Post-Exercise Treatments to Reduce Delayed-onset Muscle Soreness of Collegiate Student Athletes

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Dedication

This thesis is dedicated to anyone who may be interested or involved within the strength and conditioning profession.

Abstract

Delayed onset muscle soreness (DOMS) occurs in athletes often after a strenuous workout. For this study, two post-exercise treatments were used to see the effectiveness in reducing DOMS. The two treatments were foam rolling and water immersion. Participants initially consisted of 30 (15 participants in each group) student- athletes at a Division II University in the Midwest. Student-athletes completed a strenuous workout and received a post-exercise treatment immediately after. Athletes then completed a survey 48 hours later in which they identified their area of soreness and rated their soreness on a scale of 0-10 (0 being no soreness to 10 being extremely sore). Twenty-six (12 in foam rolling and 14 in water immersion) completed the survey for a total of 4 times over a 2-week span. Data showed that DOMS significantly decreased in both post-exercise treatments groups and the effectiveness was not different in two groups. Thus, this experiment demonstrated that both post-exercise treatments are equally effective in reducing DOMS in athletes. Further research may help determine which post-exercise treatment is the most effective over a longer period of time.

Table of Contents

List of Tables

List of Figures

Chapter One

Introduction

Intensive training and vigorous competition can lead to fatigue and soreness within the musculoskeletal system. Once fatigue sets in within the muscles, delayed-onset muscle soreness (DOMS) can occur. According to a study done by Anthony Barnett in 2006, "The efficacy of recovery modalities have focused on exercise-induced muscle damage, usually associated with DOMS, a sensation of pain or discomfort occurring 1-2 days post-exercise" (p. 784). DOMS can affect an athlete on a variety of levels, which can lead to injury, compensation, and/or improper lifting techniques if not dealt with properly. When working with athletes at the Division II level, many athletes perform at high levels while conditioning and practicing. These athletes should be ready to perform their best on the day of competition, which often times can be very strenuous on their bodies following a competition or event. For athletes to continue to perform at the highest level possible, their bodies need to be able to recover properly through post-exercise treatments in which DOMS can be reduced.

Purpose of the Study

For athletes to perform at their individual peak performance, all coaches, athletic trainers, and strength and conditioning coaches need to know what post-exercise treatments can be beneficial for athletes. The purpose of this study is to compare college football players' perspectives about the effectiveness of foam rolling versus water immersion to reduce muscle soreness. Past studies have shown these types of treatments to be effective in reducing DOMS. It's critical to know which treatment works best for athletes in order to allow the body to recovery efficiently, within a short period of time. This study could benefit any individual who

may face DOMS and will develop an inside perspective on what athletes do to address DOMS from an individual perspective.

Background and Significance of the Study

As new treatments, exercises, and the health industry continues to grow, it is key to have an understanding and knowledge of these new techniques. In this case, it will be important to comprehend what post-exercise treatment will help reduce DOMS in athletes. This study will investigate deeper what post-exercise treatments athletes find effective, with treatments consisting of either cold water immersions or foam rolling.

According to a study conducted by Ingram, Dawson, Goodman, Wallman, and Beilby (2009), "Currently, cold water immersion is commonly undertaken by athletes following strenuous exercise to prompt recovery, dimension muscle soreness, and to hasten a return to optimal performance capabilities" (p.417). Water immersion treatments have been proven to medically make an impact within athletes who receive these treatments. Cold water immersions help not only to improve blood flow but also assists in drainage of waste and improve the supply of oxygen and nutrients to the muscles (Kaczmarek, Mucha, & Jarawka, 2013). When blood flow is improved, the body can properly recover. When working with Division II athletes, it is important to guide them in the correct direction to deal with their soreness. Ingram et al. looked at the effect water immersion methods had on athletes who were part of a team-sport. Ingram et al. (2009) stated that exhaustive training and competition can potentially fatigue the musculoskeletal, nervous, and metabolic systems, as well as produce delayed-onset muscle soreness (DOMS). Ingram et al. (2009) conducted post-exercise treatments using cold water immersion (COLD), hot/cold contrast water immersion (CWI), and a control group who did not receive any water immersion treatments. Overall, results demonstrated that COLD water

immersion was the superior recovery method when compared to CWI and the control group. Ingram et al. (2009) also stated that there were significant lowered muscle soreness ratings for those who received COLD treatments compared to CWI treatments and the control group. Also, Ingram et al. (2009) found that those who received COLD had the best sprint and total sprint times after 48 hours and comparable to their baseline values. The study stated that it did find that COLD had very little impact on hip flexion strength. This research showed support towards athletes receiving cold water immersion, while in a study by Burke, Holt, Rasmussen, MacKinnon, Vossen and Pelham (2011) found that there was no significant advantage between athletes receiving cold-water immersion treatments, hot-water immersion treatments, and stretching treatments. However, Burke et al. (2011) found that there was significant improvement in hamstring lengthening from pre-test to post-test, but not a significant difference on improvement based on what treatment they received. More research needs to be conducted to identify if water immersion really plays a key role in athletes recovering from DOMS.

In a study by Pearcey, Bradbury-Squires, Kawamoto, Drinkwater, Behm, and Button, (2015) it was found that foam rolling was very effective on reducing DOMS. Pearcey et al. (2015) stated, "More specifically, foam rolling resulted in increased pressure-pain threshold score, sprint speed, power, and dynamic strength- endurance at various time points after exercise compared to the control condition" (p. 11). In conclusion, Pearcey et al. (2015) stated that to combat the adverse effects of DOMS, a 20-minute bout of foam rolling on a high-density roller immediately post-exercise and every 24 hours thereafter may reduce the likelihood of muscle tenderness and decrements in multi-jointed dynamic movements. MacDonald, Button, Drinkwater, and Behm (2014), agree that foam rolling provides recovery benefits primarily

through the treatment of connective tissue. MacDonald et al. (2014) even found that the group who foam-rolled displayed less pain in comparison with the control group.

Overall, previous data showed that foam rolling is effective to reduce DOMS, while water immersion data showed inconsistency. When working with athletes, it is important to identify the best post-exercise treatment to keep the athletes performing at their peak performance level.

Setting

This study was conducted at a Division II university in the Midwest. Football student-athletes, who competed at the Division II level, volunteered to be part of this study to identify which post-exercise treatment helped reduce DOMS. The athletes also completed surveys that asked specific questions relating to post-exercise treatments. Conducting a study that consisted of the athletes performing drills or physical exercises had a possibility of putting athletes at risk for injury, which could affect them from being able to compete in competition. This study did not consist of athletes performing drills to avoid injury, but consisted of determining athletes' personal perspectives on post-exercise treatments and input collected through the use of surveys.

Assumptions

In prior studies, inconsistent data has been collected when it comes to water immersion and foam rolling due to the lack of ways to measure muscle soreness. Past data showed more consistency with foam rolling as it is a form of self-massage. Water immersion treatments showed inconsistency because of the different forms of water immersion. Water immersion treatments can consist of cold water immersion or hot/cold contrast water immersion. Measuring soreness is often judged through individual perception, as there is not a scientific tool to measure muscle soreness. With soreness though, often change can occur within the athlete's

performance. Some current studies collected baseline data prior to working out in specific physical categories (i.e. broad jump, sprint, and then re-evaluated after completing a strenuous workout to see if the data changed due to DOMS. In this study, data was collected through conducting interviews using a scale of 0-10 of soreness/pain/discomfort, as well as an in-depth survey in which the athletes completed. This quantitative based research, as data was collected through surveys.

