UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE INFLUENCE OF COLD-WATER IMMERSION AND RED-LIGHT THERAPY ON PHYSIOLOGICAL AND PSYCHOLOGICAL MARKERS OF RECOVERY IN FEMALE COLLEGIATE ENDURANCE ATHLETES

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

In partial fulfillment of the requirements for the
Degree of
MASTER OF SCIENCE

BY MEGAN K. JOHNSON

Norman, Oklahoma

2026

THE INFLUENCE OF COLD-WATER IMMERSION AND RED-LIGHT THERAPY ON PHYSIOLOGICAL AND PSYCHOLOGICAL MARKERS OF RECOVERY IN FEMALE COLLEGIATE ENDURANCE ATHLETES

A THESIS APPROVED FOR THE

DEPARTMENT OF HEALTH AND EXERCISE SCIENCE

BY THE COMMITTEE CONSISTING OF

Dr. Rebecca Larson., Chair

Dr. Daniel Larson

Dr. Grant Chesbro

Table of contents:

List of Tables:

List of Figures:

ACKNOWLEDGEMENTS

I would like to thank my advisor Dr. Rebecca Larson for her guidance, patience, and endless support throughout this whole process. Her knowledge and constant feedback largely impacted the progression of this study. She went above and beyond to support me through the challenges and continuously encouraged me. I will be forever grateful to have been her advisee.

I would also like to thank my committee members, Dr. Daniel Larson, Dr. Grant Chesboro, and also Dr. Sam Moore for supporting guidance, knowledge, and insight. I thank them for their curiosity, bringing ideas to further enhance this study, and for supporting this research area.

I am blessed by God through the people and experiences in my life that have shaped and allowed me to be where I am and accomplish what I have. I would like to thank my family and friends for their unfailing belief in me. They consistently encouraged me to keep pushing forward and uplifted me when I needed it most. The messages and prayers allowed me to feel peace amidst the process.

I would like to thank my lab for their encouragement, positivity, and creating a welcoming environment to be in. Thank you for being the people you are.

I would lastly like to thank the University of Oklahoma Women's distance team and coaches for their participation in this study. Without them this study would not have been possible. Their participation helps add research for female athletes and I am thankful for their willingness to be a part of that.

ABSTRACT

Background: Collegiate athletes face unique challenges to balancing recovery through time in sport, stress and pressure surrounding one's sport, socializing with peers, and managing classwork. Endurance running specifically accumulates large amounts of fatigue. It is important to understand how to alleviate physical and mental fatigue these collegiate athletes face to create an athlete-centered approach to recovery. Understanding the connection between subjective and objective feelings towards recovery gives coaches, trainers, staff, and most importantly the athlete, practical solutions.

Methods: Nine healthy female collegiate endurance athletes participated in the study. Each subject underwent one bout of CWI, RLT, and CON recovery modality with a one-week washout period. Subjective measures of fatigue and recovery were assessed through VAS, POMS, ARSS, RESTQ-76, and PSQI questionnaires. Subjects were asked to answer subjective questionnaires (VAS, ARSS, POMS) at pre workout, post workout, and post recovery (VAS, ARSS). RESTQ-76 and PSQI were given post intervention during the week of the recovery modality. The objective measure was assessed through resting HRV taken at post workout and post recovery intervals. 3x3, 3x2, and one-way repeated-measures ANOVAs were conducted to examine the effects of the three recovery modalities over time as a within-subject design (pre workout vs post workout vs post recovery).

Results: Athlete's VAS scores post workout showed a main effect of time to be significantly higher than pre workout. The subjective questionnaires produced no significant results in part due to the small sample size. Partial eta square effect sizes revealed meaningful changes in subjective measures. HRV revealed a main effect of time with post recovery HRV being significantly higher than post workout. A modality x time interaction showed significant changes among all modalities post recovery. RLT was shown to improve HRV the most post recovery.

Conclusion: These findings suggest collegiate endurance athletes undergo exercise induced reductions in mood, HRV, and increased pain sensation following a training session. The type of recovery modality was shown to not significantly differ amongst each other but rather, specific modalities improved objective and subjective measures more effectively. These results imply the importance of an individualized approach to recovery rather than subjective athlete's to one modality.

Chapter I: Introduction

The world of sport is constantly evolving, pushing the limits of what we used to think was physiologically possible. The ability to adapt to this increase in physiological demands requires not only increased attention to training but also the ability of the body to recover following high levels of physiological demands. Optimizing recovery for collegiate athletes is therefore an important aspect to enhance.

Recovery is a multidimensional process involving physiological, psychological, emotional, social, and behavioral aspects (Braun-Trocchio et al., 2022). When it comes to collegiate athletes there are large interferences to recovery, such as time spent doing one's sport, academics, travel, and socializing amongst peers (Lopes Dos Santos et al., 2020). The importance of having a well-balanced approach helps athletes avoid burnout and find enjoyment within their specified sport. Chosen recovery modalities should be backed by research to avoid wasting the time of the athlete, to help support coaches and staff to enable practical solutions and empower the athlete to perform at their highest ability.

Collegiate athletes today face more obstacles with the introduction of 'name, image, and likeness (NIL) and the transfer portal (Madden & O'Hallarn, 2024). NIL allows athletes to monetize their own personal brand and opens up more opportunities for athletes to get paid aside from school-sponsored scholarships (Madden & O'Hallarn, 2024). Similarly, almost all NIL partnerships require athletes to share brand-related content via social media, forcing them to engage with platforms. Athletes who have their name utilized by a business are inherently subject to scrutiny due to the nature of being in the spotlight (Gulavani et al., 2023). Research has shown correlations of worsening mental health with student athletes social media usage as well as general mental health being compromised (Gulavani et al., 2023; Madden & O'Hallarn, 2024). The transfer portal has also caused an increase in stress and competition for college athletes (Madden & O'Hallarn, 2024). Thus, the addition of the transfer portal and NIL has added external stressors to athletes in today's landscape of collegiate athletics. Although inherently good, the pressure to be the best, most skilled, and have a social media presence adds to the already large sum of stressors that typical college students face. It goes to show that an athlete's psyche should be monitored to keep them engaged and avoid burnout from doing the sport they love (Montull et al., 2022).

When it comes to endurance training, athletes accumulate significant loads of both volume and intensity to gain the desired adaptations (Braun-Trocchio et al., 2022). The athletes desire to prioritize a high-level performance oftentimes leads to an imbalance between stress and recovery (Braun-Trocchio et al., 2022). This training causes a shift in both physical and psychological well-being that can progress from acute fatigue, overreaching, and further to overtraining syndrome (Saw et al., 2016). Referring to the definition of recovery, because of the demands of endurance running, this multidimensional approach, including physical and psychological aspects to recovery is of increased importance. "An imbalance of long-term fatigue and insufficient recovery initiates unfavorable development, resulting in negative consequences such as under recovery, nonfunctional overreaching, and overtraining syndrome" (Kellmann, 2010). Nonfunctioning overreaching (NFO) leads to psychological and hormonal disturbances that cause a decrease in performance and, in some cases, injury and illness (Kellmann, 2010). Overtraining syndrome (OTS) is a culmination of the deleterious effects of under recovery and NFO. OTS produces symptoms such as muscle soreness, pain, and clinical and/or psychological disturbances (Kellmann, 2010). The demands of physical activity can lead to large amounts of post-exercise fatigue and must be closely monitored to avoid symptoms of overtraining. Alterations in physical and cardiac performance, as well as cognitive function can help examine exercise readiness (Gifford et al., 2018). These syndromes, however, could be alleviated with proper recovery strategies like rest, the use of recovery modalities, and lifestyle factors. Therefore, the use of both subjective and objective monitoring can both potentially be seen as useful and helpful in maintaining high-level performance.

One thing that recovery modality studies overlook is the potential impact psychology has on recovery. There is a wealth of research on the impact psychology has on sports performance. Many studies prioritize objective measures (physiological) for determining an athlete's recovery status rather than subjective or perceptual beliefs. Subjective measures can provide greater sensitivity and consistency when compared to objective measures (Saw et al., 2016). These measures can be used in response to changes in training loads apart from objective measures. Evidence highlights that sports psychology interventions adopted by professionals are critical for athlete performance, and interventions that consider an athlete's emotional and psychological well-being are important components of high performance (di Fronso & Budnik-Przybylska, 2023). Although physical conditioning and correct biomechanics are integral to athletic performance, the psychological aspect plays a crucial role in unlocking an athlete's full potential (Vyas & Khanvilkar, 2024). Meta analysis suggest the use of subjective and objective measures can be used to complement one another in athlete monitoring (Saw et al., 2016). Research states athletes have higher pain tolerance than nonathletes, leading to another potential to perceptual influence on recovery, with one study finding endurance athletes have higher pain tolerances (Pettersen et al., 2020) (Diotaiuti et al., 2022) The current literature reveals a significant gap in addressing both physical and psychological measures when examining the effectiveness of recovery modality interventions.

Other gaps in the literature include research on collegiate females or females at large, compromising only 34-39% of participants in peer-reviewed publications with some showing only 6% of females in top exercise and sport science journals (Baranauskas & Rainsberger, 2025; Crowther et al., 2017). It is important to acknowledge sex differences between males and females when interpreting recovery modality results as physiology differs (Pons et al., 2023). While sex-based differences are complex, in plain terms, females may recover faster in the short-term post-exercise due to muscle fiber type; male physiology is more advantageous; heart and lung capacities are greater and HRV differs by sex (Baranauskas & Rainsberger, 2025),(Gifford et al., 2018). Research is limited on females' responses during exercise and adaptations to training (Hunter et al., 2023). The small amount of available research on female athletes provides meaningful reason to study this population.

Purpose

The purpose of this study is to investigate commonly used recovery modalities and their influence on subjective and objective measures of recovery in a group of female collegiate runners.

This study is important because of the lack of research in the community on recovery for female collegiate endurance athletes. There is also research lacking on the impact perception has on recovery. The aim of this study is to add to the body of knowledge on the effectiveness recovery modalities for a specific population being endurance collegiate athletes and to see whether perceptions play a role in feelings of recovery towards performance. This research is also important to hopefully help athletes navigate what modalities to use based on research, as many athletes choose modalities based on the influence of elite athletes (Crowther et al., 2017; Murray et al., 2018). Therefore, this study is important to reveal the impact perception has on feelings of recovery as well as closing the gap that is currently prevalent for the optimal recovery modality for endurance trained collegiate athletes.

In the realm of college athletics, a study of Division I basketball, football, and soccer players found cold-water immersion to be the most widely used modality, over half did not believe in compression, and sleep was perceived to be the most effective but was least implemented (Murray et al., 2018). In the study conducted on recovery practices of Division I athletes, the article highlighted the recovery modalities at the collegiate level are not fully supported by evidence (Murray et al., 2018). The lack of evidence on cryotherapy as a whole has not led researchers to an agreement on whether the modality is useful or harmful (Barnett, 2006).

Literature is sparse on which recovery modalities are most suited for collegiate endurance athletes. Studies that have been conducted find that perceptions the collegiate athlete has of a modality as reason for choosing recovery modalities, rather than for reasons backed by science. (Crowther et al., 2017). This research hopes to provide insight into cold-water immersion and red-light therapy modalities. There is a need for research in the endurance collegiate athlete population.

