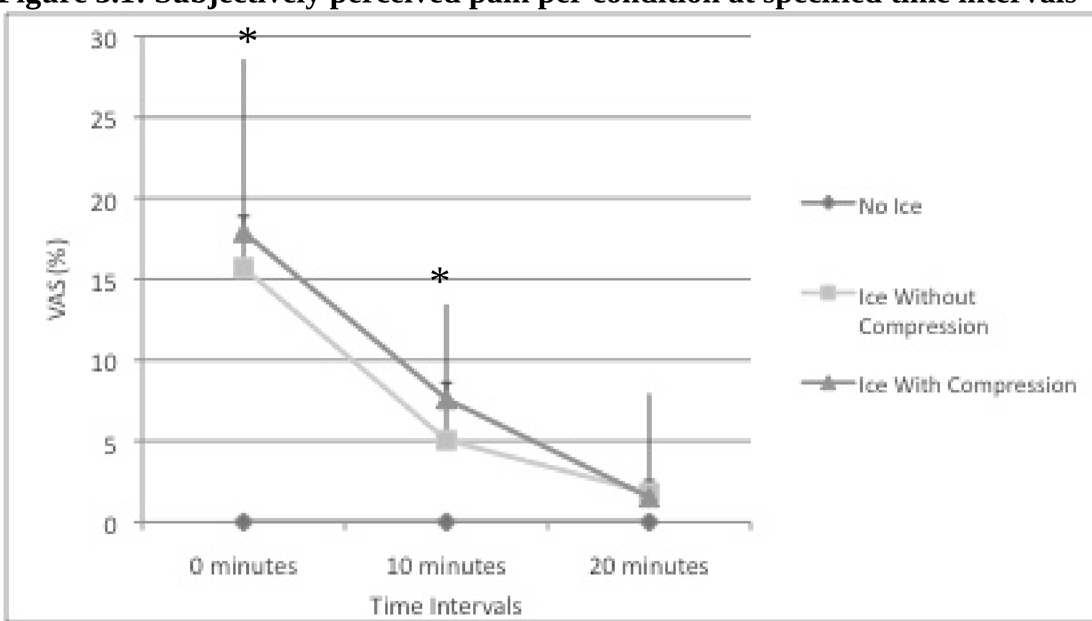
Descriptive statistics, including group means and standard deviations were calculated for the dependent variables of interest.  A one-way analysis of variance (ANOVA) was calculated to examine differences among the dependent variable means for the three conditions.  Residual analyses were conducted to ensure the data met the necessary assumptions for ANOVA.  An *a priori* alpha level of $P < 0.05$ denoted statistical significance.  When indicated, Tukey's Honestly Significant Difference post hoc test was calculated to examine pairwise comparisons among the three conditions.  A 95% simultaneous confidence interval was used to denote statistically significant pairwise comparisons.

## CHAPTER 3: RESULTS

### Perceived Pain to Cryotherapy

Residual analyses of the data set confirmed it met necessary assumptions for ANOVA. A statistically significant difference in pain was found among conditions (no ice, ice with compression, and ice without compression) when assessing perceived pain at 0-minutes ($P = 0.000$) and 10-minutes ($P = 0.002$) post-cryotherapy (**Figure 3.1**). These differences existed between the no-ice and both icing conditions at 0-minutes post-cryotherapy and between the no-ice and ice with compression conditions at 10-minutes post-cryotherapy (**Table 3.1**, **Table 3.2**, **Table 3.3**).

**Figure 3.1: Subjectively perceived pain per condition at specified time intervals**




*Denotes statistical significance ($P < 0.05$)
Error bars represent standard deviations (ice without compression: no cap; ice with compression: cap)

**Table 3.1: Subjective pain measures (%) 0-minutes post-cryotherapy**

| Pairwise comparisons | M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|
| No Ice vs: | 0 ± 0 | |
| Ice Without Compression | 15.7 ± 12.9 | (7.74, 23.62)* |
| Ice With Compression | 17.9 ± 18.3 | (9.94, 25.82)* |
| Ice Without Compression vs: | 15.7 ± 12.9 | |
| Ice With Compression | 17.9 ± 18.3 | (-5.74, 10.14) |

M = mean, SD = standard deviation
* Denotes statistical significance

**Table 3.2: Subjective pain measures (%) 10-minutes post-cryotherapy**

| Pairwise comparisons | M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|
| No Ice vs: | 0 ± 0 | |
| Ice Without Compression | 5.06 ± 8.4 | (-0.059, 10.182) |
| Ice With Compression | 7.60 ± 11.8 | (2.484, 12.725)* |
| Ice Without Compression vs: | 5.06 ± 8.4 | |
| Ice With Compression | 7.60 ± 11.8 | (-2.577, 7.664) |

M = mean, SD = standard deviation
* Denotes statistical significance

**Table 3.3: Subjective pain measures (%) 20-minutes post-cryotherapy**

| Pairwise comparisons | M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|
| No Ice vs: | 0 ± 0 | |
| Ice Without Compression | 1.80 ± 6.1 | (-1.343, 4.948) |
| Ice With Compression | 1.53 ± 6.4 | (-1.615, 4.677) |
| Ice Without Compression vs: | 1.80 ± 6.1 | |
| Ice With Compression | 1.53 ± 6.4 | (-3.418, 2.874) |

M = mean, SD = standard deviation

**Dynamic Balance**

Residual analyses of the data set confirmed it met necessary assumptions for ANOVA. There were no statistically significant differences between conditions when assessing reach distances (anterior: P = 0.568; posteromedial: P = 0.849; posterolateral: P = 0.499) for the SEBT (**Table 3.4, Table 3.5, Table 3.6**).