Scope and Limitations of the Study

It is important that this study was conducted during the start of summer season, as many student-athletes had not done strenuous workouts consistently throughout the time frame from Spring ball to summer workouts. Student-athletes are often the sorest during their first couple weeks back before the start of summer workouts. This time frame allowed the student-athletes to see what post-exercise treatments they shall use to reduce muscle soreness, which will allow the athlete to compete at the highest level possible. Limitations included the small sampling size, time restraints due to the participants being student- athletes, athletes not filling surveys out accurately, and inconsistency of the athletes to perform the post-exercise treatments and/or lack of athletes using these types of treatments.

Definitions

- Delayed-onset muscle soreness (DOMS): a predictable painful condition which often occurs after unaccustomed eccentric exercises (Ernst, 1998).
- Water immersion: It consists of athletes submerging their bodies into a tub consisting of cold water and/or hot water.
- Foam rolling: It is also known as self-myofascial release, which releases muscle tightness by self-induced massage (Boyle, 2006).

Summary

Workouts at a strenuous level can affect the body in a variety of ways. Often, the musculoskeletal system is the first to be affected. Once muscles reach a stage of fatigue, delayed-onset muscle soreness can set in. Ernst's (1998) stated, "DOMS is a painful condition which often occurs after unaccustomed eccentric exercises" (p. 212). In order for athletes to continue to perform required lifts and conditioning day-to-day, they need to reduce any DOMS. The hope of this study was to find what post-exercise treatment athletes found the most affective when attempting to reduce DOMS. The study looked at male athletes who participated at the Division II collegiate level in football.

Chapter Two

Literature Review

This study examined the relative effectiveness of two methods to reduce DOMS: water immersion and foam rolling treatments. This review will first introduce water immersion treatments, then will describe foam rolling treatments. For the water immersion section, cold-water immersion, and hot/cold contrast water immersion will be described.

Water Treatments

Within the exercise and sports world, athletes are willing to find the newest recovery trends to help them recover as quickly and efficiently as possible. According to Kaczmarek et al. (2013), "Athletes and coaches very often don't devote enough time for recovery and rest, which makes the athletes tired for the next workout or competition." Therefore, it is key for both athletes and coaches to understand the importance of completing post-exercise treatments. Water-immersion treatments have a long history of use in sports medicine for managing the edema and inflammation usually associated with sports due to strenuous workouts in which the body is in a state of imbalance. Water- immersion consists of two different forms: cold water immersion and hot/cold contrast water immersion. A review by Cochrane (2004) contrasts hot-cold baths and showers, which are common practices used by athletes after training or exercise. According to Wilcock, Cronin, and Hing (2006), "Water immersion is thought to provide benefits similar to active recovery, such as increased blood flow and lactate removal" (p. 196). Water immersion has become more suitable as a post-exercise recovery approach.

Measuring the effects that water-immersion has on an athlete's body is the biggest hindrance researchers face when deciding if water-immersion treatments are effective. There is not a medical device to measure individual soreness. Furthermore, from a psychological

perspective, everyone has a different level of pain/soreness they can embrace, making it ambitious to measure. It is difficult to determine the level of muscle soreness due to the subjective nature of pain. In an article by Lau, Muthalib, and Nosaka, 2013, many different pain scales such as visual analog scale, verbal rating scale, numerical rating scale, and descriptor scale have been used in previous studies to assess DOMS. Out of these scales, the visual analog scale is the most often used for DOMS assessment (Lau et al., 2013). The visual analog scale consists of a certain length of line in which one end of the line implies no pain while the other line implies the worst pain. (Lau et al., 2013). Regardless of which scale is used, the majority of these measurements include collecting data either pre/post exercise to develop a baseline in which the data can be further critiqued and evaluated. Overall, water immersion research is challenging due to the amount of equivoques in the literature.

Cold- water immersion. Athletes, coaches, and strength and conditioning coaches use all distinctive methods to help improve the recovery process and subsequent performance after exercise or competition. With the amount of time spent with high level competitions and strenuous lifting sessions, the body of the athlete perhaps could lead to an imbalance which in end, results in an injury. Coaches and athletes use post-exercise recovery techniques often when trying to reach peak performance and reduce recovery time when faced with muscle soreness (Ingram et al., 2009). These recovery techniques may include physical modalities such as massage, sleep, nutrition, active recovery, or foam rolling to name a few. Wilcock, et al. (2006a) stated, "Another method that is gaining popularity as a mean to improve recovery is immersion in water" (p.196).

According to Kaczmarek et al. (2013), "Immersion in cold water causes a number of physiological processes in the body: the movement of fluids within the blood and cells,

decreasing in swelling, increase blood flow to the tissues for better nutrition and more efficient transport of waste products appear" (p. 36). He stated, "15-min immersion at the temperature of 15[degrees]C will lower intramuscular temperature by ~10[degrees]C and have a beneficial effect." (Kaczmarek et al., 2013, p. 36). Better blood flow through the body improves the drainage of waste products and improves the supply of oxygen and nutrients to the muscles.

Cold-water immersion (COLD) consists of an athlete submerging certain body parts into a cold-water tub. While the body is immersed depending on the depth and body area, athletes remain in the tub for approximately 10-15 minutes. Often, athletes do COLD treatments after strenuous workouts or competition to avoid DOMS. According to a study by Ingram et al., (2009), athletes that received COLD reported significantly lower muscle soreness compared to other water-immersion treatments. Also, that same study found that athletes who received contrast hot/cold water immersion (CWI) treatments had overall better sprint and total sprint times after 48 hours compared to their baseline values. Furthermore, research suggested more evidence needs to be explored and its effect on DOMS or athletic performance, as current results are equivocal.

Hot/cold contrast water immersions (CWI). Along with cold-water immersion treatments, hot/cold contrast water immersion has also been a popular topic researched to help reduce DOMS.

Cochrane's 2004 study found the following:

> Alternating hot-cold water immersion is one technique that is very popular and is practiced with increased frequency in aiding recovery after physical training and competition. The contrast of hot-cold water technique is thought to speed up recovery by increasing the peripheral circulation by removing metabolic wastes and stimulating

the central nervous system. The contrast hot-cold increase lactate clearance reduces post exercise edema and enhances blood flow to the fatigued muscles. (pp. 25-26)

Hot/cold contrast water immersions (CWI), consist of an athlete submerging certain body parts, alternating between warm-hot water and cold water. Athletes alternate between the warm-hot and cold tub, being in the cold tub for a set amount of minutes, then the hot tub for a set amount of minutes, and then continue to alternate between them for a set amount of time. The process of CWI protocols varies but mainly entail anywhere from 30-300 seconds of one temperature extreme, instantly followed by 30-300 seconds of the contrasting temperature (Wilcock et al., 2006). This process is repeated for a number of times and can last anywhere up to 4-30 minutes according to Wilcock et al. (2006). Vascular 'pumping' caused by the different in water temperature has been suggested as the mechanism that could help determine the recovery process. While looking at it from an injury standpoint, the ratio of warm-hot to cold duration treatment normally is 3:1 or 4: 1 with warm-hot baths ranging from 37- 43-degree C (Cochrane, 2004). The extent of the process usually last between 20-30 minutes and is duplicated twice daily (Cochrane, 2004). Cochrane's 2004 study stated, "The treatment should finish on the cold treatment to encourage vasoconstriction for the injured athlete. There is correlation between the guidelines (water temperature, repetitions, and duration) for post exercise contrast water recovery and the treatment for an injured athlete. (p. 30). More groundwork is needed to support the post- exercise treatment with injury contrast treatment. As well, the appropriate time ratio between hot-cold temperatures needs to be investigated to give clear logical reasoning with its effectiveness as a recovery modality.