Research Questions

1. How do recovery modalities affect subjective measures of fatigue, soreness, and perceived recovery versus a control?
2. How do recovery modalities affect objective measure of recovery versus a control?

Hypotheses

1. H_0: There will be no significant difference in subjective recovery (REST-Q Sport 76, ARSS, POMS, VAS) between cold-water immersion, red-light therapy, or control following an intense workout in collegiate endurance athletes.

2. H_1: At least one recovery modality; cold water immersion or red-light therapy will produce a significant difference on subjective recovery (REST-Q Sport 76, ARSS, POMS, VAS) following an intense workout in collegiate endurance athletes.
3. H_0: There will be no significant difference in objective recovery between cold-water immersion, red-light therapy, or control following an intense workout in collegiate endurance athletes.
4. H_1: At least one recovery modality will produce a significant difference in objective recovery following an intense workout in collegiate endurance athletes.

Delimitations

The current study includes the following delimitations:

1. Athletes from the University of Oklahoma women's cross-country team will be used in the study
2. Athletes are considered "endurance runners" if they run greater than 40 miles per week throughout the duration of the study for a minimum of 5 days per week
3. Psychological assessment will be measured through RESTQ-Sport 76, Pittsburg Sleep Quality Index, Visual Analogue Scale, Profile of Moods, and Acute Recovery Stress Scale
4. Subjects will be randomly assigned to specific recovery modalities throughout the study (#weeks/days)

Limitations

The current study includes the following limitations:

1. Generalizability is limited due to subject selection

2. Subject size is limited due to the criterion of running >40 miles per week for a minimum of 5 days per week
3. We do not have direct measures of performance
4. We are not controlling diet or other factors that could contribute to improved recovery as well as variables that could decrease recovery

Assumptions of the Study

The current study assumes the following:

1. Subjects are adhering to running mileage
2. Subjects adhere to assigned protocols for the duration of the study
3. Subjects complete the recovery modality protocol during each visit
4. Subjects answer subjective questionnaires honestly

Operational Definitions

- **Cold-Water Immersion**: Conducted for 10 minutes at -1℃ to 15℃ (Hausswirth et al., 2011; Stenson et al., 2017; Wiewelhove et al., 2018).
- **HRV**: HRV will be collected in a resting supine position for five minutes post workout and post recovery modality. HRV is the fluctuation of beat-to-beat intervals and is altered with the interplay of one's sympathetic and parasympathetic nervous systems (Reichel et al., 2022).
- **Physical Recovery**: The physiological recovery assessed through sport specific workout and heart rate variability (HRV) (Broatch et al., 2014; Stenson et al., 2017).
- **Psychological Recovery**: The athlete's perceived recovery will be measured through subjective feedback of sport specific workout and post recovery modality. (Kellmann, 2010)

- **Red-Light Therapy**: Conducted for 10 minutes at 600-830nm (Foley et al., 2016; *Joovv Solo 3.0*, n.d.).

Chapter II: Literature Review

Currently there is a gap in the literature regarding optimal recovery strategies for endurance collegiate athletes. The purpose of this study is to investigate some commonly used recovery modalities and whether they enhance subjective outcomes related to recovery in a group of endurance trained collegiate runners. The use of qualitative data will help improve the understanding regarding recovery interventions. Literature has suggested that the belief in recovery to be just as effective as the modality itself (Braun-Trocchio et al., 2022; Broatch et al., 2014). In other words, if an athlete believes the modality is contributing to their recovery from stress it can translate into better performance, hence this rational to use qualitive outcomes for this study. However, most studies investigating recovery in athletes tend to use professional athletes such that there is limited research in collegiate athletes.

Most of the research being conducted points out the lack of scientific justification for chosen modalities in athletic populations (Murray et al., 2018). Literature states that most modalities chosen by athletes are based on perceptions rather than evidence (Braun-Trocchio et al., 2022; Crowther et al., 2017; Murray et al., 2018). A potential reason for this lack of research on collegiate athletes could be caused by low adherence to new ideas of recovery via coaches and athletes, negative effects of training to be less noticed in trained populations, and limited accessibility to certain modalities (Barnett, 2006)

Within the current study, the recovery modalities to be investigated are limited to those assessable through the University of Oklahoma athletic recovery room. The use of red-light therapy (RLT) and cold-water immersion (CWI) will be discussed below. RLT is increasing in popularity within the health and wellness communities, but the goal of the research is to test its effectiveness on athletic populations. Placebo effects regarding cold therapies have been suggested, but little has been assessed in RLT. Literature reviews of each of the modalities along with their impact on the specific population will be critiqued and analyzed. This literature review will discuss topics for the proposed research problem.

Sample sizes vary across the literature. The current study aims for 20 participants and will be discussed later. Sample sizes and sample populations vary greatly in the current literature. Studies with similar sample types with collegiate athletes have utilized CWI and whole-body cryotherapy (Murray et al., 2018). Jones et al. conducted a study on 11 collegiate DII endurance male athletes of CWI effect on hemoglobin measures (Jones et al., 2024). Crowther used a convenience sample of 331 athletes and coaches from various sports to assess recovery strategies used and opinions on various recovery strategies (Crowther et al., 2017). This research helps understand the attitudes and perception of commonly used recovery modalities amongst athletes. Meur et al. conducted research on 16, 32-year-old triathletes during an overreaching phase (Meur et al., 2017). Wiewelhove et al. and Hauswirth et al. conducted research on endurance athletes but subjects were between the ages of 30-45 years, joining the large amount of research being conducted on middle aged endurance trained males (Hausswirth et al., 2011; Wiewelhove et al., 2018). Most research conducted uses endurance trained athletes by means of purposive and convenience sampling. The gap in literature gives rise to the need for collegiate endurance athlete representation

Literature Review Criteria

Boolean strategies and backward searching were conducted to refine search results. All articles were hand retrieved. Data bases used included Google scholar, ResearchGate, NIH, and PubMed. Research began February 2025. Inclusion criteria allowed for articles, systematic reviews, meta-analyses that contained relevance to collegiate athletics and endurance-based athletes. Inclusion was further met if articles contained at least one of the recovery modalities pertinent to the research question. Papers were excluded if they largely focused on non-collegiate and/or non-endurance-based populations, inadequate sampling size, poor methodology, were older than 15 years, if research was conducted on animals, and if one of the two modalities was not included in the review or research. Other criteria included collegiate athlete mental health in the landscape of NIL's impact to mental health. Several search terms were included to retrieve as much literature on endurance collegiate athletes as possible. Several studies were retrieved but lacked correct inclusion criteria. Advanced search criteria were used to limit vast numbers of articles.

Key Words

Key words included, “Endurance Running Recovery”, “Recovery Modalities in Collegiate Athletics”, “College Athlete Recovery”, “Optimal Recovery for Endurance Athletes”. Search terms included and/or , “Endurance running recovery with red light”, “PBMT endurance recovery”, AND “Endurance Athletes” AND “Endurance Running”, “Cold Water Immersion” AND “Endurance Running Recovery”, “Endurance Athlete Recovery” OR “Recovery for Endurance Athletes” “Recovery Practices for Division I Collegiate Athletes” "Endurance Athlete Recovery Practices" OR "Recovery for Endurance Athletes”. “Perception AND Athlete Recovery”, “College Athlete Mental Health”, “College Athlete Mental Health AND NIL”, “Student Athlete Mental Health Struggles AND NIL”, “Mental Health in Collegiate Athletes Regarding NIL”. “HRV in Endurance Collegiate Athletes”.

Red Light Therapy

Red light therapy has been introduced in athletic recovery. In recent years, red light therapy has received much attention in terms of its antiaging, anti-inflammatory effects, and ability to enhance muscular performance (Ferraresi et al., 2016). The underlying mechanisms of red light are attributed to its impact on mitochondrial function which can potentially enhance athletic performance along with vasodilation to increase peripheral blood flow (Ferraresi et al., 2016; Hausswirth et al., 2011). Red light has the largest wavelengths of all colors which allows for high tissue penetrance and, therefore, treatment time is relatively short (Cheng et al., 2021). The infrared radiation emitted through RLT acts on cellular energy metabolism and induces increased mitochondrial membrane potential and provides higher levels of ATP through increased cellular respiration (Ferraresi et al., 2016). Other mechanisms to highlight red light's effectiveness include stimulation of defenses against oxidative stress by the upregulation of antioxidants, prevention and repair of muscle damage, increase in nitric oxide, and treatment of pain. (Cheng et al., 2021; Ferraresi et al., 2016; Hamblin, 2017). Without expanding the scope of this study, reactive oxidative species (ROS) limit muscle contraction by decreasing myofibrillar sensitivity to calcium and damaging proteins involved in excitation-contraction coupling (Powers et al., 2020). Exercise produces ROS, which highlights the need to minimize or counteract its negative effects on performance. Through red light stimulation, improved sensitivity of myofibrils can help reduce muscle fatigue and therefore improve muscle performance (De Marchi et al., 2012). Due to the abovementioned mechanisms underlying red light, recovery can potentially be enhanced by use of this modality.

Few studies have assessed RLT as a potential aid in athletic performance. One systematic review looked at the effects red light has on muscle tissue but several of the studies were conducted on populations outside the desired inclusion criteria. Many of the reviews used red light as a preconditioning modality rather than as a recovery modality. One relevant study included within the review looked at a single endurance runner. The runner conducted a treadmill run till exhaustion. They found that the use of red light before was able to reduce time to exhaustion, decrease oxygen deficit, and improve markers of muscle damage (Ferraresi et al., 2016). These results align with literature that states potential benefits of using red light or also known as photo-biomodulation therapy (PBMT) pre-run. A study conducted on twenty male endurance athletes tested the impact PBMT has on running economy on 3000-meter performance. Subjects received treatment after a submaximal test, completed the 3000-meter run, completed a treatment, and then were measured on running economy post intervention. The researchers were able to find support that PBMT can improve running time by seven seconds and improve running economy (RE) by about 5% 24 hours after the test. RE was not improved for placebo or PBMT treatment immediately following the track test (Lanferdini et al., 2021). These findings suggest red light treatments could improve recovery and enhance subsequent performance. However, these results conflict with another study conducted on eighteen male and female recreational endurance runners which did not find improvements in 5000-meter running performance. This study looked at the effects of running performance and RPE after the use of various light intensities (300, 900, 1260 J). This study found that red light did not impact a 5km time trial performance or RPE with any condition (do Nascimento et al., 2024). The results regarding RPE in this study conflict with another study comparing cryotherapy and red light, in which the study was unable to find improvements in RPE post-simulated trail run. The participants reported a lower RPE but all physiological measures were not conducive to an effect (Hausswirth et al., 2011). Subjective measures have been found to indicate a positive effect of red light, along with improved running performance and economy. The review by Lanferdini et al. indicates possible benefits using red light for recovery and the ability to see improvements 24 hours post intervention (Lanferdini et al., 2021).