**Table 3.4: Anterior reach distance measures (%LL)**

| Pairwise comparisons | M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|
| No Ice vs: | 75.1 ± 6.6 | |
| Ice Without Compression | 77.0 ± 6.6 | (-2.877, 5.653) |
| Ice With Compression | 75.1 ± 6.6 | (-4.721, 3.819) |
| Ice Without Compression vs: | 77.0 ± 6.6 | |
| Ice With Compression | 75.1 ± 6.6 | (-6.104, 2.436) |

M = mean, SD = standard deviation

**Table 3.5: Posteromedial reach distance measures (%LL)**

| Pairwise comparisons | M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|
| No Ice vs: | 103.2 ± 9.4 | |
| Ice Without Compression | 104.1 ± 12.4 | (-7.36, 6.09) |
| Ice With Compression | 103.2 ± 9.4 | (-8.33, 5.12) |
| Ice Without Compression vs: | 104.1 ± 12.4 | |
| Ice With Compression | 103.2 ± 9.4 | (-7.70, 5.75) |

M = mean, SD = standard deviation

**Table 3.6: Posterolateral reach distance measures (%LL)**

| Pairwise comparisons | M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|
| No Ice vs: | 94.8 ± 11.5 | |
| Ice Without Compression | 98.3 ± 10.1 | (-4.85, 9.30) |
| Ice With Compression | 94.8 ± 11.5 | (-8.32, 5.83) |
| Ice Without Compression vs: | 98.3 ± 10.1 | |
| Ice With Compression | 94.8 ± 11.5 | (-10.55, 3.61) |

M = mean, SD = standard deviation

**Static Balance**

Residual analyses of the data set confirmed it met necessary assumptions for ANOVA. There were no statistically significant differences among conditions when assessing center of pressure excursions under eyes open (path length: $P = 0.835$; average velocity: $P = 0.844$) (**Table 3.7**) and eyes closed (path length: $P = 0.713$; average velocity: $P = 0.800$) conditions (**Table 3.8**).

**Table 3.7: Static balance center of pressure excursions; eyes open condition**

| **Pairwise comparisons** | **Path Length (cm) M ± SD** | **95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)** | **Average Velocity (cm/s) M ± SD** | **95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)** |
|---|---|---|---|---|
| No Ice vs: | 36.3 ± 10.2 | | 3.62 ± 1.0 | |
| Ice Without Compression | 34.3 ± 10.7 | (-8.09, 4.84) | 3.47 ± 1.1 | (-0.806, 0.491) |
| Ice With Compression | 35.6 ± 10.6 | (-7.14, 5.79) | 3.56 ± 1.1 | (-0.712, 0.585) |
| Ice Without Compression vs: | 34.3 ± 10.7 | | 3.47 ± 1.1 | |
| Ice With Compression | 35.6 ± 10.6 | (-5.51, 7.42) | 3.56 ± 1.1 | (-0.554, 0.743) |

M = mean, SD = standard deviation

**Table 3.8: Static balance center of pressure excursions; eyes closed condition**

| Pairwise comparisons | Path Length (cm) M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) | Average Velocity (cm/s) M ± SD | 95% Simultaneous Confidence Interval (Lower Bound, Upper Bound) |
|---|---|---|---|---|
| <u>No Ice vs:</u> | 76.6 ± 18.7 | | 7.53 ± 1.7 | |
| Ice Without Compression | 75.9 ± 24.2 | (-14.25, 12.94) | 7.55 ± 2.3 | (-1.290, 1.342) |
| Ice With Compression | 72.2 ± 22.9 | (-17.95, 9.24) | 7.22 ± 2.3 | (-1.623, 1.009) |
| <u>Ice Without Compression vs:</u> | 75.9 ± 24.2 | | 7.55 ± 2.3 | |
| Ice With Compression | 72.2 ± 22.9 | (-17.29, 9.89) | 7.22 ± 2.3 | (-1.648, 0.984) |

M = mean, SD = standard deviation

**Functional Performance**

Residual analyses of the data set confirmed it met necessary assumptions for ANOVA. There were no statistically significant differences among conditions when assessing single-leg vertical hop height (P = 0.610) (**Table 3.9**).

**Table 3.9: Single-leg vertical hop measures (cm)**

| **Pairwise Comparisons** | **Hop Height M ± SD** | **95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)** |
|---|---|---|
| No Ice vs: | 24.8 ± 7.58 | |
| Ice Without Compression | 22.9 ± 8.13 | (-4.85. 9.30) |
| Ice With Compression | 24.1 ± 6.99 | (-8.32, 5.83) |
| Ice Without Compression vs: | 22.9 ± 8.13 | |
| Ice With Compression | 24.1 ± 6.99 | (-10.55, 3.61) |

M = mean, SD = standard deviation

## CHAPTER 4: DISCUSSION

The purpose of this study was to examine the effects of cryotherapy to the ankle joint on dynamic and static balance and functional performance. We hypothesized that ice applied to the ankle would decrease balance as well as functional performance due to the proprioceptive and nerve conduction velocity decrements associated with cryotherapy[23]. Furthermore, based on previous findings[2], we hypothesized that added compression to a cryotherapeutic treatment would result in heightened deficiencies with the aforementioned measures. However, our results indicated no decreases in dynamic and static balance or functional performance regardless for the type of cryotherapeutic intervention, when compared among the different treatment or baseline conditions.

We attribute the lack of deficits in our study to the fact that we iced a joint; while previous studies[21,22,24] demonstrating negative clinical effects have targeted muscle tissue. This observation also contributes to the conflicting results of many comparable prior studies investigating a similar cryotherapeutic modality theme. Prior findings lend to the notion that cooling the tissues surrounding a joint[24,25] will affect proprioception differently than cooling muscle tissue[21,22,24]. For example, the application of cryotherapy to a joint has not been conclusively shown to alter joint position sense, which would theoretically lend to proprioceptive deficits.[7,26] Cryotherapy effects nerve conduction velocity[3] which would ultimately lead to a decrease in proprioception as evidenced by related studies where a muscle was cooled. Cooling a muscle inhibits muscle spindles, as well as adenosine triphosphate production and impairs calcium release[7]. Studies have proposed that the cooling of a joint elicits different responses.[24,25]

The findings observed in our research study complement those of studies where a joint was cooled. Hopkins et al[24,25] proposed that the physiological mechanisms that elicited such outcomes may be attributed to alterations in afferent input from the skin and joint receptors as well as altered supraspinal drive due to joint cooling[27]. For example, cryotherapy has been shown to increase joint and musculotendinous stiffness[28] as well as inhibit the golgi tendon organ (GTO); thereby lending to heightened muscular performance about a joint[29]. Thus, such physiological mechanisms may serve as a basis for the lack of balance and functional performance noted in our study, which supports the work of Hopkins et al[24,27].