Foam Rolling Treatments

Foam rolling treatments have been an aid for optimum recovery, which became a familiar procedure for treating and preventing soft tissue restrictions. Foam rolling can be considered a form of self-induced massage, simulating the pressure placed on the muscle through a manipulation by a massage therapist. According to Pearcey et al. (2015), "Self- massage through foam rolling could benefit athletes seeking a recovery modality that is relatively affordable, easy to perform, and time efficient that enhances muscle recovery" (p. 5).

This method can be used by applying pressure to specific areas of the body in order to aid in recovery of the muscle and to assist in returning the muscle to normal function. Trigger points, which are "knots" that form within the muscle, can be reduced from this type of treatment. The motion of the foam roll places direct pressure on a specific spot, which causes sweeping of the soft tissue, stretches it, and generates friction between the specific spot and the foam roller (Pearcey et al., 2015). The end result assists in breaking up the muscle tissue, reducing pain and reestablishing normal movement.

In a study conducted by MacDonald, Button, Drinkwater, and Behm (2014), they measured the effects of foam rolling before physical activity, during which all the subjects were required to participate in five testing sessions. The sessions included 1) 1 rep max (1RM) test, 2) pretest measurements, 3) posttest 24 hours, 4) posttest 48 hours, 5) posttest 72 hours. Once the subjects were assigned to their test groups, the subjects' 1RM for a free weight back squat was performed. After, they were assigned to a group- 1) Control group which consisted of perceived pain and test measurements and 2) Foam Roll group which includes perceived pain, test measurements and foam rolling. The foam rolling was measured while subjects performed the exercise protocol using a 11-point Numerical Rating Scale (NRS), ranging from 0-10, "0" is being defined as "absolutely no muscle soreness" and "10" being defined as "the worst muscle

soreness you have ever felt" (MacDonald, Button, Drinkwater, & Behm, 2014, p. 134). The measurements were taken before each testing session. The subjects performed a squat, using only bodyweight in which their thighs needed to be parallel with the floor. The subjects were then asked to rate their perceived pain based on muscle soreness.

From the findings, foam rolling provides recovery benefits through the treatment of connective tissue. Since some of the evidence is indirect, further research should be completed. Research by Crane et al. (2012) also supports MacDonald's findings, stating that massage decreased pain and inflammation.

Summary

Studies have demonstrated that both water immersion (Cochrane, 2004; Lau, Muthalib, & Nosaka, 2013; Wilcock, Cronin, & Hing, 2006) and foam rolling treatments (Crane et al., 2012; MacDonald, Button, Drinkwater, & Behm, 2014; Pearcey et al., 2015) were effective in reducing DOMS. Water immersion is a more traditional post-exercise treatment, and foam rolling is similar to message and convenient in terms of time and access. However, there has been little research to compare these two methods and this study attempted to directly compare two treatments: cold water immersion and foam rolling. This study consisted of student- athletes completing surveys to see which post-exercise treatments Division II athletes found effective.

Chapter Three

Methodology

The purpose of this study was to identify what post-exercise treatments Division II athletes found effective to reduce delayed on-set muscle soreness (DOMS). The study focused on foam rolling and cold-water immersion as the main forms of post-exercise treatments at this University. By identifying what benefits athletes felt they gained from implementing post-exercise treatments into their exercise routines, future practice can be informed. This chapter will describe the steps taken in the research methodology to determine what post-exercise treatments athletes found effective. First, the research design will be described in this chapter, followed by the description of the setting and participants. Next, this chapter will discuss the development and implementation of the surveys and conclude with a description of how the data was gathered and analyzed.

Research Design

This study explored what post-exercise treatment helped reduce delayed-onset muscle soreness (DOMS) within athletes using quantitative methods, in specific, an experimental design with two groups: cold water immersion and foam rolling. The first quantitative component to this study consisted of the researcher presenting the overall research experiment to all Division II collegiate football student-athletes who competed in the 2016 Spring season at this University. During the presentation, the researcher explained the baseline data survey which needed to be completed by all football players. The researcher then explained the overall research experiment and asked if any student-athletes who wanted to participate, to complete the back part of the survey, which gives the researcher consent. Once the base line data was collected, the student-athletes who gave consent were randomly selected and they were assigned randomly to two

groups. Initially, 15 athletes were arranged to the foam rolling group, and 15 athletes were to the cold-water immersion group. Athletes were identified by a number. Once athletes returned from an extended break, the athletes started experiment and followed the plan below (see Table 3. 1) for a 2-week cycle.

Table 3.1

Weekly Schedule of Data Collection

Step/ Day	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	Lift	X	Fill out survey (Time 1 at week 1; Time 3 at week 2)	X	Fill out survey (Time 2 at week 1; Time 4 at week 2)
Step 2	Complete Post-exercise treatment you are assigned for the designated time frame	X	Lift	X	Lift
Step 3	X	X	Complete Post-exercise treatment you are assigned for the designated time frame	X	Complete Post-exercise treatment you are assigned for the designated time frame

Creswell (2015) suggested the following steps for data collection: There are five interrelated steps in the process of quantitative data collection. The five steps are: "1) determining the participants to study, 2) obtaining permissions needed from several individuals and organizations, 3) considering what types of information to collect from several sources available to the quantitative research, 4) locating and selecting instruments to use that will net useful data for the study, and 5) administering the data collection process to collect data. (p. 139)" These are five crucial steps needed to be followed to implement quantitative components

effectively. As mentioned in the reading, it described the importance in the early stage in data collection deciding what level the data needs be gathered (Creswell, 2015). Taking the time to understand what post-exercise treatments these student-athletes found effective and the processes they take to reduce DOMS was key to make this study reliable.

Setting and Participants

This study was conducted within the weight room at a Division II State University in the Midwest of the United States of America and consisted of football athletes. Prior to the start of off-season training starting (June 2016), baseline data was collected by having all athletes who had participated in the 2016 Spring season (total of 52 on players), anonymously filled out a general survey on what post-exercise treatments they used, how often they used them, and why they used them. From that baseline data, a smaller participant group was formed based on who was willing to participate in the actual study. Thirty participants were randomly selected to participate in this study and randomly arranged to one of two post exercise treatment conditions. Fifteen participants for each cold-water immersion and foam rolling post exercise treatments were initially arranged to two conditions, but 14 in the cold water immersion condition and 12 in the foam rolling completed all data at four time points. The mean age (with standard deviations in parentheses) for cold water immersion was 20.71 (1.20) and for foam rolling was 20.75 (1.22). All participants were white, except one African American in the foam rolling group.