Cold-Water Immersion

The other recovery modality that will be covered is cold-water immersion (CWI). CWI is noted to be one of the prevalent sources of recovery in athletes but is seen to be more of a placebo or belief effect regarding its efficacy for recovery (Broatch et al., 2014; Crowther et al., 2017; Wilson et al., 2018). The mechanisms of CWI, through post-exercise cooling are thought to limit temperature-induced metabolic damage to tissue (Jones et al., 2024). The vasoconstrictive effects of CWI combined with the hydrostatic effects of water pressure remove heat, reduce edema, reduce inflammation, and decrease the transport time of metabolic waste (Stenson et al., 2017). These mechanisms, therefore, limit muscle damage, swelling, and pain sensation. The use of CWI is widely used by athletes due to its convenience and theorized physiological benefits.

A study assessed WBC and CWI against a placebo following a marathon. Regarding CWI, objective measures indicated no positive or even harmful effects when compared to placebo. Inflammatory markers such as CK, IL-6, and TNF-α were found to have little evidence in being reduced by CWI. It was found however that CRP was decreased after the use of cryotherapy (Wilson et al., 2018). The results of this study on perception of recovery contrast with much of the literature out there. A study looking at recovery following a half-marathon noted CWI to have no beneficial effect on objective markers (blood, CMJ, muscle contractile components) but improved subjective measures (muscle soreness and perceived recovery) (Wiewelhove et al., 2018). The mechanistic reasoning of decreased muscular performance is attributed to the thought of slower calcium and sodium exchange when creating action potentials as well as the cold temperatures creating a stress response within the body (Wiewelhove et al., 2018; Wilson et al., 2018). Stenson et al. also agree to the notion that CWI could be a placebo or belief effect. The researchers had nine males perform repeat 1200-meter runs, followed by CWI for 12-minutes in 12°C water or a control treatment in thermoneutral water, then 24-hours later completed a 5000-meter run. They found no significant difference in 5km run times, RPE was lower for CWI vs control, and no difference in thigh circumference (Stenson et al., 2017). The lack of significance between the two contrasts with another study, which found that CWI was able to significantly improve time to failure of a VO_2 max test. Dunne et al. had nine middle-distance runners complete a VO_2 max test, then into CWI at 8°C and 15°C or control group for 15-minutes. Following the recovery intervention, they completed another VO_2 max test. After completion of the second test, the time to failure was longer post CWI 8°C than the control group, with both 8°C and 15°C showing lower intestinal and heart rates during the second test. They found blood lactate, running economy, and VO_2 to not be significantly different or altered compared to control (Dunne et al., 2013).

The effects of CWI have been shown to reduce perceptions of fatigue and RPE though evidence suggests the belief effect may be attributed to its benefits (Broatch et al., 2014; Wiewelhove et al., 2018; Wilson et al., 2018). There are mixed reviews on whether CWI is beneficial to physiological mechanisms in the endurance population. Some research states benefits (Crowther et al., 2017; Dunne et al., 2013), while others state the lack of benefit. (Broatch et al., 2014; Stenson et al., 2017; Wiewelhove et al., 2018; Wilson et al., 2018). The literature out there lacks cohesive agreement. Again, research using CWI as a recovery modality is lacking in collegiate endurance athletes. From the above study, they focused primarily on objective measures of performance, but as we know, subjective readiness has an impact on recovery.

Perception of Recovery and the Influence on Performance

An athlete's psychological state has a great effect on unlocking their full potential (di Fronso & Budnik-Przybylska, 2023). Psychological state has been shown to impact physiological responses to exercise, which highlights the importance of looking at recovery through both a physical and psychological lens. A study conducted on runners found that those who performed a mentally fatiguing task had higher session RPE's and lower VO_2 max values when compared to a control group (p = .013; p = .007) (Smith et al., 2015). These findings suggest an athlete's psychological state can impact performance regardless of physiological state.

A study conducted on sport psychology beliefs and performance, collected 117 responses through a questionnaire of people ranging from academia to athletes. The study aimed to add to the growing body of knowledge on psychology's influence on sport performance. 88% of participants stated confidence affects their performance, and 70% noticed a decline in sport performance due to mental factors (Vyas & Khanvilkar, 2024). When it comes to recovery modalities, belief in a certain recovery modality often leads to greater adherence. A study found that the most highly rated reason to use a certain modality was the psychological reason of "decreases muscle soreness" (Crowther et al., 2017). The study also found that water immersion recovery had the highest percentage of responses classified as psychological benefits. This research suggests that perception may be related to feelings of recovery.

In addition to psychological fatigue, chronic imbalance of emotion can result in poorer recovery, avoidance of rehab, and social connection with evidence suggesting psychological intervention can help lower the risk of injury (Weiß et al., 2024). Effective self-regulation strategies apparent in athletes have been shown to improve endurance performance, decision making, motor learning, lower anxiety, and improve competition prep which further acknowledges the need for optimal recovery (Balk & Englert, 2020). Without balancing the load of physical and mental fatigue, burnout, decreased performance, and injury can occur (Balk & Englert, 2020). Additionally, a meta-analysis found psychological interventions can reduce the rate of injury and loss of exercise (Li et al., 2020).

Collectively, these findings highlight the need for monitoring an athlete's mental and physical recovery state through subjective measures such as those in the current study. It is important to note how an athlete feels or perceives recovery, rather than only looking at objective means of recovery. These measures give a whole body approach to recovery rather than a one-dimensional, physical approach.

Conclusion

The literature exposes the gap regarding endurance collegiate athlete recovery. There is also a lack of evidence regarding the effects of recovery modalities on both subjective and objective performance indicators. The literature points out the need for both subjective and objective measures when conducting research on recovery. Along with this, many studies face the limitation of small sample sizes. The use of red light and cold water needs to be further researched. Red light therapy lacks the potential benefit of using post-workout, with most research being used immediately before a workout. Cold-water immersion seems to elicit a placebo effect or belief effect, and the objective measure underlying recovery needs to be researched in endurance collegiate athletes to better understand if this population could benefit from the recovery modalities in question. Overall, the lack of literature highlights the need to investigate this population to better aid the student-athletes and give them a potential competitive advantage.

Chapter III: Methodology

There is a gap in the literature regarding the optimal recovery for endurance collegiate female athletes. The world of sport is evolving and the need to adapt and recover is important. The purpose of this study was to find which modality or modalities produced enhanced recovery in female collegiate endurance athletes.

Sample

The subject sample includes the University of Oklahoma women's team aged of 18-24. The sample was limited to endurance collegiate athletes at the University of Oklahoma. The chosen subjects were based on purposive sampling and recruited to fill the gaps in the literature. Sample sizes of reported studies range from nine subjects to as large as sixty (Broatch et al., 2014; de Paiva et al., 2019; Dunne et al., 2013; Lanferdini et al., 2021; Meur et al., 2017; Smith et al., 2015; Wiewelhove et al., 2018; Wilson et al., 2018). Given the large range of sampling sizes, the current study included nine endurance trained collegiate athletes.

Inclusion Criteria

1. University of Oklahoma female cross-country athlete
2. Run > 40 miles per week

Exclusion Criteria

1. Non-University of Oklahoma female cross-country athlete
2. Run < 40 miles per week
3. Contraindications to cold therapies

Research Design

The research design was a repeat-measure experimental design (treatment x subjective or objective outcomes). The collection of data occurred throughout the months of March to April, while being aware of athletic competition to account for additional fatigue. Athletes who were competing would not be tested during that week. Those responsible for collecting data were lead researchers, assistant researchers, and subjects participating in the study. Physiological data was measured through HRV and sleep quality. Subjects were randomly assigned to a treatment of either cold water immersion (CWI), red light therapy (RLT), or control (CON) and performed the modality one day of the week with a washout period of roughly six days until the next treatment. Throughout the duration of the study, athletes were not asked to change their typical recovery routine. The use of CON group assessed the impact either recovery modality had on the athlete's perception of fatigue and any physiological benefit. Session one included signing consent and forms, recovery modality assignment, and participants answered the subjective questionnaires. Participants answered the subjective questionnaires pre-and-post workout and post recovery modality. The next week was the same but included a different modality or CON.

Recovery Modalities

- Cold-Water Immersion: Conducted for 10 minutes at -1°C to 15°C (Hausswirth et al., 2011; Stenson et al., 2017; Wiewelhove et al., 2018).
- Control: Sit for 10 minutes in a climate-controlled environment. No modality will be given but questionnaires will still be answered
- Red-Light Therapy: Conducted for 10 minutes at 600-830nm (Foley et al., 2016; *Joovv Solo 3.0*, n.d.; Lawrence & Sorra, 2024).

Forms & Subjective Questionnaires

Participants will be asked to complete and sign informed consent and PAR-Q questionnaires prior to the collection of data. Time to complete all questionnaires upon initial visit will be roughly 30 minutes but will decrease in time after familiarization. Furthermore, participants will be asked to consistently answer the questionnaires pre-post workout and pre-post recovery as outlined in the experimental design. Appendices A-E will include an example of all subjective questionnaires. Figure one below shows the timeline of when measures were taken. Post workout refers to after the track specific workout and post recovery refers to after the randomly assigned recovery modality or CON (CWI, RLT). HRV was measured immediately post-track-specific workout for five minutes and immediately post-recovery modality or CON for five minutes.

1. **Informed Consent**: This form informed participants what the study entails and of the proposed benefits and risks. The form was signed by subjects before participating in the study.
2. **Profile of Moods Short Form**: The Profile of Mood States questionnaire is a mood state questionnaire. The questionnaire gives information about tension, vigor, anger, depression, and fatigue (McGuigan, 2017). It was used to assess the feelings of fatigue and vigor pre- and post-sport specific workout effort. The short version contains 37 items, and athletes rate each item on a 5-point scale, rating each item from 0 (“not at all”) to 4 (“extremely”) (McGuigan, 2017). This short version has high correlation to the original POMS ($r > 0.95$) and high internal consistency ($\alpha = 0.80$ to 0.90) (Curran et al., 1995). Using the short-form version creates ease of administration to athletes while still being robust to capture athlete’s subjective measures (Curran et al., 1995; McGuigan, 2017).

3. **Visual Analog Scale (VAS)**: The VAS is a self-reported 10-centimeter pain rating scale and was used to measure acute muscle pain, training intensity, and mood (Delgado et al., 2018; McGuigan, 2017). The left side of the scale indicates no pain, whereas the right side indicates worse pain. This scale was used for pre-workout, post-workout, and post-recovery. The VAS is a reliable tool used by many practitioners in measuring pain (Alghadir et al., 2018; Bird et al., 2016; Delgado et al., 2018; McGuigan, 2017).
4. **The Recovery-Stress Questionnaire for Athletes-76 (REST-Q)**: The REST-Q for athletes is widely used for athlete recovery and stress monitoring (McGuigan, 2017). It was developed to measure the frequency of current stress symptoms and recovery activities in athletes (Kellmann & Kallus, 2025). The REST-Q is comprised of 76 questions divided into 19 scales; seven related to general stress, five related to general recovery, three to stress in sport, and four to specific recovery in sport (McGuigan, 2017). The questionnaire differentiates sport-specific and non-specific areas of recovery and stress, thus making it one of the only questionnaires to try to address the full complexities of stress and recovery (Kellmann & Kallus, 2025). This questionnaire has been shown to be a valid and reliable source for psychological evaluation of an athlete's recovery and was utilized in the current study at the end of the week after completion of the recovery bout. (Gnacinski et al., 2021; Nicolas et al., 2019). It took roughly 15 minutes for the first session but decreased with familiarity.
5. **The Acute Recovery and Stress Scale (ARSS)**: The ARSS measures current recovery-stress states of an athlete's emotional, mental, and physical states (Kellman & Kölling, 2019). It is comprised of 32 adjectives listed on a seven-point Likert scale, '0' (does not apply at all) to '6' (fully applicable) and takes roughly 4-5 minutes to complete (Kellman

& Kölling, 2019). The questionnaire is a self-assessment with no normative values, making it highly individualized to the athlete. It is intended for athletes 16 years and older and is comprised of physical performance capability, mental performance capability, emotional balance, overall recovery, muscular stress, lack of activation, negative emotional state, and overall stress (Kellman & Kölling, 2019). The ARSS is more detailed than the short form version (short recovery and stress scale) and is better at detecting variations in response changes. To evaluate scores, the mean value of the accumulated points from the adjectives is calculated, and this method has been proven to be reliable and valid ($\alpha = 0.77 - \alpha = 0.88$) (Kellman & Kölling, 2019). The ARSS questionnaire was used to assess subjective fatigue pre-workout, post-workout, and post recovery.