The fact that we observed no differences in outcome measures when assessing the addition of compression with ice is also a noteworthy finding. Previous investigators have eluded to compression potentially increasing the depth of penetration for a cryotherapeutic modality such as ice[2], which we assumed would result in heightened performance measure decrements. In prior studies[21,22], where muscle tissue was iced, further deficiencies in performance were noted after an ice bag was applied to the respective area with added compression when compared with no compression. However, our study, which targeted cryotherapy to the ankle joint, reported no such differences. The basis for our contrasting results for this variable, when compared to prior studies[21,22], may stem from the different responses elicited when icing a joint or muscle. Depth of penetration is dependent upon many factors, such as structural and material characteristics of the tissues being cooled, which include: thickness, density and overlying adiposity[2] The ankle joint does not have a considerable amount of thick and dense soft tissues that envelope the area as opposed to mid-body segments such as the thigh and shank, which possess the thick and dense muscle tissues overlaid with adipose.

## Perceived Pain to Cryotherapy

Gauging perceived pain responses to cryotherapy was not a primary aim of our research study. Instead, the inclusion of such data was incorporated as a descriptive component. Nonetheless, we did note interesting results that may aid clinicians and researchers that are interested in this specific variable. Upon the application of ice, the amount of perceived pain was significantly greater in the ice with and without compression conditions compared to no ice at the 0-minute time point. This finding was expected due to the typical perceived responses associated with the application of ice.[30] Interestingly, at the 10-minute time point, participants also reported significantly more pain when undergoing the ice with compression condition when compared to no ice. However, this response was not noted when comparing the ice without compression condition to no-ice. Such a descriptive finding may be associated with the depth of penetration theory related to compression.[4] Yet, additional study is necessary to compared or contrast our results for this variable as a means to support or oppose this theory and better profile comprehensive perceived responses to pain associated with different modes of cryotherapy.

## Dynamic Balance

Few studies have examined the effects of cryotherapy on dynamic balance but our results are similar to one investigation that did. Miniello et al[31] examined time to stabilization from a jump-landing task, as an index of dynamic balance, following a lower leg cold water-ice immersion treatment and found no associated deficiencies. In instances where our results contrast those of prior similar studies, related discrepancy may be attributed to differences in the experimental methods used. For example, we focused our cryotherapeutic intervention to the ankle joint, where as other investigations targeted muscle tissue[21,22]. As previously discussed, dynamic balance outcomes may differ based on the premise that joints and muscle tissue respond differently to cryotherapy, which may account for conflicting reports in the related literature. Thus, physiological mechanisms, such as muscle inhibition[24,25], may contribute to dynamic balance decrements in studies reporting such findings that iced muscle tissue.

**Static Balance**

We reported no significant differences for static balance among our cryotherapeutic conditions to the ankle when compared to one another or to baseline. Similarly, Saam et al[32] and Kernozek et al[33] found that postural sway, a measure of static balance, was not effected by an ice bag application to the ankle when compared to a baseline or control. Furthermore, our results complement Rubley et al[34] who found no significant differences in mediolateral and anteroposterior center of pressure distance measures following a cold-water immersion to the lower extremity.

Proprioception is central in maintaining posture, balance, joint position sense and coordination of multi-joint movements[26]. Though we did not directly measure proprioception or components of it, such as joint position sense and kinesthesia, our outcomes, which suggest a crude indication of neuromuscular control capacity, propose cryotherapy did not have a detrimental effect on the proprioceptive information used to maintain balance. This theme has been previously demonstrated in comparative cryotherapy studies focal to the lower extremity. For example, Thieme et al[26] examined the effects cryotherapy on proprioception at the knee by examining joint angle reproduction. In their results, cryotherapy did not significantly affect joint position sense at the knee.

## Functional Performance

There are many studies that have examined the effects icing has on functional performance; however, the majority of these studies have applied a cryotherapeutic intervention to muscle tissue. Richendollar et al[21] studied three measures of functional performance and how they were affected by an ice bag application to the anterior thigh. The ice proved to be detrimental to the shuttle run, single-leg vertical hop and 40-yard sprint. Similarly, Fischer et al[22] found a decrease in functional performance on the shuttle run and single-leg vertical hop immediately after icing the hamstrings muscle group. Wassinger et al[7] reported complementary results when upon icing the shoulder joint and noting deficits in throwing accuracy. Conversely, we found no significant decrements in functional performance among cryotherapy conditions and when cyrotherapy was compared to baseline. We attribute the discrepancies in our data and previous studies[7,21,22] to the fact that we localized our cryotherapy to the ankle joint and not musculature.

Hopkins et al[25] noted that localized cooling of the ankle joint increased surrounding muscle activity, reflex amplitude and allowed for greater force production about the respective joint. Furthermore, Hopkins et al[24] reported an increase in peroneus longus activation that lasted approximately 60 minutes post-cryotherapy applied to the ankle joint. An increase in ankle joint stiffness following cyrotherapy was also noted by Evans et al[35] who subsequently found no associated decrease in agility task performance. Evans et al[36] attributed the lack of a detrimental effect on agility task performance to the fact that the ice was applied 8 cm above the lateral malleolus, which is below the large muscle groups of the lower leg. Comparably, the cryotherapeutic intervention was applied similarly in our research study, which may explain why we observed no functional performance deficits.

## Clinical Implications

Base on our findings, icing the ankle joint does not appear to detrimentally affect dynamic and static balance or functional performance for the dominant leg in a healthy population without ankle injury. Furthermore, compression applied with ice does not appear to differ to ice without the application of compression for the dominant leg in a related population. These data may help clinicians make more informed decisions regarding icing before physical activity as commonly performed in athletic training and sports medicine. With this information, clinicians could use cryotherapy in a more effective way while being educated of the different responses associated with icing a joint or muscle tissue as well as the impact of applied compression with ice to a joint. However, further research is needed to examine the mechanisms that underpin the various affects of icing different tissues.