Prior to the any quantitative data collected for this study, all 30 athletes were given a form requesting their voluntary permission to be included in this study which was used to identify specific post-exercise treatments that helped Division II football student athletes at this specific University to reduce DOMS. Student-athletes were given the option to opt out and not be included in the research activities without any negative consequences. The participants could

terminate their participation in the research without repercussions at any time. The group consisted of 30 Football players from this Midwest University.

Measures

An initial survey (see Appendix III: Baseline Data Survey) was created by the researcher to identify what post-exercise treatments were being used by majority of football student athletes to reduce DOMS. On that survey, the student-athletes also identified when are they more likely to do these treatments and why do they do them. This baseline data survey was crucial to this study because it allowed the student athlete to address further information and recovery modalities in which they may use. The initial survey also helped get a baseline number of how many athletes use post-exercise treatments. Thirty student-athletes were then anonymously selected for this study. The student- athletes were explained what the purpose of the study was and if they were willing to continue in this study, what the expectations were. The 30 student-athletes were then split up into two groups. One group of student-athletes received cold water immersion post-exercise treatments and the other group of student-athletes received foam rolling post-exercise treatments for a total of two weeks.

The student-athletes then completed a survey 48 hours after the workout [see Appendix III: Post- Exercise Treatment Survey (Phase Two- Time 1 and 2) and Post- Exercise Treatment Survey (Phase Two- Time 3 and 4)]. This survey was filled out prior to the next strenuous workout, in which the athletes received another post-exercise treatment. All student-athletes had strenuous workouts on Mondays, Wednesdays, and Fridays and completed the surveys on Wednesdays and Fridays prior to the next workout. Treatments occurred on Mondays, Wednesdays, and Fridays after working out. The student-athletes completed the surveys a total of 4 times within a two-week time frame.

Data Gathering and Analysis

In order to make this study effective, it was crucial for the student-athletes to have a similar workout program (same repetition and sets) regardless of position or year. By randomly selecting participates to be divided into two separate groups, the researcher was able to look specifically at how cold-water immersion or foam rolling helped reduce DOMS within student-athletes at the Division II level. Since soreness was measured by self-perception, survey formed based research was considered as the most effective and safest way to collect research. Quantitative methods were implemented to collect a large group of athletes' thoughts.

Summary

A quantitative experimental design was used to identify student-athletes' perspectives regarding post-exercise treatments to reduce DOMS. Surveys gave a deeper look as to why athletes used post-exercise treatments, when they used them, and how it helped the athlete from a recovery standpoint. The researcher avoided using qualitative research, as that would have consisted of the athletes completing an actual physical task, which would put the athletes at risk for injury. Quantitative data allowed the researcher to better understand Division II football players' perspectives on the impact post-exercise treatment had on their DOMS. The results of the research are explained in the following chapter.

Chapter Four

Results and Discussion

This chapter includes the data collected from the experiment to see which post-exercise treatment, foam rolling or cold-water immersion, reduced soreness in collegiate football athletes. Surveys were completed on a scale from 0-10 were used to collect each athlete's perspective on his muscle soreness. Once the two-week cycle was completed, the researcher looked at the overall average of the muscle soreness per group. The goal of this study was to identify what post-exercise treatment group had the lowest average of soreness (ex. Did cold water immersion or foam rolling group rate their soreness to be lower than the other?).

Results

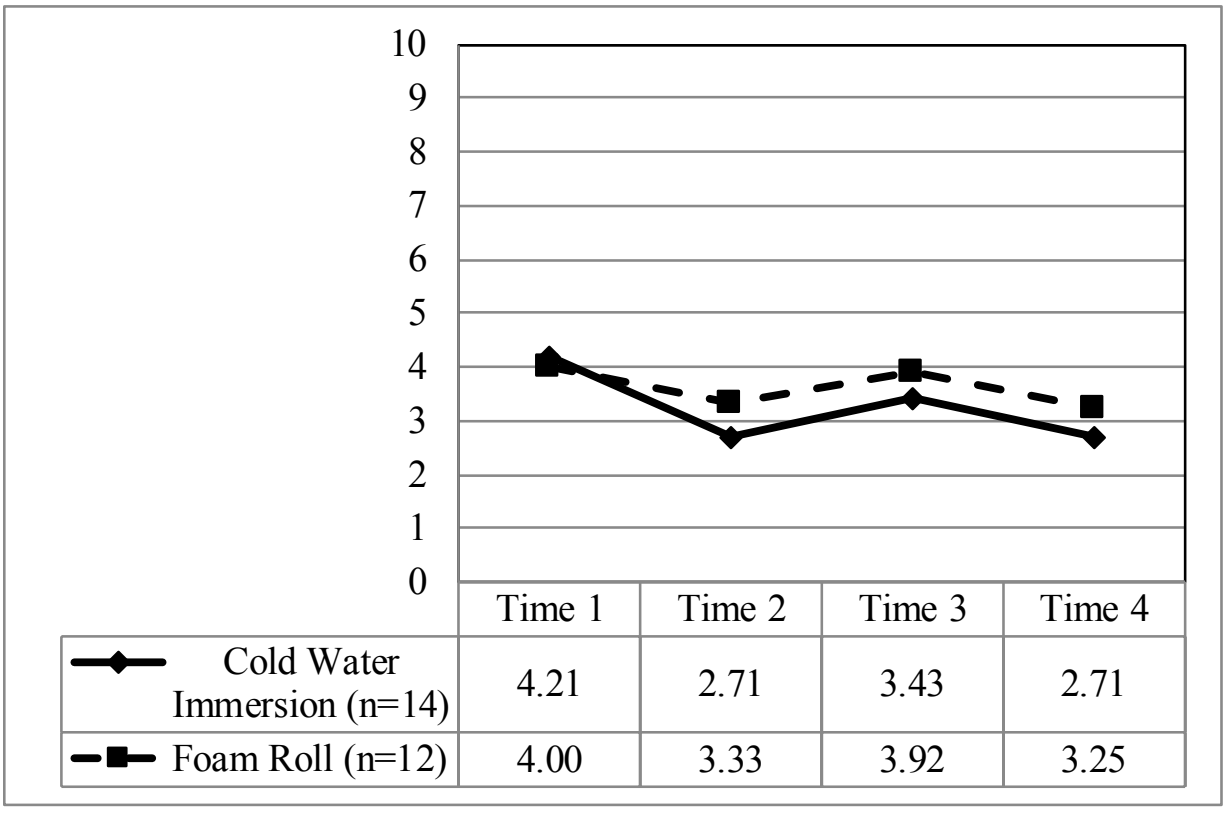
The study was completed at a Division II University and the participants consisted of 30 male football student-athletes. Final data analysis included data from 26 participants; 14 participants for cold water immersion and 12 participants for foam rolling. The reasons for incompletion for participants unable to finished included illness for 1 participant in the cold-water immersion condition and illness for 2 and injury for 1 participant in the foam rolling condition. The study looked at what post exercise treatment would reduce delayed onset muscle soreness in athletes. The two post-exercise treatments that were used included foam rolling and cold-water immersion. Past research has shown that both these treatments are effective, but little research has been found regarding which of the two is the most effective.