6. **Pittsburgh Sleep Quality Index** (**PSQI**): The PSQI is commonly used in clinical and non-clinical practice settings to provide information on a subjects sleep quality (Grandner et al., 2006). It assesses the quality of sleep by analyzing objective and subjective measures that influence sleep (Grandner et al., 2006). It's composed of 19 self-reported items, seven subcategories which include: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction (Shahid et al., 2011). Initial evaluation has found the PSQI to have high internal and test-retest reliability ($\alpha = 0.83, 0.85$) (Shahid et al., 2011). The PSQI was used in the current study at the end of the week after completion of the recovery bout.

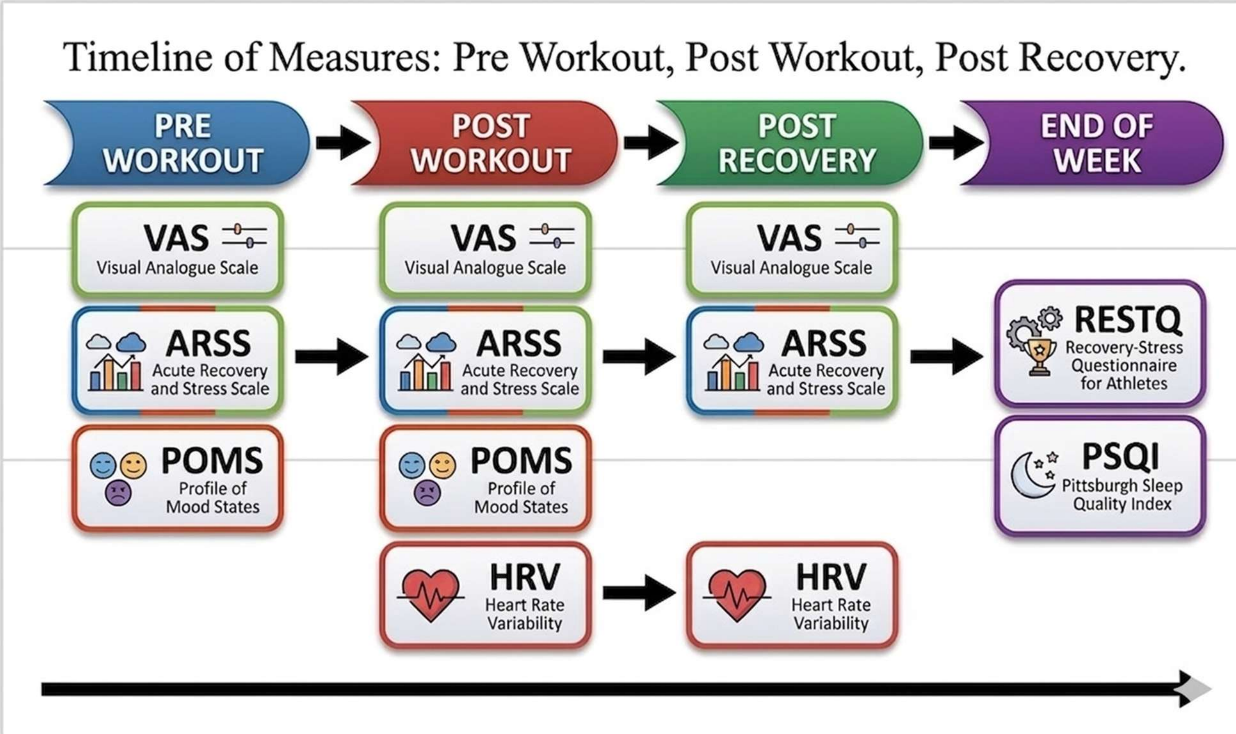

Figure 1. Timeline of measurements. A 5-minute HRV was collected post workout and post recovery modality. Figure created with authors conceptual design with use of AI for image rendering

Objective Measure

HRV was collected for five minutes immediately post-workout and five minutes immediately post-recovery modality in a seated supine position, this was done for consistency as body position can impact HRV readings (Esco et al., 2025). Using HRV provided a method of testing physiological recovery. HRV is the fluctuation of beat-to-beat intervals and is altered with the interplay of one's sympathetic and parasympathetic nervous systems (Reichel et al., 2022). HRV is a suitable measurement because it is noninvasive. HRV is also useful for athlete monitoring to give a measure of overall training adaptation and physiological states of readiness (Sekiguchi et al., 2021). To collect data, the Elite HRV app was used as it is shown to be a reliable and validated app when compared to the gold standard ECG (Lundstrom et al., 2023; Moya-Ramon et al., 2022). The parameter used through the Elite HRV app was the five-minute log-transformed root mean square of successive R-R interval (LnRMMSD), which has been shown as a suitable athletic assessment that is less influenced by breathing rate compared to frequency HRV domains (Flatt & Esco, 2016; Lundstrom et al., 2023). LnRMSSD is used for standard practice to stabilize variance as HRV variables typically follow a non-normal distribution and reflect vagal tone (Esco et al., 2025).

The study included the following set of questionnaires listed above to rate subjective measures. The objective measure was collection of HRV. The study could not be conducted in a blind procedure, as subjects would have knowledge of the modality they were receiving and participating in. However, subjects were randomly assigned a recovery modality on the day of treatment. Psychological evaluations and physiological parameters were measured to answer the question of which recovery modality would recover female endurance collegiate athletes most optimally. The goal was to have all subjects perform each modality for one day a week with a six-day washout period.

Threats to the research that were experienced included experimental mortality as injury occurred throughout the duration of the experiment. To help mitigate the threats to validity, the researcher verbally informed the expectations of participants and informed them of the potential risks involved detailed in the informed consent prior to the start of the study. A washout period followed the completion of the subject's modality intervention to attenuate any potential treatment carryover.

Physiological recovery was assessed through HRV. Psychological assessment was conducted through REST-Q, PSQI, POMS, ARSS, and VAS questionnaires. Subjects were randomly assigned to a specific recovery modality following a high-intensity workout. The modalities used were a cold tub regulated by OU athletic training staff (HydroWorx) and standing red-light therapy stations (JOOV Elite 3.0 Kit). Prior to all cold water immersion, the temperature was checked to ensure consistency. Subjects performed a 10-minute ice bath (-4°C) and stood in red light stations for 10-minutes (600-830nm). OU athletic training and OU recovery room staff administered red-light therapy sessions. The use of CWI has frequently been used as a modality for recovery, with red light therapy has been used pre or as a post-workout recovery option (Ferraresi et al., 2016; Hausswirth et al., 2011; Meur et al., 2017; Nasi et al., 2020; Wilson et al., 2018).

Data Management and Analysis

All data was kept on Excel and Word documents. All subjects were assigned a number to provide confidentiality. Answers to questionnaires and physiological measures were kept on file under the participants' designated number to take into account and take note for any changes that occurred during the study. This allowed researchers to analyze within-subject measures. All data was conducted on IBM SPSS Statistics (Version 31.0). Repeated measures of ANOVA (ARSS, POMS, VAS, HRV) (n = 9) and one-way repeated measures ANOVA (RESTQ-Sport 76, PSQI) were conducted for the following data, with significance set to $p < 0.05$ (Hausswirth et al., 2011; Jones et al., 2024; Lanferdini et al., 2021; Stenson et al., 2017). All tests were checked for sphericity and if violated, the Greenhouse-Geisser correction was made. If significant main effects or interactions were found, Bonferroni post hoc analyses was used. All data were reported as mean ± standard error except for subject characteristics which were reported as mean ± standard deviation. Partial eta square (η^2_p) was used to determine if meaningful differences could be found due to the small statistical power of the data sample (n = 9). Data was stored on a password-protected computer to prevent any breaches to confidentiality.

Chapter IV: Results

Timeline of Measurements Taken

Figure 1 is a reminder of when the subjective and objective measures were taken throughout the duration of the study.

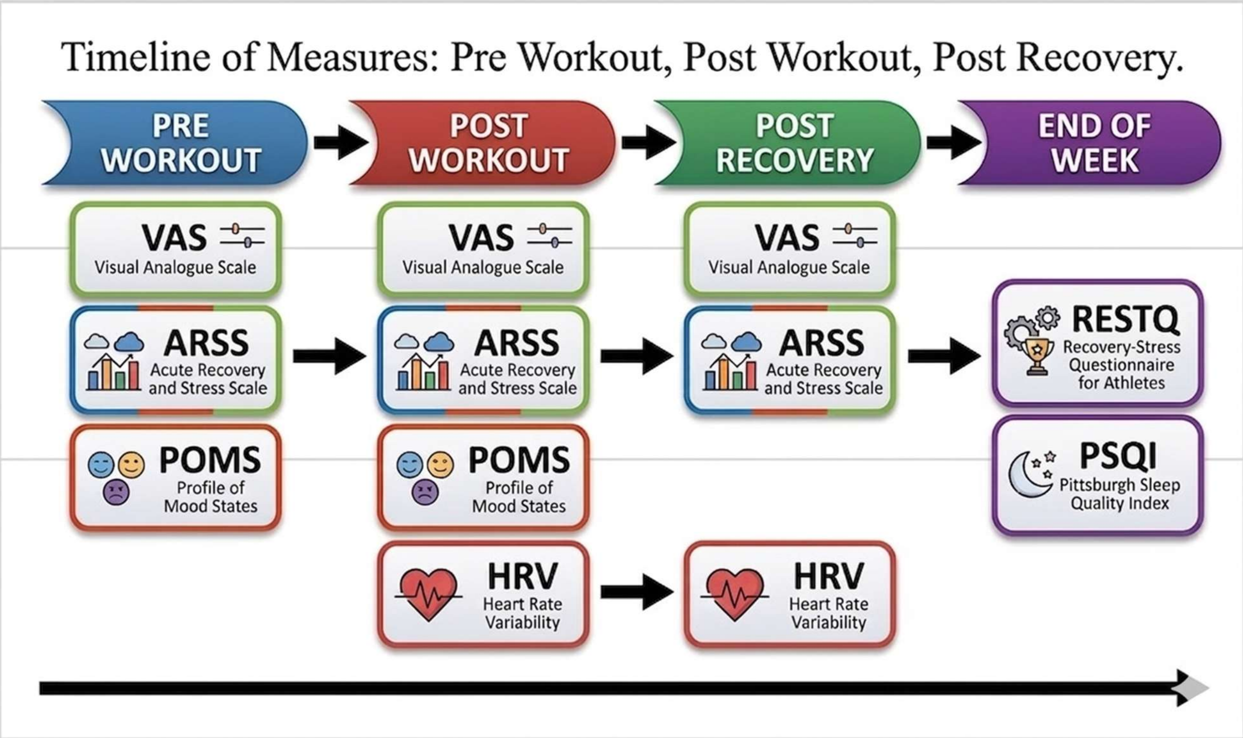

Figure 1. Timeline of measurements. A 5-minute HRV was collected post workout and post recovery modality. Figure created with authors conceptual design with use of AI for image rendering

Sample Descriptive Statistics

A total of 9 participants completed the study. Subject characteristics are listed in Table 1 below.