## Limitations

All participants in the present study had uninjured ankles. Since cryotherapy is indicated for acute injuries, the injury or inflammation present after injury may not make these results applicable to an injured population. We also studied a relatively young participant pool (mean age = 20.6 ± 1.0). Results may differ in an older population. Also, participants were recreationally active and more competitive participants could have responded differently to the cryotherapy conditions. We also limited our study to the immediate effects of ice; however, continued study is necessary to determine if delayed effects exist. Moreover, changes in surface and subcutaneous temperature were not measured. As such, we assumed that our cryotherapy applications penetrated to depths that would possibly cause a change in our measures. Furthermore, we did not investigate if compensatory mechanisms at the knee, hip or trunk contributed to outcome measures we noted. Additionally, a blind study would have prevented examiner biased.

## CHAPTER 5: CONCLUSION

In conclusion, our research study demonstrated that cryotherapy was not detrimental to dynamic and static balance as well as functional performance. Additionally, we found that cryotherapy in combination with external compression did not decrease balance and functional performance more than just cryotherapy alone. We attribute our lack of significance to fact that we localized the cryotherapy to a joint rather than a muscle. Based on our results, we propose that the immediate effects of cryotherapy applied to the ankle joint are not detrimental to balance and performance. Further research is warranted to examine the differential effects of icing a muscle and icing a joint as well as the delayed effects.

## REFERENCES


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

**2.** Levy AS, Kelly B, Lintner S, Speer K. Penetration of cryotherapy in treatment after shoulder arthroscopy. *Journal of Arthroscopic and Related Surgery.* 1997;13:461-464.

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

**4.** Bleakley C, McDonough S, MacAuley D. The use of ice in the treament of acute soft-tissue injury: A systematic review of randomized controlled trials. *Am J Sports Med.* 2004;32(1):251-261.

**5.** Costello JT, Donnelly AE. Cryotherapy and joint position sense in healthy participants: a systematic review. *J Ath Train.* 2010;45(3):306-316.

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

**7.** Wassinger CA, J B Myers, Gatti JM, Conley KM, Lephart SM. Proprioception and throwing accuracy in the dominant shoulder after cryotherapy. *J Ath Train.* 2007;47:84-89.

**8.** Lephart SM, Pincivero DM, JK JKG, Fu FH. The role of proprioception in the management and rehabilitation of athletic injuries. *Am J Sports Med.* 1997;25:130-137.

**9.** Merrick MA, Knight KL, Ingersoll CD, Potteiger JA. The effects of ice and compression wraps on intramuscular temperature at various depths. *J Ath Train.* 1993;28(3):236-245.

**10.** Lowden BJ, Moore RJ. Determinants and nature of intramuscular temperature changes during cold therapy. *Am J Phys Med.* 1975;54(223-228).

**11.** Kinzey S, Armstrong C. The reliability of the Star Excursion test in assessing dynamic balance. *J Orthop Sports Phys Ther.* 1998;27:356-360.

**12.** Hertel J, Miller SJ, Denegar CR. Intratester and intertester reliability during the Star Excursion Balance Test. *J Sports Rehab.* 2009;9(2):104-116.

**13.** McKeon PO, Ingersoll CD, Kerrigan DC, Saliba E, Bennett BC, Hertel J. Training improves function and postural control in those with chronic ankle instability. *Med Sci Sports Exerc.* 2008;40(10):1810-1819.

**14.** Robinson RH, Gribble PA. Support for a reduction in the number of trials needed for the Star Excursion Balance Test. *Arch Phys Med Rehabil.* 2008;28:364-370.

**15.** Gribble PA, Hertel J. Considerations for normalizing measures of the Star Excursion Balance Test. *Meas Phys Educ Exerc Sci.* 2003;7(2):89-100.

**16.** Gribble PA, Hertel J, Denegar CR. Chronic ankle instability and fatique create proximal joint alterations during performance of the Star Excursion Balance Test. *Int J Sports Med.* 2007;28:236-242.

**17.** Hertel J, Olmsted-Kramer LC. Deficits in time-to-boundary measures of postural control with chronic ankle instability. *Gait and Posture.* 2007;25:33-39.

**18.** Hertel J, Olmsted-Kramer LC, Challis JH. Time-to-boundary measures of postural control during single leg quiet standing. *J Appl Biomech.* 2006;22:67-73.

**19.** Palmieri RM, Ingersoll CD, Stone MB, Krause BA. Center-of-pressure parameters used in the assessment of postural control. *J Sports Rehab.* 2002;11:51-66.

**20.** LeClair K, Riach C. Postural stability measures: what to measure and for how long. *Clin Biomech (Bristol, Avon).* 1996;11:176-178.

**21.** Richendollar ML, Darby LA, Brown TM. Ice bag application, active warm-up, and 3 measures of maximal functional performance. *J Ath Train.* 2006;41(4):364-370.

**22.** Fischer J, VanLunen BL, Branch JD, Pirone JL. Functional performance following an ice bag application to the hamstrings. *J of Strength and Conditioning Research.* 2009;23(1):44-50.

**23.** Hopper D, Whittington D, Davies J. Does ice immersion influence ankle position sense? *Physiother Res Int.* 1997;2:223-236.

**24.** Hopkins JT, Hunter I, McLoda T. Effects of ankle joint cooling on peroneal short latency response. *J of Sports Science and Medicine.* 2006;5(333-339).

**25.** Hopkins JT, Adolph JT. Effects of joint cryotherapy on lower chain function. *Clinical Kinesiology.* 2003;57(3):42-48.

**26.** Thieme HA, Ingersoll CD, Knight KL, Ozmun JC. Cooling does not affect knee proprioception. *J Ath Train.* 1996;31:8-11.

**27.** Oksa J, Rintamaki H, Rissanen S, Rytky S, Tolonen U, Komi PV. Stretch adn H-reflexes of the lower leg during whole body cooling and local rewarming. *Aviation, Space, and Environmental Medicine.* 2000;71:156-161.

**28.** LeBlanc JS. Impairment of manual dexterity in the cold. *J Appl Physiol.* 1956;9:62-64.

**29.** Turner AN, Jeffreys I. The stretch-shortening cycle: proposed mechanisms and methods for enhancment. *Strength and Conditioning Journal.* 2012;32(4):87-99.

**30.** Ingersoll CD, Magnus BC. Sensations of cold reexamined: a study using the McGill Pain Questionnaire. *Athletic Training.* 1991;26:240-245.