The participants completed this study after a 2- week break. The participants started their intense summer workouts, and soreness was a major factor in their overall ability to perform at the highest level. Those that decided to participate in this study followed the schedule delineated

in Chapter 3 of this study. Once the athletes completed a strenuous workout, they completed a post-exercise treatment based on their assigned group. The participants then completed the survey 48 hours after the strenuous workout using their own perspective on how sore their body was from the workout. A scale from 0-10 was used to measure their overall body soreness. The athletes also identify the areas where they were sore, using a body outline. The athletes completed the survey a total of 4 times over a 2-week span. Once all the data was collected, the researcher entered the information into a table to determine which post-exercise treatment was the most effective for the athletes and had the lowest average of soreness (0 on the scale is the lowest and 10 is the highest). Figure 4.1 includes results of the study, shown as the average soreness rated by each group, in all four-time points.

Figure 4.1

Daily Average of Delayed-onset Muscle Soreness: Cold Water Immersion and Foam Roll



	Time 1	Time 2	Time 3	Time 4
Cold Water Immersion (n=14)	4.21	2.71	3.43	2.71
Foam Roll (n=12)	4.00	3.33	3.92	3.25

Overall, results indicated a significant linear decrease in both post-exercise treatments. The repeated measure ANOVA revealed significant decrease over time, $F(3, 24) = 7.17$, $p = .000$. When comparing two methods at each time point, cold water immersion group showed a slightly lower average of muscle soreness than foam rolling treatment group; however there was no significant statistical differences between two groups; $F(1, 24) = 0.47$, $p = .500$. In other words, when analyzing data from time 1 to time 4, there was a significant decrease of muscle soreness in participants in both post-exercise treatments. This data helps determine that both post-exercise treatments are equally effective in reducing DOMS in athletes.

Foam Rolling Data. Foam rolling was one of the two post-exercise treatments that student- athletes used throughout this study. There was a total of 15 student-athletes who initially were assigned to the foam rolling group. In the end, only 12 participants completed the full 2-week post exercise schedule. Three student athletes had to withdraw from the study due to injury (not related to this study; 1 participant) and sickness (2 participants).

The participants completed a 5-7-minute foam rolling treatment after completing a strenuous workout. The participants then completed a survey 48 hours later indicating where they felt soreness on their body and used the scale to indicate their overall body soreness.

Cold Water Immersion Data. The cold water- immersion group followed the same protocol as the foam rolling group. The water-immersion group had a total of 15 participants initially, and 14 completed survey at all four-time points: Participant #3 was unable to complete the full study as he became sick the last week and was unable to complete surveys #3 and #4.

The participants in the water-immersion group followed the same schedule and complete their post-exercise treatment after a strenuous workout. The student-athletes emerged their body in a cold bath for a total of 10 minutes. The goal was to make sure the area of soreness was 2-3

Table 4.1

Foam Rolling: Average Soreness at Four Data Collection Time Points

Participant #	Week 1- Time 1	Week 1- Time 2	Week 2- Time 3	Week 2- Time 4	Avr.
16	4	2	3	2	2.75
17	2	1	3	1	1.75
18	4	3	2	4	3.25
19	NA	NA	NA	NA	NA
20	2	3	NA	NA	NA
21	4	3	4	3	3.50
22	3	1	2	3	2.25
23	4	5	2	2	3.25
24	4	3	3	2	3.00
25	8	7	7	5	6.75
26	NA	NA	NA	NA	NA
27	4	4	7	5	5.00
28	1	5	4	5	3.75
29	3	2	3	2	2.50
30	7	4	7	5	5.75

Table 4.2

Cold Water Immersion: Average Soreness at Four Data Collection Time Points

Participant #	Week 1- Time 1	Week 1- Time 2	Week 2- Time 3	Week 2- Time 4	Avr.
1	5	3	3	2	3.25
2	4	2	4	2	3.00
3	3	2	NA	NA	NA
4	4	3	4	2	3.25
5	5	3	2	4	3.50
6	4	3	5	2	3.50
7	3	2	0	1	1.50
8	3	2	4	1	2.50
9	2	2	4	2	2.50
10	6	3	5	6	5.00
11	7	4	4	5	5.00
12	6	5	6	5	5.50
13	4	2	2	3	2.75
14	3	2	2	1	2.00
15	3	2	3	2	2.50

inches below the waterline to ensure the area was being treated. If muscle soreness occurs in the shoulders or neck, the student-athletes were allowed to use bags of ice to ensure the appropriate areas were being targeted.

Discussion

Soreness is based on an athlete's perspective. When completing this study, it was key for participants to be completing the same workout after the same amount of time off to ensure more accurate data. Both groups initially started with 15 participants. Participants could withdraw at any time with no consequences. A total of 28 participants (14 in cold water immersion and 12 in foam rolling) completed the post-exercise treatments and surveys based on their own perspective of soreness. When comparing the data from foam rolling and cold-water immersion, those who completed the cold-water immersion treatment had a lower average of soreness compared to those student- athletes that completed the foam rolling treatment. The cold-water immersion soreness average was 3.27 (Averages at four-time points: 4.21, 2.71, 3.43, and 2.71) on a 11-point rating scale (0 – 10). The average soreness for the student-athletes who completed the foam rolling treatments was 3.63 (Averages at four-time points: 4.00, 3.33, 3.92, and 3.25). There was a statistically significant linear decrease in both post-exercise treatments and two groups were not different in the decrease; thus, data supported that both treatments are effective in reducing DOMS in athletes over a certain period of time.

Based on data and other research that has been conducted on post-exercise treatment, there is not an objective tool or instrument created that can measure muscle soreness. In the strength and conditioning world, new concepts and ways to reduce soreness continue to be developed and implemented in many facilities all around the world. This research though is

important because it is a great reminder to both those who work with student- athletes and the student-athletes themselves, that having a variety of post-exercise treatments help reduce muscle soreness. Furthermore, what is effective for one athlete may not be as effective for another athlete. This data is pivotal to share with athletes so they can see that cold-water immersion has been shown in this study to reduce muscle soreness compared to foam rolling.

When looking at how this study connects with other studies done in the past, additional data would still be beneficial. In Chapter Two, a study that was completed by Cochran (2004) was introduced. Cochrane looked at how water-immersion treatments reduced DOMS in athletes. Cochrane's study found significant soreness reduced in athletes when receiving contrasting (hot/cold) water bath treatments. Even though the athletes in this study did not receive contrast treatments (hot/cold water immersion baths), data from this study still shows that cold water immersion treatments were effective in reducing DOMS. Cold water immersions help not only to improve blood flow, they also assist in drainage of waste and improves the supply of oxygen and nutrients to the muscles (Kaczmarek, Mucha, & Jarawka, 2013), which is what athletes in this study reported that they received. Another difference in the data found by Cochrane and what was found in this study, is that Cochrane's participants received contrast (hot/cold) water bath immersion treatments twice a day. The athletes in this study, due to limited time, only received treatment once a day. Regardless of the type of treatment received (contrast water immersion vs. ice bath water immersion), data indicates that athletes' soreness was reduced by receiving water immersion treatments in both Cochrane's study and this study.