`Table 1. Subject characteristics as Mean ± SD of age, height, and weight

	Age (yrs)	*Height (cm)*	*Weight (kg)*
Female	21.78 ± 1.39	164.39 ± 7.27	55.14 ± 3.30

All data are represented as mean ± SD.
n = 9.

Profile of Mood States (POMS)

A repeated-measures ANOVA revealed no significant recovery modality x time interaction on the POMS total mood disturbance scores (n = 9), (F (2,16) = 1.08, p = 0.363, η^2_p = 0.119). There was no significant main effect of recovery modality (F (2,16) = 0.510, p = 0.630, η^2_p = 0.060) or main effect of time (F (1,8) = 1.561, p = 0.247, η^2_p = 0.163) respectively. See Figure 2.

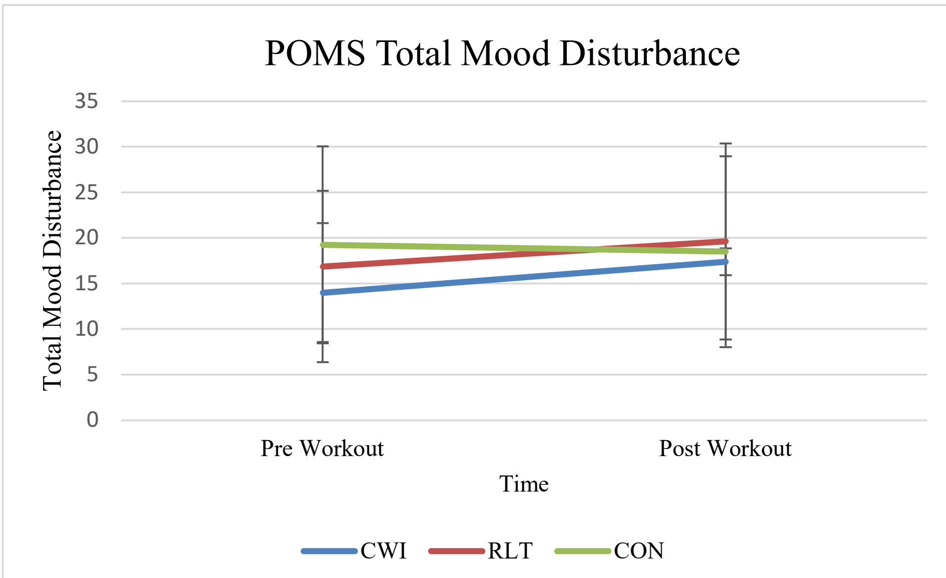

Figure 2. Profile of moods states (POMS) questionnaire total mood disturbance amongst the three modalities taken pre to post workout. All data and bar plots are mean ± SE. CWI = cold water immersion; RLT = red light therapy; CON = control.

Visual Analog Scale (VAS)

A repeated-measures ANOVA revealed no significant recovery modality x time interaction for the VAS, (n = 9), (F (4,32) = 0 .666, p = 0.620, η^2_p = 0.077). The main effect of recovery modality was not significant (F (2,16) = 2.186, p = 0.145, η^2_p = 0.215). However, there was a significant main effect for time (F (2,16) = 5.183, p = 0.013, η^2_p = 0.421). See Figure 3. The Bonferroni-adjusted pairwise comparison revealed that VAS was significantly higher at post workout compared to pre workout (MD = -1.407. p = 0.012), however no significance was observed pre workout to post recovery (MD = -0.778, p = 0.448), and post workout to post recovery (MD = 0 .630, p = 0.426).

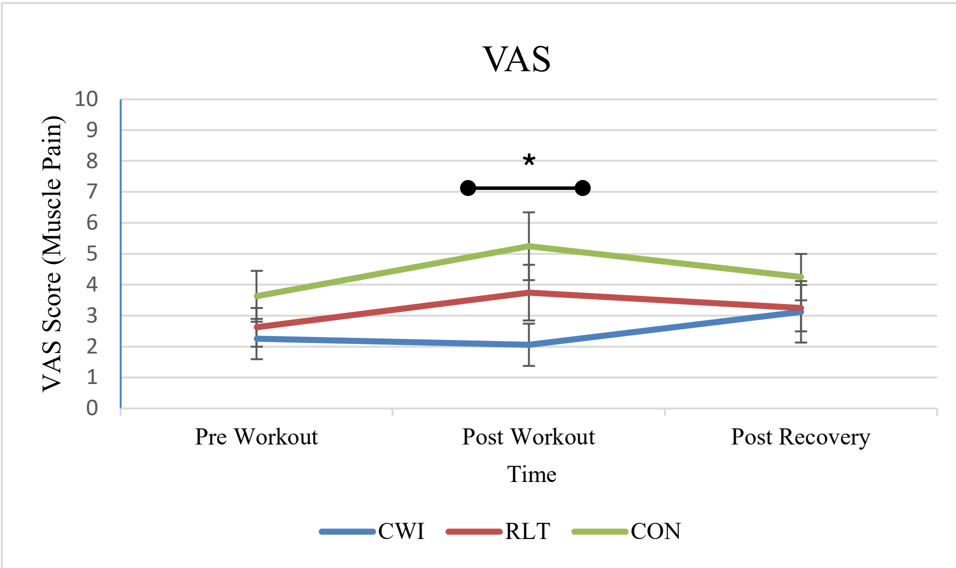

*Figure 3. Visual analog scale (VAS) amongst the three modalities taken a pre workout, post workout, and post recovery. All data and bar plots are mean ± SE. CWI = cold water immersion; RLT = red light therapy; CON = control. * p < .05 denotes significant difference from pre workout across all conditions.*

Acute Recovery and Stress Scale (ARSS)

Stress Dimension

A repeated-measures ANOVA revealed no significant recovery modality x time interaction for the ARSS Stress Dimension domains (overall stress, muscle stress, lack of activation, and negative emotion) ($p > 0.05$). In addition, there was no significant main effect of recovery modality or main effect of time ($p >$ 0 .05). See Table 2 and Figure 4.

Table 2. ARSS Stress Dimension Scores

ARSS Domain	*Modality*	*Pre-Workout*	*Post-Workout*	*Post-Recovery*	*F*	η^2_p	P
Overall Stress							

	CWI	10.63 ± 1.99	13.13 ± 2.33	13.63 ± 2.36	.679	.088	.523
	RLT	10.0 ± 2.59	14.63 ± 3.11	12.25 ± 2.45			
	CON	12.75 ± 2.81	14.13 ± 2.83	2.808 ± 2.63			
Muscle Stress							
	CWI	13.38 ± 1.02	14.75 ± 0.77	13.38 ± 1.82	.622	.082	.551
	RLT	13.63 ± 1.44	13.25 ± 1.22	14.0 ± 1.5			
	CON	15.75 ± 1.49	13.88 ± 1.54	14.0 ± 1.36			
Lack of Activation							
	CWI	10.63 ± 2.04	13.5 ± 2.39	12.88 ± 3.34	1.67	.194	.221
	RLT	10.13 ± 2.52	10.25 ± 2.0	11.25 ± 2.40			
	CON	11.63 ± 3.07	13.5 ± 3.29	13.75 ± 2.8			
Negative Emotion							
	CWI	11.13 ± 2.92	10.63 ± 1.93	10.0 ± 1.71	.596	.078	.565
	RLT	9.25 ± 2.65	9.63 ± 2.20	9.25 ± 2.13			
	CON	9.5 ± 2.28	10.63 ± 2.46	10.25 ± 2.16			

ARSS Stress Dimension scores are represented as mean ± SE.
n = 8.
CWI = cold water immersion; RLT = red light therapy; CON = control group.

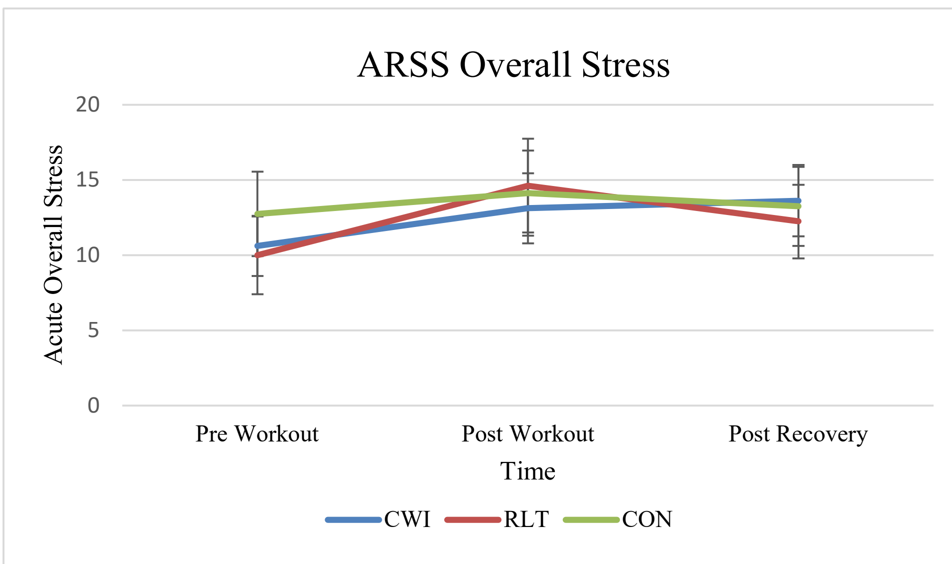

Figure 4. Acute recovery stress scale, overall stress domain amongst the three modalities taken pre workout, post workout, and post recovery. All data and bar plots are mean ± SE. CWI = cold water immersion; RLT = red light therapy; CON = control.

Recovery Dimension

A repeated-measures ANOVA revealed no significant recovery x time interaction as well as no significant main effect for recovery modality or time for the ARSS Recovery Dimension domains (overall recovery, physical performance capability, mental performance capability) ($p >$ 0.05). See Table 3 and Figure 5.