**31.** Miniello S, Dover G, Powers M, Tillman M, Wikstrom E. Lower leg cold immersion does not impair dynamic stability in healthy women. *J Sports Rehab.* 2005;14(3):234 247.

**32.** Saam F, Leidinger B, Tibesku CO. The influence of cryotherapy of the ankle on static balance. *Sportsverletz Sportschaden.* 2008;22(1):45-51.

**33.** Kernozek TW, Greany JF, Anderson DR. The effect of immersion cryotherapy on medial-lateral postural sway variability in individuals with a lateral ankle sprain. *Physiother Res Int.* 2008;13(2):107-118.

**34.** Rubley MD, Gruenenfelder AR, Tandy RD, Holcomb WR. Effects of cold and warm bath immersions on postural stability. *J Ath Train.* 2004;39(suppl 2):S-33.

**35.** Evans TA, Ingersoll C, Knight KL, Worrell T. Agility following the application of cold therapy. *J Ath Train.* 1995;30(3):231-234.

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

**37.** Haines J. A survey of recent developments in cold therapy. *Physiotherapy.* 1967;53:222.

**38.** Riemann BL, Lephart SM. The sensorimotor system, part 1: the physiologic basis of functional joint stability. *J Ath Train.* 2002;37:71-79.

**39.** Lephart SM, Pincivero DM, Rozzi SL. Proprioception of the ankle and knee. *Sports Med.* 1998;25(3):149-155.

**40.** Uchio Y, Ochi M, Fujihara A, Adanachi N, Iwasa J, Sakai Y. Cryotherapy influences joint laxity and position sense of the healthy knee joint. . *Arch Phys Med Rehabil.* 2003;84:131-135.

**41.** LaRiviere J, Osternig LR. The effect of ice immersion on position sense. *J Sports Rehab.* 1994;3:58-67.

**42.** Risberg MA, Ekeland A. Assessment of functional tests after anterior cruciate ligament surgery. *J Orthop Sports Phys Ther.* 1994;19:212-217.

**43.** Semnick D. The vertical jump. *Natl Strength Cond Assoc.* 1990;12:68-69.

**44.** Kinzey SJ, Cordova ML, Gallen KJ, Smith JC, Moore JB. The effects of cryotherapy on ground reaction forces produced during a functional task. *J Sports Rehab.* 2009;9:3-14.

**45.** Ingersoll CD, Knight KL, Merrick MA. Sesnory Perception of the foot and ankle following therapeutic application of heat and cold. *J Ath Train.* 1992;27:231-234.

**46.** Rubley MD, Denegart CR, Buckley WE, Newell KM. Cryotherapy, sensation, and isometric-force variability. *J Ath Train.* 2003;38(2):113-119.

## REVIEW OF LITERATURE

Cryotherapy is a commonly used modality in sports medicine and rehabilitation. It is typically used to decrease pain and limit swelling.[1] Although these positive effects are attributed to cryotherapy, other potentially detrimental effects on somatosensory system function, neuromuscular control, and functional task performance have been suggested.[3,6,7,21]

### *Physiologic Effect of Cryotherapy*

Cryotherapy has been proven to control muscle spasticity through mechanisms involving negative feedback and muscle inhibition. Cold diminishes the sensitivity of the muscle spindles, which detect static tension load, and the rate of change of that tension within the muscle.[1,36] Cold is indicated for pain control where muscle spasms are the cause of pain. In addition to controlling muscle spasms, cold has been proven to depress the excitability of free nerve endings and peripheral nerve fibers[1,37] as well as decreasing nerve condition velocity and increasing pain threshold.[3]

### *Cryotherapy and Proprioception*

A commonly used way to assess neuromuscular control, the reflexive activation of muscular patterns to provide stability[38], in a joint is looking at postural sway and balance.[39] Uchio et al[40] reported a decrease in afferent proprioception from the knee after the used of cryotherapy. Wassinger et al[7] investigated the affect cryotherapy has on proprioception in the shoulder. They observed a decrease in proprioception and throwing accuracy through active joint position replication, path of motion replication, and a functional throwing index after a 20-minute cryotherapy application. Additionally, Hopper et al[23] found a decrease in ankle proprioception after a 15-minute ankle immersion. Since efferent activation of muscle by the central nervous system requires accurate afferent somatosensory information, a decrease in afferent somatosensory information could thereby decrease functional stability in a joint potentially leading to injuries. Conversely, LaRiviere et al[41] reported no significant decrease in joint position sense and proprioception in the ankle joint after cryotherapy.

*Cryotherapy and Balance*

Balance is a measure of neuromuscular control and is vital in preventing injury.[8] A commonly used method to assess neuromuscular control, the reflexive activation of muscular synergies in response to afferent somatosensory information to provide joint stability[38], is looking at a measure of balance mechanisms.[39] The effect of cryotherapy on balance is unclear. Some authors report a negative relationship between balances as measured by postural sway and cryotherapy, while other report no effect.

Kernozek et al[33] found that balance was negatively affected by ice immersion. This was thought to be the result of increased area of surface contact because of the depth of muscle cooling resulting in cooling of proprioceptive receptors and muscles resulting in decreased strength. Conversely, Miniello et al[31] observed no negative effects of ice immersion on dynamic stability and Rubley et al[34] also found no negative effects on static stability.

*Cryotherapy and Single-Leg Vertical Hop*

The single-leg vertical hope test as a very reliable way of measuring an athlete's performance ability and has been reported to most closely simulate the functional stability experienced during sport activities.[42,43]Many studies have observed decreases in performance on a single-leg vertical hop test after the application of ice.[6,21] This decrease was thought to be the result of decreased muscle spindle activity in the triceps surae muscle group and decreased nerve conduction velocity.[6,44] However, many other studies showed no significant decrease in functional performance.[23,45,46]

Functional performance has been measured through other tasks such as a shuttle run, 40-yard sprint, and a carioca task. Evans et al[35] examined agility in the form of a shuttle run, carioca task, and a cocontraction test and found that there was no decrease in agility after a lower leg ice immersion. Conversely, Fischer et al[22] examined functional performance using the cocontration test, shuttle run, and single leg vertical hop following an ice bag application to the hamstrings. They found that there was a decrease in functional performance after cryotherapy was applied to the hamstrings.