When examining past studies completed on foam rolling, the study completed by MacDonald, Button, Drinkwater, and Behm (2014), examined how foam rolling reduced DOMS in the participants. The study completed by MacDonald et al. (2014) used a 11-point Numerical

Rating Scale (NRS) to measure athletes' soreness. In the study completed in this paper, an 11-point NRS was also used for athletes to identify their soreness, with "0" being defined as "absolutely no muscle soreness" and "10" being defined as "the worst muscle soreness you have ever felt" (MacDonald et al., 2004). In the study completed by MacDonald et al. results indicated that those who were part of the foam rolling group displayed substantially less pain when compared to the control (not receiving treatments) group. The data collected in this study indicated that the foam rolling was as effective as cold-water immersion in reducing the overall soreness.

Summary

When looking at the data found in this study and reviewing data found in past studies, both cold water immersion treatments and foam rolling treatments significantly reduced DOMS in participants. This study consisted of two groups, the foam rolling group and the cold-water immersion group. The participants completed the same strenuous workout and completed the post-exercise treatments immediately after their workouts were completed. Athletes had the same amount of "rest time" between each work out and completed the surveys prior to the next workout, 48 hours later. Data shows significant linear decrease in muscle soreness over time in both groups. The average soreness amongst athletes in the foam rolling group was 3.63 and the average soreness amongst cold water immersion was 3.27, on a 11-point rating scale. Based on the averages identified over the 2-week period, the difference between the two groups was not significant, indicating that both post-exercise treatments were seen as effective in reducing delayed on-set muscle soreness.

Chapter Five

Summary and Conclusions

The purpose of this study was to identify what post-exercise treatments help reduce delayed onset muscle soreness in athletes. This study specifically looked at two post-exercise treatments - foam rolling and cold-water immersion - and the effect they had on reducing muscle soreness in Division II student-athletes. The researcher identified that both treatments were considered effective as data showed a decrease in both treatments from time 1 to time 4. When looking closer at the data, results showed no significant difference in soreness reduction between the two post-exercise treatments. This chapter reviews the significant findings, educational implications, and presents recommendations for future research.

Significant Findings

During this study, the goal was to identify what post-exercise treatment reduced delayed onset muscle soreness in football athletes at a Division II University in the Midwest. The study initially started with 30 participants, and 26 participants completed all stages to the study. The participants were randomly selected and randomly arranged into one of two groups; the foam rolling group and the cold water-immersion group. All student-athletes had a two-week break from all strenuous workouts as they transitioned from Spring ball to summer workouts.

A schedule was created based on the football workout schedules (see Chapter 3). The athletes agreed to complete a post-exercise treatment after a strenuous workout. The student-athletes then completed a survey indicating their level of soreness 48 hours later, on a 11-point rating scale. This schedule was completed over 2 weeks and a total of 4 surveys were completed per participant.

Once all data was collected, the researched compared the data to determine which post-exercise treatment was the most effective amongst the participants. All athletes completed the same workouts, which would allow athletes to compare their own muscle soreness. The participants that received cold water immersion post-exercise treatments had an average muscle soreness of 3.27, while those athletes who completed foam rolling as their post-exercise treatments had an average of 3.63. There were no group differences, indicating both methods were equally effective in reducing DOMS.

Educational Implications

This study is very crucial to any person who participates in strenuous workouts as muscle soreness effects ability to perform. Often, people who engage in strenuous regiments experience DOMS, and are not able to perform at their highest level. Being aware of what post-exercise treatment helps reduce DOMS and will allow them the opportunity to be pro-active and choose what post-exercise treatment is effective for them. In this study, cold water immersion treatments and foam rolling both showed significant reduction in DOMS.

In the fitness industry, new strategies and ways to complete workouts are developing every day. When these new concepts are created, it is important to take the time to identify their effectiveness. When looking at foam rolling and water-immersion treatments, foam rolling is often easier to complete and more realistic. With cold water immersion treatments, the preparation time is longer and is not always the most convenient treatment to complete. Completing the treatment that is less time restraining and impactful, doesn't necessarily indicate it is the most effective treatment. In this study, results indicated that both cold water immersion treatments and foam rolling treatments were equally effective in reducing muscle soreness over a

given period of time. This means that many athletes might find that foam rolling is more convenient than cold water immersion, with the same level of effectiveness.

Recommendations for Future Research

After completing this study, there are still questions and ideas I have gathered as the researcher. Being there is little research out there or concrete evidence that shows what post-exercise treatment is the most effective for reducing delayed-onset muscle soreness, further research still needs to be completed. This study can be extended to collect more specific data on location of soreness, instead of just overall body soreness. Further research could provide targeted information on areas of athletes who were the sorest and if the treatment helped reduced that specific area of soreness. Also, it could be beneficial to conduct a study over a longer period of time to see the overall effectiveness.

Limitations

The small sample size and limited time frame are limitations of this study. Although 26 participants who were college football players were sufficient to run a statistical analysis, it would help to have a larger sample size or different sport players with both males and females. This study was conducted within a 2-week schedule, and a typical time frame of past studies varies from one week to four weeks. By extending this study for 6-8 weeks would allow for more accurate data on soreness as a whole.

The idea of having multiple, not just two recovery methods, may provide even more information in treating DOMS.

Summary

Overall, this study compared two post-exercise treatments and their effectiveness on reducing muscle soreness in Division II football athletes. As someone who works with athletes

on a daily basis, it is important to provide athletes with resources to properly care for their bodies and provide techniques and concepts to reduce muscle soreness. This study indicated that athletes who completed the post-exercises treatment of cold water- immersion had the same low levels of muscle soreness as those who completed foam rolling treatments. Given that cold water immersion treatments are more time consuming than foam rolling, some athletes may choose foam rolling against the traditional cold-water immersion due to convenience.

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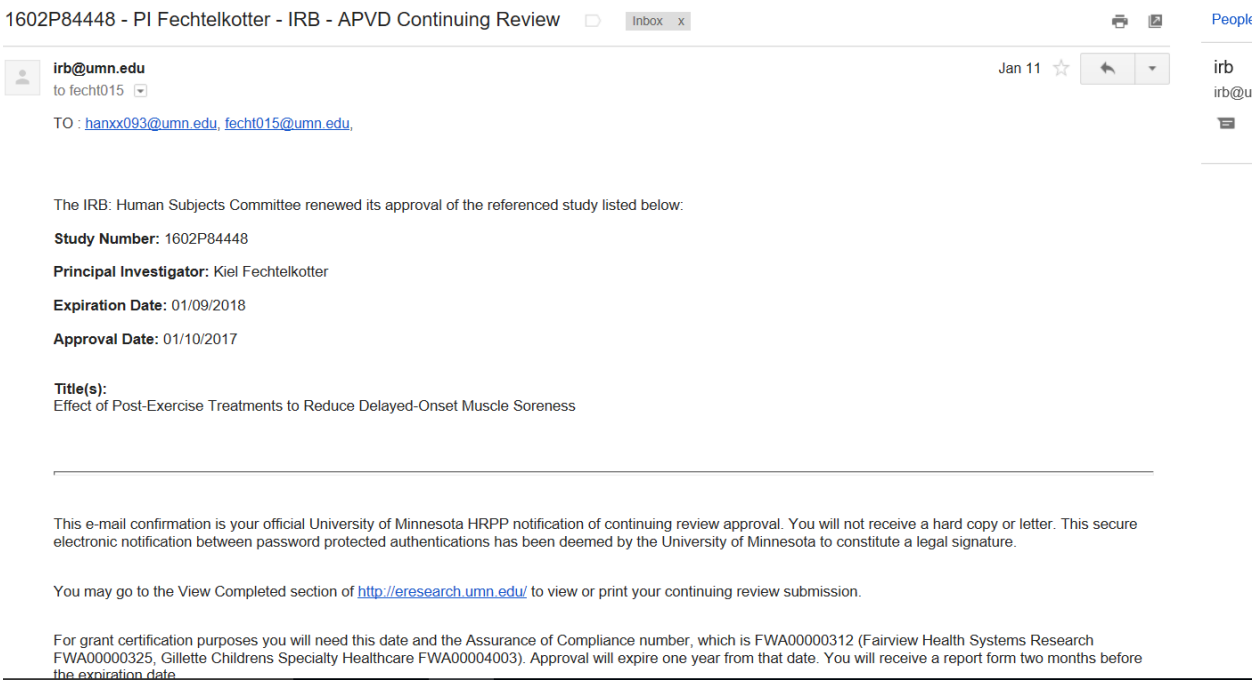
Appendices