Table 3. ARSS Recovery Dimension Scores

ARSS Domain	*Modality*	*Pre-Workout*	*Post-Workout*	*Post-Recovery*	*F*	η^2_p	*p*
Overall Recovery							
	CWI	16.0 ± 1.88	15.25 ± 1.72	14.88 ± 1.42	.009	.001	.991
	RLT	17.63 ± 1.76	14.0 ± 1.74	14.88 ± 1.72			
	CON	16.63 ± 2.28	15.0 ± 2.2	15.13 ± 1.48			
Physical Performance Capability							
	CWI	18.25 ± 1.86	18.38 ± 1.75	16.25 ± 1.97	.024	.003	.880
	RLT	20.12 ± 1.29	17.25 ± 2.31	18.88 ± 2.32			
	CON	18.13 ± 2.60	16.38 ± 2.60	16.38 ± 2.80			
Mental Performance Capability							
	CWI	16.5 ± 1.76	15.25 ± 1.73	15.75 ± 1.58	1.44	.171	.269
	RLT	18.38 ± 1.87	15.63 ± 1.74	17.5 ± 2.42			
	CON	15.25 ± 2.31	14.38 ± 2.09	15 ± 2.05			
Emotional Balance							
	CWI	16.88 ± 1.76	16.25 ± 1.73	16.88 ± 1.58	3.60	.340	.055
	RLT	18.5 ± 2.04	17.25 ± 1.59	18.5 ± 1.79			
	CON	17.75 ± 1.85	15.0 ± 1.88	16.88 ± 1.33			

ARSS Overall Recovery scores are represented as mean ± SE.
n = 8.
CWI = cold water immersion; RLT = red light therapy; CON = control group.

Recovery-Stress Questionnaire (RESTQ-76)

A repeated-measures ANOVA revealed no significant difference for any of the RESTQ-76 domains (overall stress, overall recovery, sport stress, sport recovery). ($p > 0.05$). See Table 4 and Figure 6.

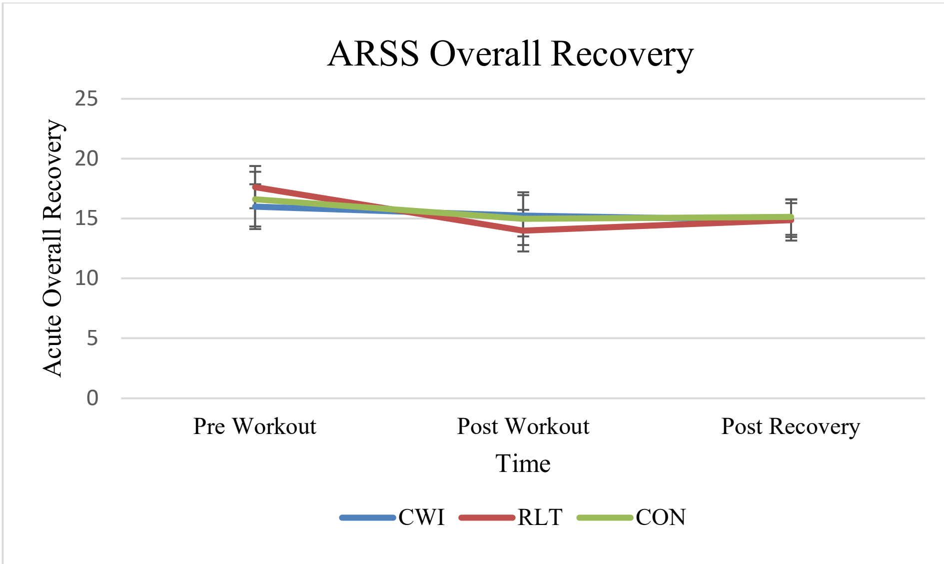

Figure 5. Acute recovery stress scale, overall recovery domain amongst the three modalities taken pre workout, post workout, and post recovery. All data and bar plots are mean ± SE. CWI = cold water immersion; RLT = red light therapy; CON = control.

Table 4. RESTQ-SPORT 76

Domains	*Modality*	*Mean ± SE*	*F*	η^2_p	*p*
Overall Stress					
	CWI	28.56 ± 5.74	.322	.040	.722
	RLT	31.78 ±5.13			
	CON	30.11 ±5.28			
Overall Recovery					
	CWI	35.89 ± 5.48	.800	.091	.466
	RLT	31.33 ± 4.90			
	CON	32.89 ± 5.96			
Sport Stress					
	CWI	31.56 ± 5.66	.784	.089	.473
	RLT	29.75 ± 6.09			
	CON	32.22 ± 3.61			
Sport Recovery					
	CWI	62.44 ± 5.41	.559	.065	.583
	RLT	58.67 ± 4.91			
	CON	61.0 ± 4.65			

RESTQ-76 scores are represented as mean ± SE.
n = 9.
CWI = cold water immersion; RLT = red light therapy; CON = control group.

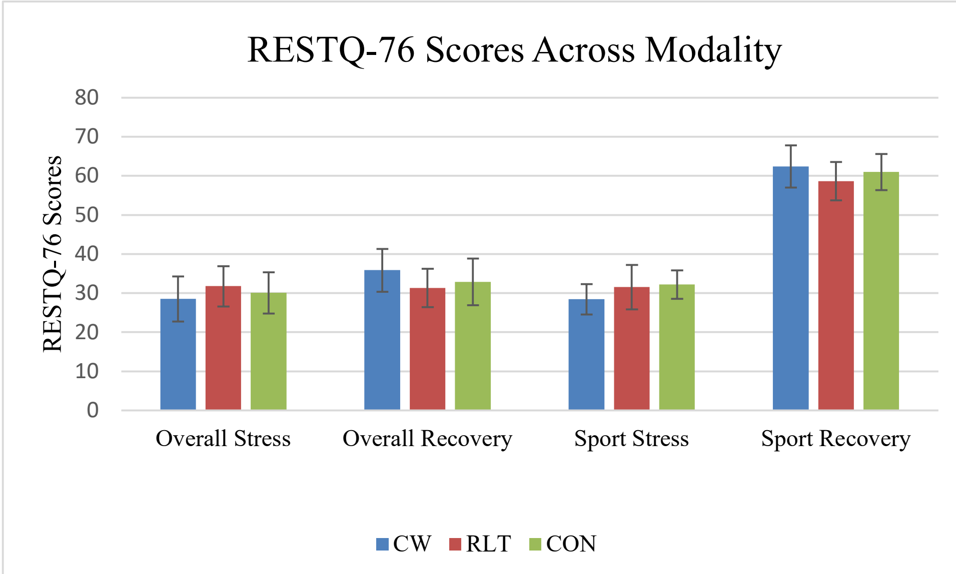

Figure 6. Recovery stress questionnaire -76 for athletes. The four domains amongst the three modalities taken on the week after completion of the recovery modality. All data and bar plots are mean ± SE. CWI = cold water immersion; RLT = red light therapy; CON = control.

Pittsburgh Sleep Quality Inventory (PSQI)

A one-way repeated measures ANOVA was conducted for the PSQI of all three recovery modalities given the week of the treatment. There was no significant main effect of recovery on PSQI scores (n = 7) (F (2,12) = 1.866, p = 0.197, η^2_p = 0.237).

Heart Rate Variability (HRV)

A repeated-measures ANOVA revealed no significant main effect of recovery modality (F (2,16) = 1.159, p = 0.339, η^2_p = 0.127). There was a significant main effect of time (F (1,8) = 24.409, p = 0.001, η^2_p = 0.753). Bonferroni-adjusted pairwise comparisons revealed a significant difference between post-workout and post recovery HRV (MD = -1.082, p = 0.001). Importantly, a significant recovery modality x time interaction was observed (F (2,16) = 20.64, p = < 0.001, η^2_p = 0.721), indicating that changes over time differed across recovery conditions. Bonferroni-adjusted pairwise comparisons indicated no significant differences between recovery conditions at either post-workout or post recovery (all $p > 0.05$). However, significant changes over time were observed within all recovery conditions. Specifically, CWI demonstrated significant improvement from post-workout to post recovery (MD = -0.813, $p = 0.014$). RLT showed a larger increase in post-workout to post-recovery (MD = -1.636, $p = < 0.001$), and CON also exhibited a significant improvement in HRV (MD = -0.977, $p = 0.003$). These findings indicate that all conditions changed over time, the magnitude of change differed across recovery conditions, with RLT showing the greatest change.

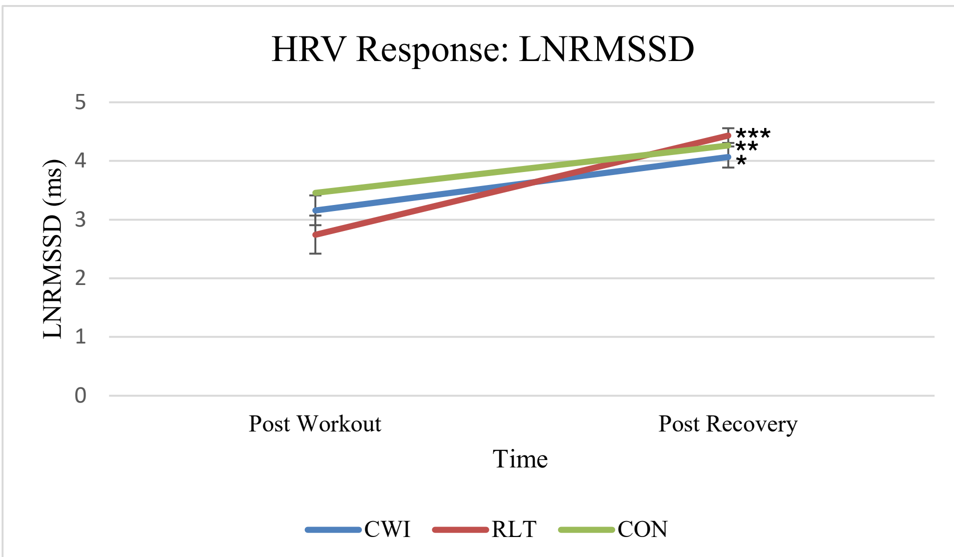

*Figure 7. Heart rate variability. The log of RMSSD compared amongst the three modalities taken post workout and post recovery. All data and bar plots are mean ± SE. CWI = cold water immersion; RLT = red light therapy; CON = control. * p = .014, ** p = .003, *** p < .001 denote significant change from post workout to post recovery within each condition.*

Chapter V: Discussion

Recovery is a multidimensional approach, and therefore the present study sought to explore how recovery modalities affect subjective and objective measures of fatigue, soreness, and perceived recovery. To our knowledge, this is the first study that evaluates recovery by using the subjective questionnaires given at the different time points, measurement of HRV, and of the specified population, female collegiate endurance athletes. The small sample size (*n* = 9) lowered the statistical power of many analyses; however, large effect or meaningful changes were found (η^2_p). Partial eta squared is useful in sport science to help provide more insight into how an intervention affects the athlete by way of attributing a particular factor within an ANOVA test (*Fatma Hilal et al. - 2024 - Statistical Effect Sizes in Sports Science*, n.d.). The following study aimed to address whether certain modalities affect physiological or psychological states of recovery best and address the many gaps in literature as stated above in the introduction. The lack of objective markers collected within the current study can be supported by prior research. Wilson et al. found no positive impact on blood borne markers of inflammation when compared to placebo (Wilson et al., 2018). Saw et al. (2016) also proved common blood makers could not reflect training load in a 56 article systematic review, finding 85% of studies favored subjective measures in athlete monitoring (Saw et al., 2016). The efficacy of subjective measuring was also supported by Brauers et al. who promoted the integration of self-report to create a multidimensional approach to recovery (Brauers et al., 2024).