**APPENDIX A**

PENNSTATE

# Athletic Training Research Laboratory

Research Volunteers Needed

*Are you interested in learning more about the effects icing has on balance and functional performance?*

*If so, you may be interested in participating in our research study at Penn State.*

**Measurements:** single-leg balance and functional performances and perception of cold questionnaires

**Purpose:** Study the effects of icing on observed single-leg balance and functional performance.

Three one-hour sessions at the Athletic Training Research Laboratory in 21D Recreation Building

**Requirements:**

- Men and women ages 18 – 35 years old
- Good general health
- Non-smoker or consumer of nicotine products
- Not overweight

***Research participants will be given a $10.00 compensation after completion of the study***

Dr S John Miller, John Vairo, Dr Lauren C Kramer, Dr Wayne Sebastianelli, and Emily Williams
Departments of Kinesiology, Orthopaedics and Rehabilitation

For more information, contact John Vairo at
glv103@psu.edu or 814-865-2725

PENNSTATE 1855

| | |
|---|---|
| **Title of Project:** | Comparative Stability and Performance Outcomes Among Cryotherapeutic Interventions |
| **Principal Investigator(s):** | Giampietro L Vairo, MS, ATC and Emily E. Williams |
| **Other Investigator(s):** | Sayers John Miller, PhD, PT, ATC and Wayne J Sebastianelli, MD |
| **Research Support:** | Lauren C. Kramer, PhD, ATC |
| **Verbal Script:** | Healthy Young Adults (18-35 years old) |

Hello, my name is (*Penn State Institutional Review Board-approved investigator*) and I work with the Athletic Training Research Laboratory at Penn State. I am currently looking for research volunteers and was wondering if you would be interested in participating or at least hearing more about this study. I am looking for a group of participants who are 18 to 35 years old, have no history of lower body or low-back injury in the past six months and no related surgeries. Participants in this research study should be in good general health, not overweight and non-smokers. If you are undergoing physical therapy or sports rehabilitation under the supervision of a physical therapist or athletic trainer you will not be eligible to participate. I will be examining how various cryotherapeutic interventions may affect postural control and functional performance in healthy young adults. If you are interested in participating, you would be required to come to the Athletic Training Research Lab in 21D & E Recreation Building for a total of three testing sessions lasting approximately one hour each over the course of approximately two weeks. During the testing sessions we will measure your postural control abilities, as you will be asked to perform two balancing exercises as well as your performance in a functional single-leg hop for height. During the sessions you will be exposed to three cryotherapeutic interventions; ice with compression, ice without compression, and no ice. As a participant we will be happy to provide you with your specific data results. If you have any questions or need to get in touch with our research group for any reason, please call or e-mail John Vairo at 814-865-2725 or glv103@psu.edu. Thank you.

PENNSTATE

1855

| | |
|---|---|
| **Title of Project:** | Comparative Stability and Performance Outcomes Among Cryotherapeutic Interventions |
| **Principal Investigator:** | Emily E. Williams |
| **Project Coordinator:** | Giampietro L Vairo, MS, ATC |
| **Other Investigator(s):** | Sayers John Miller, PhD, PT, ATC and Wayne J Sebastianelli, MD |
| **Research Support:** | Lauren C. Kramer, PhD, ATC |
| **Screening Checklist:** | Healthy Young Adults (18-35 years old) |

**Participant Identification Number:**________________________________________

As a general health screen, you must be able to answer 'YES' to the following questions.

1. Are you between 18 to 35 years old? **Yes** **No**
2. Do you speak English? **Yes** **No**
3. Do you read at a minimum of an eighth-grade level? **Yes** **No**
4. Are you generally healthy (not overweight and a non-smoker or non-consumer of nicotine products)?
   **Yes** **No**
5. Are you recreationally active (defined as individuals engaging in physical activity at least three days per week for 30 minutes over the past six months)?
   **Yes** **No**

As a general health screen, you must be able to answer 'NO' to the following questions.

1. Do you have a history of musculoskeletal or neurological injury to the low-back or lower body within the last six months? **Yes** **No**
2. Do you have a history of low-back or lower body surgery? **Yes** **No**
3. Have you sustained a concussion within the past six months? **Yes** **No**

4. Have you followed a formal physical rehabilitation program in the last six months? **Yes** **No**

5. Do you have any low-back or lower body pain described as above '1' on a 10-point pain scale? **Yes** **No**

6. Are you diabetic or suffer from peripheral neuropathy? **Yes** **No**

7. Have you ever been diagnosed with epilepsy? **Yes** **No**

8. Do you currently have any lower body joint swelling? **Yes** **No**

9. Are you pregnant? **Yes** **No**

10. Have you sustained an upper respiratory infection in the past month? **Yes** **No**

# Data Sheet

Number:__________________________________ Date:_____________________

Leg Dominance: R L

**Participant Demographics:**

Sex: ___________

Age: _____________ years

Height: ___________ m _____________cm ______________in

Mass: ___________lbs / ____________ kg

True leg length: __________ cm

# CRYOTHERAPY RESEARCH STUDY

## **Balance Reach Task**

| **Direction** | **Random Order** | **Excursion Distances** |
|---|---|---|
| *Anterior* | _______________ | *1)_______________cm* |
| | | *2)_______________cm* |
| | | *3)_______________cm* |
| *Posteromedial* | _______________ | *1)_______________cm* |
| | | *2)_______________cm* |
| | | *3)_______________cm* |
| *Posterolateral* | _______________ | *1)_______________cm* |
| | | *2)_______________cm* |
| | | *3)_______________cm* |

# CRYOTHERAPY RESEARCH STUDY

## Balance Stance Task

**Random Order**

*Eyes Open* ___________ **Path Length:** *1)*___________*cm*

*2)*___________*cm*

*3)*___________*cm*

**Ave. Velocity:** *1)*___________*cm/s*

*2)*___________*cm/s*

*3)*___________*cm/s*

*Eyes Closed* ___________ **Path Length:** *1)*___________*cm*

*2)*___________*cm*

*3)*___________*cm*

**Ave. Velocity:** *1)*___________*cm/s*

*2)*___________*cm/s*

*3)*___________*cm/s*

# CRYOTHERAPY RESEARCH STUDY

## <u>Functional Performance Task</u>

**Maximal Reach Height:**

*1)*______________*cm*

*2)*______________*cm*

*3)*______________*cm*

**Peak Height:**

*1)*______________*cm*

*2)*______________*cm*

*3)*______________*cm*

**Vertical Hop Height:**

*1)*______________*cm*

*2)*______________*cm*

*3)*______________*cm*

## APPENDIX B

**Informed Consent Form for Biomedical Research**
The Pennsylvania State University
**HEALTHY YOUNG ADULTS (18-35 years old)**