Appendix I

IRB Approval Email



1602P84448 - PI Fechtelkotter - IRB - APVD Continuing Review Inbox x

irb@umn.edu Jan 11
to fecht015

TO : hanxx093@umn.edu, fecht015@umn.edu,

The IRB: Human Subjects Committee renewed its approval of the referenced study listed below:

Study Number: 1602P84448

Principal Investigator: Kiel Fechtelkotter

Expiration Date: 01/09/2018

Approval Date: 01/10/2017

Title(s):
Effect of Post-Exercise Treatments to Reduce Delayed-Onset Muscle Soreness

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This e-mail confirmation is your official University of Minnesota HRPP notification of continuing review approval. You will not receive a hard copy or letter. This secure electronic notification between password protected authentications has been deemed by the University of Minnesota to constitute a legal signature.

You may go to the View Completed section of http://eresearch.umn.edu/ to view or print your continuing review submission.

For grant certification purposes you will need this date and the Assurance of Compliance number, which is FWA00000312 (Fairview Health Systems Research FWA00000325, Gillette Childrens Specialty Healthcare FWA00004003). Approval will expire one year from that date. You will receive a report form two months before the expiration date

Appendix II

Consent Form

CONSENT FORM

Effect of Post-Exercise Treatments to Reduce Delayed-Onset Muscle Soreness

You are invited to be in a research study to look at the effects of post-exercise treatments that may help reduce delayed onset muscle soreness (DOMS). You were selected as a possible participant because you are a Division II football athlete, who is currently completing strenuous workouts. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Kiel Fechtelkotter. While completing his Master of Education (M.Ed) degree at the University of Minnesota Duluth, Kiel is a Graduate Assistant as a strength and conditioning coach. As graduate assistant, Kiel does not have a position of authority.

Background Information

The purpose of this study is to compare college football players' perspectives about the effectiveness of foam rolling versus water immersion in order to reduce muscle soreness. Past studies have shown these to be effective treatments in reducing DOMS. It's critical to know which treatment works best for athletes in order to allow the body to recovery efficiently, within a short period of time. This study could benefit any individual who may face DOMS and will develop an inside perspective on what athletes do in order to address DOMS from an individual perspective.

Procedures:

All football athletes will be explained the study and the phases (phase one- baseline survey, phase two- first week of treatments, phase three-second week of treatments) within the study. Any additional information the athletes may need will also be addressed prior to consent forms being distributed. The PI will then distribute the consent forms to all athletes. The PI will explain that the consent form needs to be completed in order to receive general baseline data, but not all athletes will participate in the final two phases (phase two and phase three). The PI will read through the consent form and ask if the athletes have any questions and address the questions. Once the athletes have an understanding for the study, the PI will explain that he would like all football players to complete the baseline survey in order to identify what common post-exercise treatments athletes use currently. The PI will explain if the athlete would like to be part of phase two and phase three, they need to complete the contact information at the bottom of the baseline survey. Athletes are asked to fill the survey out in an area where they feel is private and data is confidential. Once completed, athletes will turn the survey into the box on the PI's supervisor's desk.

Once all surveys are collected, a total of 40 athletes who provided contact information will be anonymously selected and randomized to the foam rolling group or water immersion group. Once that is completed, the PI will call a meeting and review the overall study and provide details on the research. The PI will explain that there will be two groups, one group will be part of the foam rolling group and the other group will be the water immersion group. PI will also demonstrate foam rolling and water immersions protocol prior to the athletes completing them. The groups will be randomly assigned.

PI will explain that this study will take place over a two week span and they will complete the post-exercise treatment on Mondays, Wednesdays, Fridays right after their workouts. Athletes will then complete the survey Wednesday prior to their work out and Friday prior to their workout. The surveys will be completed 48 hours from a strenuous workout followed by the post exercise treatment they are part of. The post-exercise treatments will take a total of 10 minutes and a set protocol is created per treatment. Completing the surveys should take less than 2 minutes. Surveys will be completed a total of 4 times. The table below represents the schedule for completion:

PHASE TWO- Week 1

PHASE TWO Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1:	Lift	X	Complete survey	X	Complete survey
Step 2:	Complete Post-exercise treatment: Form Rolling or Water Immersion see script	X	Lift	X	Lift
Step 3:	X	X	Complete Post-exercise treatment: Form Rolling or Water Immersion see script	X	Complete Post-exercise treatment: Form Rolling or Water Immersion see script

PHASE THREE- Week 2

	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1:	Lift	X	Complete survey	X	Complete survey
Step 2:	Complete Post-exercise treatment: Form Rolling or Water Immersion see script	X	Lift	X	Lift
Step 3:	X	X	Complete Post-exercise treatment: Form Rolling or Water Immersion see script	X	Complete Post-exercise treatment: Form Rolling or Water Immersion see script

The PI will explain that athletes are able to withdrawal from this study at anytime with no consequences.

Risks and Benefits of being in the Study

The study has minimal risks. The study consists of two treatments that may reduce DOMS in athletes. The treatments are non-strenuous and consist of minimal risks. Athletes perhaps could become impatient with filling out forms and surveys.

The benefits to participation may include a better understanding of what post-exercise treatments they benefit from, based on their perception.