POMS total mood disturbance scores (TMD) showed an insignificant but a large main effect of time ($\eta^2_p = 0.163$). Pre-workout TMD scores were lower than post-workout meaning the workout caused a greater disturbance in the athlete's mood. These findings are similar with Tsuda S. and Uetani S. who noted insignificant main effect of time but trends that TMD increased following training in female collegiate endurance athletes during a training camp (Tsuda & Uetani, 2011). The role of TMD on performance Pang et al. found that decreased TMD scores were indicative of better track performances (Pang et al., 2023). This study was conducted on college students who performed track events from 100 meters up to 5,000 meters. Interestingly, they found that TMD decreases to improve track performance but not field performance (Pang et al., 2023). Liao et al. assessed changes in mood in collegiate triathletes who also found increased scores following an intense training volume period (Liao et al., 2022). These studies highlight that training induces greater TMD scores and the effect that mood has on an athlete's performance. It is important to note that one's TMD scores can greatly impact how they perform. These studies help illustrate the impact of psychological state on athletes performance.

VAS scores for the main effect of time and main effect of recovery modality had meaningful changes ($\eta^2_p = 0.215$; $\eta^2_p = 0.421$), again showing the impact training induces on subjective measures. Gang et al. and Wilson et al state the VAS to be superior and or successful in detecting changes to exercise-induced fatigue, with Gang et al. noting subjective measures may not always correspond to objective changes in physiology (Gan et al., 2025). Following the recovery modality, all VAS scores decreased, however post recovery VAS was not returned to pre workout conditions. The main effect of recovery modality impacted VAS scores, with CON having higher scores compared to CWI and RLT overall (MD = 1.037, MD = 1.11) and CWI having higher scores when compared to RLT (MD = .074). These results show RLT to produce lower feelings of pain. Both RLT and CWI lowered VAS, but RLT was found to be most beneficial. It also indicates recovery is beneficial to one's sensation of pain as was highlighted with high post recovery CON scores. These results agree with much of the literature regarding

CWI ability to subjectively improve fatigue (Bosak et al., 20090401; Ihsan et al., 2016; Stenson et al., 2017; Wiewelhove et al., 2018). Wiewelhove et al. conducted a study comparing CWI to massage, passive, and active recovery, and much like the current study, found large improvement in subjective measures rather than objective means of recovery assessed through CMJ, DOMS, contraction time, and muscle belly displacement (Wiewelhove et al., 2018). Ihsan et al. review warranted the notion of CWI effect of post exercise cooling to mediate sensation of pain or CNS fatigue, which the current study is in agreement of (Ihsan et al., 2016). Further agreement was met with the current study by Lanferdini et al. and Hamblin MR. who citied in their work that RLT has the ability to lower muscle pain due to anti-inflammatory factors, reduced muscle damage, and increased oxidative stress defense, and Lanferdini et al found a decrease in VAS scores from the use of RLT in runners (Hamblin, 2017; Lanferdini et al., 2021).

In references to ARSS domains, the main effect of recovery and main effect of time showed meaningful change on emotional balance ($\eta^2_p = 0.340$; $\eta^2_p = 0.157$). CWI and RLT had higher levels of emotional balance compared to CON, with RLT showing significance. (MD = 1.542, $p = 0.009$). RLT had higher scores than CWI in emotional balance (MD = 1.33). Regarding the main effect of time, pre workout emotional balances scores were higher than post workout and post recovery, proving the workout caused stress to the athlete. Post recovery emotional balance was higher than post workout alluding to improved states of emotional balance following the recovery interventions. A review by Laborde et al. stated the interplay of HRV on mood states. Their review connected a higher vagal tone to improve cognitive performance as well as emotional regulation (Laborde et al., 2017). Soon to be mentioned, HRV did improve from post workout to post recovery allowing for changes in mood to be potentially attributed to raised HRV. Hausswirth et al. compared the effects of whole-body cryotherapy, far infrared, and passive modalities which is most similar to the current. Hausswirth et al. found RLT to recover psychological well-being 48-h post recovery rather than immediately post recovery as what was found in the current study (Hausswirth et al., 2011). Mental performance had a meaningful change main effect of recovery (η^2_p = 0.171). CWI and RLT had higher mental performance scores compared to CON while RLT was higher than CWI. This shows the potential of RLT to improve mental states when compared to CWI and CON.

The PSQI showed a meaningful change of recovery (η^2_p = 0.237). CWI was shown to have worse sleep quality compared to both RLT and CON (MD = 2.143; MD = 1.571) while RLT had greater sleep quality than CON (MD = -.571). A high PSQI index score is associated with poorer sleep quality. Although this data signifies meaningful change, it is hard to associate whether the one bout of the modality was able to change sleep as collegiate athletes undergo many other external stressors that could affect sleep quality. Liao et al. found that collegiate triathletes had the lowest PSQI index scores during a period of low academic stress despite engaging in an intense training block, potentially connecting one's subjective state towards one sleep quality (Liao et al., 2022). Liao et al. did not include recovery strategies but connects an important link in psychological stress to sleep quality.

HRV is an emerging metric in recovery with its significant use as a biomarker in clinical and athletic populations; it is the interplay between the sympathetic and parasympathetic nervous systems (Esco et al., 2025; Lundstrom et al., 2023). Ihsan et al. supports monitoring parasympathetic activity as a whole body tool to assess recovery status in athlete's effectively and to assess recovery interventions (Ihsan et al., 2016). Our results showed a significant and meaningful change between the interaction of recovery and time on HRV (p = <0.001, η^2_p = 0.721). After the recovery bout, RLT showed higher HRV values versus CWI and CON. In the present study, CWI had a lower post recovery HRV than CON. These results show the possibility of RLT to have a greater impact on increasing HRV after a workout or returning to a less stressed physiological state. These findings are not similar in regards to CWI as Ihsan et al. found CWI to act as an ideal intervention to accelerate parasympathetic activation (Ihsan et al., 2016). However, the study did not compare to RLT. Studies mention the restoration of HRV to be a useful tool in assessing recovery status or the effectiveness of recovery interventions (Lanferdini et al., 2021). Research by Ferraresi et al. also suggest that red light could enhance mitochondria function and reduce oxidative stress, which therefore may accelerate parasympathetic reactivation, which the current study could conclude by the immediate increase in post recovery HRV (Ferraresi et al., 2016).

Strengths and Limitations

A limitation to the current study is a small sampling size. Research was conducted on the University of Oklahoma's women's distance team only. The study was purposefully conducted in a way that would most reflect practice routines of the athletes; therefore, the nature of the study can prove to be a strength as monitoring was done in the athlete's most familiar environment and routine schedule. There are multiple factors that contribute to one's recovery such as daily sleeping habits, nutrition, and hydration that the current study did not take into consideration. Along with, menstrual cycle was not accounted for, potentially causing limitations to results. However, another strength of the study is ease of replicability which can help further investigate the connection of objective and subjective markers of recovery.

The results of both the PSQI and RESTQ-76 are hard to associate with the modality as there are many confounding variables that could affect the outcomes. The daily stressors college students and specifically, college athletes face could have greatly impacted the stress and sleep disturbance scores. Another limitation was answered timing of the subjective questionnaires. Not all participants answered within the proposed time frame of immediately pre workout, post workout, or post recovery. However, because of the nature of this study, making it most applicable to practice function of the endurance collegiate athlete, this would be inevitable with structure of practices, team meetings, and class schedules. Another limitation to subjective questionnaires is how deliberate each participant was in answering, it would therefore affect subjective measure outcomes.

Future Implications

Future research should test the effects of repeated bouts of CWI and RLT on recovery of both objective and subjective measures. The current study conducted one bout of recovery throughout the entirety of the week, providing athletes with acute recovery suggestions. Additionally, menstrual cycle considerations could be useful to assess which modality may worsen or improve recovery during specific phases.

Future research should continually include female collegiate athletes to broaden the data available as this research can help develop a greater understanding of the athlete. Treatment suggestions can therefore be catered to the female athlete to provide meaningful impact on changes to recovery state. The world of sport is evolving, and research is needed to better inform the athlete in how to recover smarter and consequently enhance their performance.

Conclusions

The results of the study indicate both CWI and RLT improved objective and subjective measures of recovery when compared to a CON. RLT was found to have superior rebound in post recovery HRV therefore the null hypothesis was rejected which stated at least one recovery modality would produce a significant effect on objective recovery. RLT had significantly higher emotional balance compared to CON, higher mental performance capacity, and produced lower VAS scores. However, CWI still showed improvements over CON in VAS scores, and higher emotional and mental performance scores. Changes in RESTQ-76 had neither significant *p* values or large effect sizes (η^2_p). The data produced large effect sizes, albeit without reaching statistical significance in subjective measures. However, sport science data is able to accept meaningful change with a $\eta^2_p > 0.14$ (*Fatma Hilal et al. - 2024 - Statistical Effect Sizes in Sports Science*, n.d.). The current study consistently found meaningful change across all objective and subjective measures, offering athletes practical solutions to recovery.

References

Alghadir, A. H., Anwer, S., Iqbal, A., & Iqbal, Z. A. (2018). Test–retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain. *Journal of Pain Research*, *11*, 851–856. https://doi.org/10.2147/JPR.S158847

Balk, Y. A., & Englert, C. (2020). Recovery self-regulation in sport: Theory, research, and practice. *International Journal of Sports Science & Coaching*, *15*(2), 273–281. https://doi.org/10.1177/1747954119897528

Baranauskas, M. N., & Rainsberger, K. (2025). Toward a comprehensive understanding of sex-specific differences in recovery following high-intensity interval exercise. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, *329*(6), R872–R873. https://doi.org/10.1152/ajpregu.00175.2025

Barnett, A. (2006). OLDUsing Recovery Modalities between Training Sessions in Elite Athletes. *Sports Medicine*, *36*(9), 781–796. https://doi.org/10.2165/00007256-200636090-00005

Bird, M.-L., Callisaya, M., Cannell, J., Gibbons, T., Smith, S., & Ahuja, K. (2016). Accuracy, Validity, and Reliability of an Electronic Visual Analog Scale for Pain on a Touch Screen Tablet in Healthy Older Adults: A Clinical Trial. *Interactive Journal of Medical Research*, *5*, e3. https://doi.org/10.2196/ijmr.4910

Bosak, A., Bishop, P., Green, J., & Hawver, G. (20090401). Impact of Cold Water Immersion on 5km Racing Performance. *Sport Journal*, *12*(2), 1–1.