ORP OFFICE USE ONLY:

**DO NOT REMOVE OR MODIFY**

**IRB#37649 Doc. #1001**

The Pennsylvania State University

Institutional Review Board

**Title of Project:** Comparative Stability and Performance Outcomes Among Cryotherapeutic Interventions


**Principal Investigator:**
Emily E Williams
Schreyer Honors College Undergraduate Students
Department of Kinesiology
21E Recreation Building
University Park PA 16802
eew135@psu.edu
814-865-4303

**Project Coordinator:**
Giampietro "John" L Vairo, MS, ATC
Instructor of Kinesiology
PhD Candidate (ABD) in Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
glv103@psu.edu
814-865-2725

**Adviser:**
S John Miller, PhD, PT, ATC
Assistant Professor of Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
sjm221@psu.edu
814-865-6782

**Co-investigator:**
Wayne J Sebastianelli, MD
Professor of Orthopaedics and Rehabilitation
Department of Orthopaedics and Rehabilitation
Penn State | Hershey Orthopaedics – State College
1850 East Park Ave, Suite 112
State College PA 16803
wqs1@psu.edu
814-865-3566

**Research Support:**
Lauren C Kramer PhD, ATC
Instructor of Kinesiology
Program Director, Athletic Training Education Program
Department of Kinesiology
146 Recreation Building
University Park PA 16802
lco100@psu.edu
814-863-1758

1. **Purpose of the study:** The proposed study is designed to provide athletic training and sports medicine practitioners with additional information regarding the effects of various "cryotherapeutic" interventions, the application of ice to a body part, typically used in clinical physical rehabilitation on performance outcome measures. A total of 30 people between the ages of 18-35 years old will be taking part in this study.

2. **Criteria for inclusion of participants:** You are being invited to participate in this research study because you are healthy, physically active and between the ages of 18-35 years old. You have no history of lower body or back injuries within the last six months and have never undergone surgeries for injuries to these areas. You are also not diagnosed with diabetes, peripheral neuropathy or epilepsy.

3. **Procedures to be followed:** If you chose to participate in this research study, you will be asked to perform the following procedures:

<u>Procedures</u>

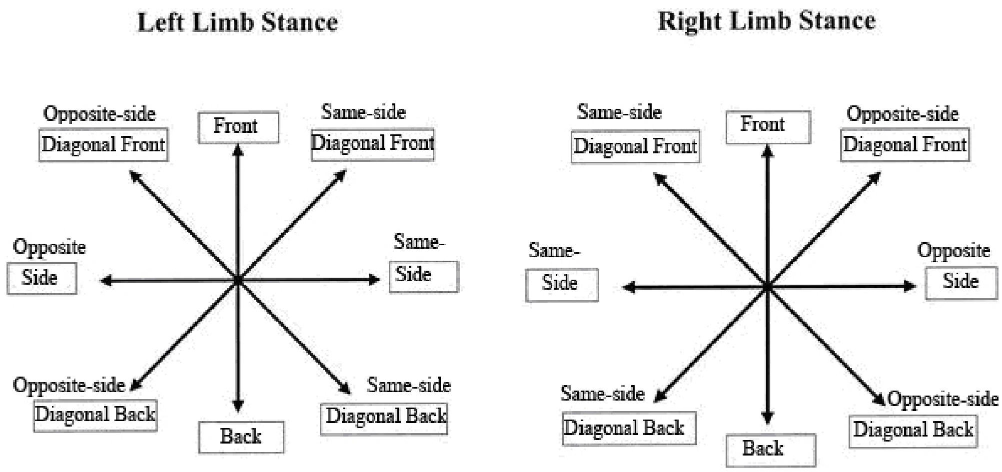
A. We will begin the study by measuring your height, weight, and true leg length. We will also ask you what leg you like to kick a ball with.

B. You will then have a bag of ice placed on your dominant ankle. One session you will have an ice bag paired compression via elastic wrap for 20 minutes, another session you will have only an ice bag on your ankle for 20 minutes, and another session you will not have any ice on your ankle. The order of your ankle condition (ice with elastic wrap, ice with no elastic wrap, no ice) will be randomized.

C. Immediately after and at the 10-minute and 20-minute marks following the application of ice, you will be asked to complete a short perception of pain questionnaire.

D. You will be asked to perform a single-leg balance stance task. You will be standing barefoot on one leg with your arms crossed over your chest while bending your knee on the opposite leg. You will be asked to keep balance for 10 seconds. We will ask that you complete three trials with your eyes open and then three trials with your eyes closed. Your balance performance will be measured by a force platform, which stays still on the floor and is electronically hooked up to a computer. You will be asked to this task on your dominant leg only.

E. You will then be asked to perform a single-leg balance reach task. You start the single-leg balance reach task by standing in place on one leg in the middle of an asterisk drawn on the floor. You then reach as far as possible with your other leg in each of the following directions: front, opposite-side diagonal back, same-side diagonal back. A picture of the single-leg balance reach task is below.




F. You will be asked to complete three trials in each direction. You will be given practice trials and rest between each trial. You will be asked to perform this task on your dominant leg only.
G. You will then be asked to perform a single-leg hop for height task. You will stand next to a measuring device mounted on the wall. Measurements of maximal vertical reach will be recorded. You will then be asked to jump with countermovement as high as possible. That measurement will be taken from the mounted measuring device and recorded. You will repeat this task three times. You will be asked to perform the single-leg vertical hop on your dominant leg only.

H. The order in which you complete these tasks (Procedures D through G) will be randomized for each session.

I. After you are done with testing procedures A through F you have finished one of three sessions. You will then be asked to schedule two more sessions approximately 72 hours apart where you will undergo a the same balance and performance tasks under a different ankle condition (ice with elastic wrap, ice with no elastic wrap, no ice).