Compensation:

There is no compensation while being a participant in this study.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records. Study data will be encrypted according to current University policy for protection of confidentiality.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota Duluth. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study are: Kiel Fechtelkotter. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact them at my office, located in the weight room, call at 218-428-5463, or e-mail at fecht015@d.umn.edu. Advisor is Diane Rauschenfels, who can be reached at 218-726-8547 or by e-mail at djrausch@d.umn.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study. *[Avoid statements that begin with "I understand…".]*

Signature:_____
Date: _____
Signature of Investigator:_____
Date: _____

Appendix III

Survey Instruments

Baseline Data Survey (Phase One)

1. What post-exercise treatments do you use to reduce muscle soreness: (X what applies to you)

Exercises	Never-0	Sometimes-1	Often-2	Always-3
Foam Rolling				
Cold Tub (Water Imersion)				
Stretching				
Other_____ (Identify what you do)				

2. Please describe *why* you do any of the post-exercise treatments identified above:

_____

_____

_____

_____

3. Please describe how much time you spend approximately per post-exercise treatment (Example: 10 minutes per treatment, 3x a week)

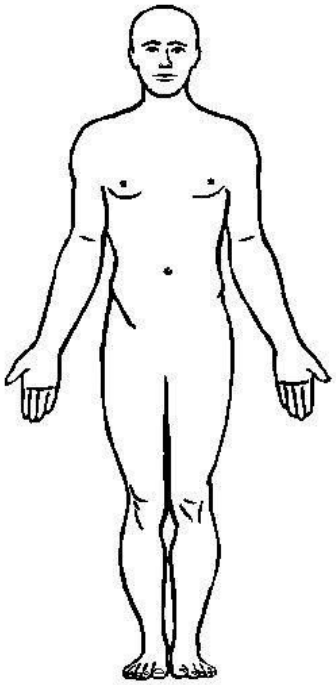
_____

_____

_____

_____

4. Please mark with an "X" the areas you target the most with the post-exercise



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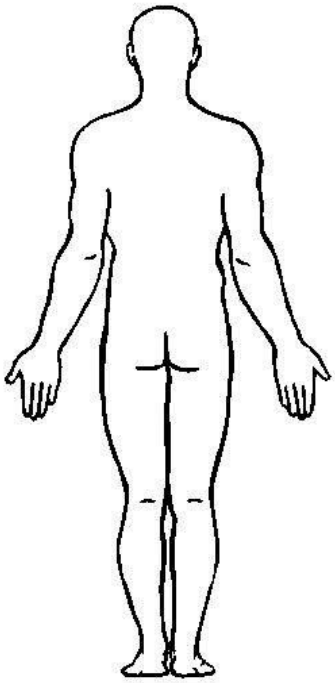


BACK

treatment described above:

If you would like to participate in phase two and three of Kiel Fechtelkotter's research study for his graduate thesis paper, please fill out the following information. This will give Kiel permission to contact you with further information pertaining to this study. Not all athletes will participate in phase two and three of this study. A total of 40 athletes will be randomly selected for participation in phases two and three and anonymous grouped (ice bath/foam roll). Athletes who are randomly selected, will be contacted by Kiel. Athletes who wish to participate in phase two-three, please fill out the following information:

Name:
Phone Number:
Email Address:
Signature:

Post- Exercise Treatment Survey (Phase Two- Time 1 and 2)

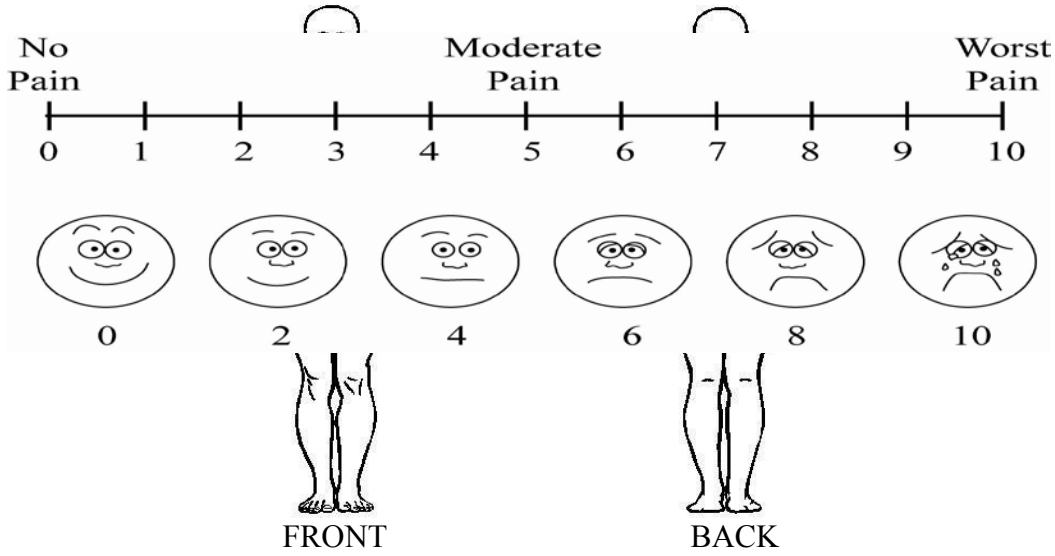
Athlete's #:_____ Date:_____

Age_____ Race:_____

(Please complete and place in the box on supervisor's desk)

1. Identify what treatment you used: Foam Rolling Ice Bath

2. Identify where you are sore by placing an "X" in that specific area:



3. Using the scale below, rate your soreness by circling that number

Post- Exercise Treatment Survey (Phase Three- Time 3 and 4)

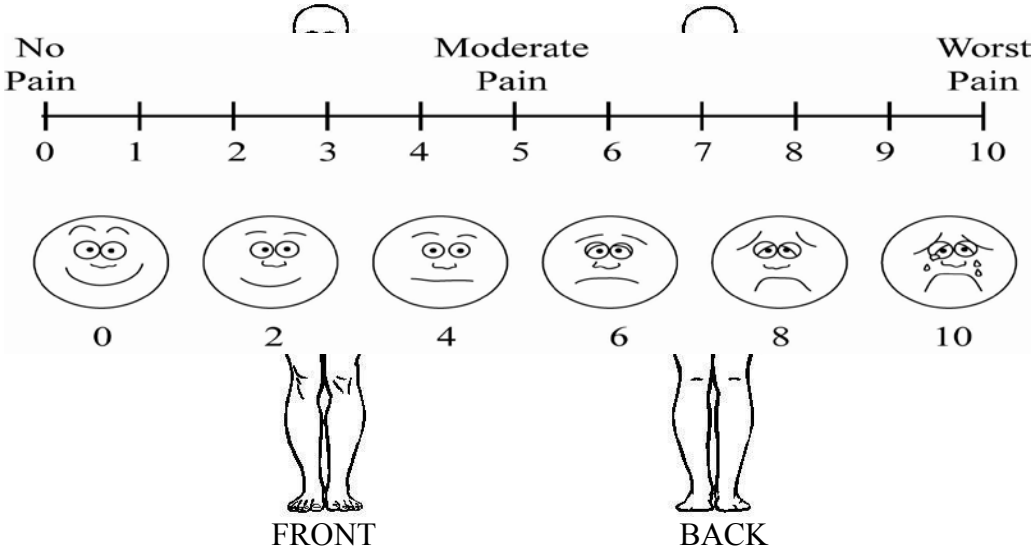
Athlete's #:_____ Date:_____

Age_____ Race:_____

(Please complete and place in the box on supervisor's desk)

1. Identify what treatment you used: Foam Rolling Ice Bath

2. Identify where you are sore by placing an "X" in that specific area:



3. Using the scale below, rate your soreness by circling that number

4. What did you like about this study?

5. What did you not like about this study?

6. Did you find this study to be beneficial in terms of recovery treatments?

Thank you for being part of my study. I appreciate your participation.