4. **Discomforts and risks:** The discomforts and risks with participation in this type of research study are minimal. The tests used are within expected ranges for physically active people. During the ice application, slight discomfort in the form of coldness and/numbness. To lessen the chance of injury, you will also be shown how to properly perform every task in the experiment. Possible discomfort may consist of delayed onset muscle soreness 48 to 72 hours following testing. As with any research study, it is possible that unknown harmful effects may happen. However, the chance for injury in this type of research study is minimal and includes muscle strains, ligament sprains and bone fractures. We will take every possible effort to watch for and help prevent against any discomforts and risks.

5. **Benefits:** There is no direct benefit to you from participating in this research study. The benefits to athletic training and sports medicine practitioners is that it will

provide them with additional information regarding the effects of various ice treatment methods.

6. **Duration/time of the procedures and study:** Participants will be asked to report to the Athletic Training Research Laboratory for the experiment three times over the course of two weeks. Each session will last approximately 1 hour and include your icing treatment of 20 minutes and the balance and performance tasks and will be separated by a 72-hour rest interval. All testing takes place in the Athletic Training Research Laboratory in 21E Recreation Building on Penn State's University Park Campus.

7. **Statement of confidentiality:** Your participation in this research study is strictly confidential. All research records are available only to the approved research personnel. No one outside of the research team will see the individual records. All records will be secured in locked file cabinets at the Athletic Training Research Laboratory. A unique case number will indicate your identity on research records. In the event of any publication resulting from this research study, no personally identifiable information will be disclosed. Penn State's Office for Research Protections, the Institutional Review Board and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this research study. Penn State policy requires that research records be kept for a minimum period of three years at the end of the study. Three years following the end of this research study all records will be appropriately destroyed.

8. **Right to ask questions:** Please contact John Vairo at (814) 865-2725 or Emily Williams at (570) 660-4949 with questions, complaints or concerns about this research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact Penn State University's Office for Research Protections at (814) 865-1775. The Office for Research Protections cannot answer questions about research procedures. Questions about research procedures can be answered by the research team. Referral information for those who wish to seek additional assistance includes the following:

    **Penn State University Health Services**
    **Student Health Center**
    **University Park PA 16802, 814-863-0774**

9. **Voluntary participation:** Your decision to be in this research study is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this research study will not involve penalty or loss of benefits you would receive otherwise. You may be removed from this research study by investigators in the event you cannot complete the testing procedures.

10. **Injury Clause:** In the unlikely event you become injured as a result of your participation in this research study, medical care is available. If you become injured

during testing procedures the investigators listed on this informed consent form will provide you with appropriate first aid care and instruct you on proper steps for follow-up care. If you were to experience any unexpected pain or discomfort from participating in this research study after leaving the Athletic Training Research Laboratory please contact S John Miller immediately at (814) 865-6782 or John Vairo at (814) 865-2725. If you cannot reach S John Miller or John Vairo please leave them a voicemail and contact your doctor.

If you are a Penn State student and cannot reach S John Miller, John Vairo or your doctor, please leave them voicemails and contact Penn State University Health Services at:

**Student Health Center**
**University Park PA 16802**
**814-863-0774**

It is the policy of this institution to provide neither financial compensation nor free medical treatment for research-related injury. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

11. **Abnormal Test Results:** In the event that abnormal test results are obtained, you will be made aware of the results in three days and recommended to contact your private medical provider for follow-up consultation.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

______________________________________ __________________

Participant Signature Date

______________________________________ __________________

Person Obtaining Consent Date

## ACADEMIC VITA

**Emily E. Williams**
224 S. Burrowes St. Apt. 203
State College, PA 16801
eew135@psu.edu | 703-401-4887

***Education***
**The Pennsylvania State University**
The Schreyer Honors College
Bachelor of Science in Athletic Training
Anticipated Graduation: May 2012

***Academic Experience***
**Penn State University,** *Undergraduate Teacher's Assistant*, **2010- 2012**
**2012 Pennsylvania Athletic Trainers' Society Student Symposium,** *Student Presenter*
"Comparative Immediate Lower Extremity Performance Outcomes Among Cryotherapeutic Interventions at the Ankle"- Williams EE, Vairo GL, Miller SJ, Kramer LC, Sebastianelli WJ

***Continuing Education***
**National Athletic Trainers' Association Annual Conference,** *Student Attendee*, **June 2011**
**Chapman University Study Abroad Program 2011 partnered with**
**The German Academy of Applied Sports Medicine,** *Student,* **January 2011**

***Awards/Honors***

| | |
|---|---|
| Dean's List | **Fall '08, Spring '09, Fall '09, Spring '10, Fall '10, Spring '11, Fall '11** |
| The College of Health and Human Development Scholarship | **2008-2009, 2009-2010, 2010-2011, 2011-2012** |
| The Schreyer Honors College Academic Excellence Scholarship | **2008-2009, 2009-2010, 2012-2011, 2011-2012** |
| Edward A. Sulkowski Athletic Training Scholarship | **2010-2011** |
| Jimmy Warfield Athletic Training Scholarship | **2011-2012** |
| Alvin and Jean Snowiss Scholarship | **2009-2012** |
| Schreyer Honors College Summer Research Grant | **Summer 2011** |

***Activities/Memberships***
**National Athletic Trainers' Association,** *Member,* **January 2010- Present**
**Eastern Athletic Trainers' Association,** *Member,* **January 2010- Present**
**Pennsylvania Athletic Trainers' Association,** *Member*, **January 2010- Present**
**The German Academy of Applied Sports Medicine,** *Student Fellow,* **January 2011-Present**
**Penn State University Athletic Training Club,** *Member,* **2010- 2012;** *Vice-President,* **2010-2011,** *President,* **2011-2012**
**Penn State University Women's Club Soccer Team,** *Member,* **2008- 2012;** *THON Chair,* **2009-2011**
**Penn State University Schreyer Honors College Student Council,** *Member,* **2008-2012**
**Phi Eta Sigma National Honor Society,** *Member,* **2008-2012**
**Penn State Dance MaraTHON,** *Volunteer,* **2009-2012**
**Penn State University Blue and White Society,** *Member,* **2008-2012**