Brauers, J. J., Den Hartigh, R. J. R., Jakowski, S., Kellmann, M., Wylleman, P., Lemmink, K. A. P. M., & Brink, M. S. (2024). Monitoring the recovery-stress states of athletes: Psychometric properties of the acute recovery and stress scale and short recovery stress scale among Dutch and Flemish athletes. *Journal of Sports Sciences*, *42*(2), 189–199. https://doi.org/10.1080/02640414.2024.2325783

Braun-Trocchio, R., Graybeal, A. J., Kreutzer, A., Warfield, E., Renteria, J., Harrison, K., Williams, A., Moss, K., & Shah, M. (2022). Recovery Strategies in Endurance Athletes. *Journal of Functional Morphology and Kinesiology*, *7*(1). https://doi.org/10.3390/jfmk7010022

Broatch, J. R., Petersen, A., & Bishop, D. J. (2014). Postexercise Cold Water Immersion Benefits Are Not Greater than the Placebo Effect. *Medicine & Science in Sports & Exercise*, *46*(11). https://journals.lww.com/acsm-msse/fulltext/2014/11000/postexercise_cold_water_immersion_benefits_are_not.14.aspx

Cheng, K., Martin, L. F., Slepian, M. J., Patwardhan, A. M., & Ibrahim, M. M. (2021). Mechanisms and Pathways of Pain Photobiomodulation: A Narrative Review. *The Journal of Pain*, *22*(7), 763–777. https://doi.org/10.1016/j.jpain.2021.02.005

Crowther, F., Sealey, R., Crowe, M., Edwards, A., & Halson, S. (2017). Team sport athletes' perceptions and use of recovery strategies: A mixed-methods survey study. *BMC Sports Science, Medicine & Rehabilitation*, *9*, 1–10. SPORTDiscus with Full Text.

Curran, L. S., Andrykowski, A. M., & Studts, L. J. (1995). (PDF) Short Form of the Profile of Mood States (POMS–SF): Psychometric Information. *Psychological Assessment*, *7*(80–83). https://www.researchgate.net/publication/232603131_Short_Form_of_the_Profile_of_Mood_States_POMS-SF_Psychometric_Information

De Marchi, T., Leal Junior, E. C. P., Bortoli, C., Tomazoni, S. S., Lopes-Martins, R. Á. B., & Salvador, M. (2012). Low-level laser therapy (LLLT) in human progressive-intensity running: Effects on exercise performance, skeletal muscle status, and oxidative stress. *Lasers in Medical Science*, *27*(1), 231–236. https://doi.org/10.1007/s10103-011-0955-5

de Paiva, P. R. V., Casalechi, H. L., Tomazoni, S. S., Machado, C. dos S. M., Miranda, E. F., Ribeiro, N. F., Pereira, A. L., da Costa, A. S., Dias, L. B., Souza, B. C. G., Aguiar Lino, M. M., de Carvalho, P. de T. C., & Leal-Junior, E. C. P. (2019). Effects of photobiomodulation therapy in aerobic endurance training and detraining in humans: Protocol for a randomized placebo-controlled trial. *Medicine*, *98*(18). https://journals.lww.com/md-journal/fulltext/2019/05030/effects_of_photobiomodulation_therapy_in_aerobic.14.aspx

Delgado, D. A., Lambert, B. S., Boutris, N., McCulloch, P. C., Robbins, A. B., Moreno, M. R., & Harris, J. D. (2018). Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. *Journal of the American Academy of Orthopaedic Surgeons. Global Research & Reviews*, *2*(3), e088. https://doi.org/10.5435/JAAOSGlobal-D-17-00088

di Fronso, S., & Budnik-Przybylska, D. (2023). Special Issue: Sport Psychology Interventions for Athletes' Performance and Well-Being. *International Journal of Environmental Research and Public Health*, *20*(4), 3712. https://doi.org/10.3390/ijerph20043712

Diotaiuti, P., Corrado, S., Mancone, S., Palombo, M., Rodio, A., Falese, L., Langiano, E., Siqueira, T. C., & Andrade, A. (2022). Both Gender and Agonistic Experience Affect Perceived Pain during the Cold Pressor Test. *International Journal of Environmental Research and Public Health*, *19*(4), 2336. https://doi.org/10.3390/ijerph19042336

do Nascimento, A. P., de Oliveira, G. A., Bressanin, J. P. B., Aguirra, P., Ribeiro, A. S., Caldeira, L. F. S., Casonatto, J., Ferraresi, C., & Aguiar, A. F. (2024). Acute dose-response effect of photobiomodulation therapy on 5-km running performance in trained runners: A randomized, double-blind, placebo-controlled, crossover study. *Lasers in Medical Science*, *39*(1), 145. https://doi.org/10.1007/s10103-024-04099-8

Dunne, A., Crampton, D., & Egaña, M. (2013). Effect of post-exercise hydrotherapy water temperature on subsequent exhaustive running performance in normothermic conditions. *Journal of Science and Medicine in Sport*, *16*(5), 466–471. https://doi.org/10.1016/j.jsams.2012.11.884

Esco, M. R., Fields, A. D., Mohammadnabi, M. A., & Kliszczewicz, B. M. (2025). Monitoring Training Adaptation and Recovery Status in Athletes Using Heart Rate Variability via Mobile Devices: A Narrative Review. *Sensors (Basel, Switzerland)*, *26*(1), 3. https://doi.org/10.3390/s26010003

Fatma Hilal et al. - 2024—Statistical Effect Sizes in Sports Science. (n.d.).

Ferraresi, C., Huang, Y.-Y., & Hamblin, M. R. (2016). Photobiomodulation in human muscle tissue: An advantage in sports performance? *Journal of Biophotonics*, *9*(11–12), 1273–1299. https://doi.org/10.1002/jbio.201600176

Flatt, A. A., & Esco, M. R. (2016). Heart rate variability stabilization in athletes: Towards more convenient data acquisition. *Clinical Physiology and Functional Imaging*, *36*(5), 331–336. https://doi.org/10.1111/cpf.12233

Foley, J., Vasily, D. B., Bradle, J., Rudio, C., & Calderhead, R. G. (2016). 830 nm light-emitting diode (led) phototherapy significantly reduced return-to-play in injured university athletes: A pilot study. *Laser Therapy*, *25*(1), 35–42. https://doi.org/10.5978/islsm.16-OR-03

Gan, J., Dong, G., Xu, Y., Chen, Y., Zhang, Y., Gao, Q., & Bao, D. (2025). Establishing the minimal important difference of the visual analog scale for assessing exercise-induced fatigue. *BMC Sports Science, Medicine and Rehabilitation*, *17*, 69. https://doi.org/10.1186/s13102-025-01122-5

Gifford, R. M., Boos, C. J., Reynolds, R. M., & Woods, D. R. (2018). Recovery time and heart rate variability following extreme endurance exercise in healthy women. *Physiological Reports*, *6*(21), e13905. https://doi.org/10.14814/phy2.13905

Gnacinski, S. L., Meyer, B. B., & Wahl, C. A. (2021). Psychometric Properties of the RESTQ-Sport-36 in a Collegiate Student-Athlete Population. *Frontiers in Psychology*, *12*, 671919. https://doi.org/10.3389/fpsyg.2021.671919

Google. (2024) *Gemini* (v1.0) [Image generation tool]. https://gemini.google.com

Grandner, M. A., Kripke, D. F., Yoon, I.-Y., & Youngstedt, S. D. (2006). Criterion validity of the Pittsburgh Sleep Quality Index: Investigation in a non-clinical sample. *Sleep and Biological Rhythms*, *4*(2), 129–136. https://doi.org/10.1111/j.1479-8425.2006.00207.x

Gulavani, S. S., Henry, T. E., Floyd, C., Du, J., Pifer, N. D., & Su, Y. (2023). *Putting Athletes First: An Empirical Examination of the Hedonic Well-Being of College Student-Athletes in Response to NIL*.

Hamblin, M. R. (2017). Mechanisms and applications of the anti-inflammatory effects of photobiomodulation. *AIMS Biophysics*, *4*(3), 337–361. https://doi.org/10.3934/biophy.2017.3.337

Hausswirth, C., Louis, J., Bieuzen, F., Pournot, H., Fournier, J., Filliard, J.-R., & Brisswalter, J. (2011). Effects of Whole-Body Cryotherapy vs. Far-Infrared vs. Passive Modalities on Recovery from Exercise-Induced Muscle Damage in Highly-Trained Runners. *PLOS ONE*, *6*(12), e27749. https://doi.org/10.1371/journal.pone.0027749

Hunter, S. K., S. Angadi, S., Bhargava, A., Harper, J., Hirschberg, A. L., D. Levine, B., L. Moreau, K., J. Nokoff, N., Stachenfeld, N. S., & Bermon, S. (2023). The Biological Basis of Sex Differences in Athletic Performance: Consensus Statement for the American College of Sports Medicine. *Medicine & Science in Sports & Exercise*, *55*(12), 2328. https://doi.org/10.1249/MSS.0000000000003300

Ihsan, M., Watson, G., & Abbiss, C. R. (2016). What are the Physiological Mechanisms for Post-Exercise Cold Water Immersion in the Recovery from Prolonged Endurance and Intermittent Exercise? *Sports Medicine*, *46*(8), 1095–1109. https://doi.org/10.1007/s40279-016-0483-3

Jones, B., Waterworth, S., Tallent, J., Rogerson, M., Morton, C., Moran, J., Southall-Edwards, R., Cooper, C. E., & McManus, C. (2024). Cold-Water Immersion and Lower Limb Muscle Oxygen Consumption as Measured by Near-Infrared Spectroscopy in Trained Endurance Athletes. *Journal of Athletic Training*, *59*(3), 317–324. https://doi.org/10.4085/1062-6050-0532.22

Joovv Solo 3.0. (n.d.). Joovv. Retrieved September 9, 2025, from https://joovv.com/products/joovv-solo-3-0

Kellman, M., & Kölling, S. (2019). *Recovery and Stress in Sport: A Manual for Testing and Assessment*. Routledge.

Kellmann, M. (2010). Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine & Science in Sports*, *20*(s2), 95–102. https://doi.org/10.1111/j.1600-0838.2010.01192.x

Kellmann, M., & Kallus, W. (2025). The Recovery-Stress Questionnaire for Athletes. In *The Recovery-Stress Questionnaires: A User Manual* (1st ed., pp. 76–136). Routledge.

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart Rate Variability and Cardiac Vagal Tone in Psychophysiological Research – Recommendations for Experiment Planning, Data Analysis, and Data Reporting. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.00213

Lanferdini, F. J., Silva, E. S., Boeno, F. P., Sonda, F. C., Rosa, R. G., Quevedo, R., Baroni, B. M., Reischak-Oliveira, Á., Vaz, M. A., & Peyré-Tartaruga, L. A. (2021). Effect of photobiomodulation therapy on performance and running economy in runners: A randomized double-blinded placebo-controlled trial. *Journal of Sports Sciences*, *39*(12), 1348–1355. SPORTDiscus with Full Text.

Lawrence, J., & Sorra, K. (2024). Photobiomodulation as Medicine: Low-Level Laser Therapy (LLLT) for Acute Tissue Injury or Sport Performance Recovery. *Journal of Functional Morphology and Kinesiology*, *9*(4), 181. https://doi.org/10.3390/jfmk9040181

Li, S., Wu, Q., & Chen, Z. (2020). Effects of Psychological Interventions on the Prevention of Sports Injuries: A Meta-analysis. *Orthopaedic Journal of Sports Medicine*, *8*(8), 2325967120928325. https://doi.org/10.1177/2325967120928325

Liao, Y.-H., Hsu, C.-K., Wei, C.-C., Yang, T.-C., Kuo, Y.-C., Lee, L.-C., Lin, L.-J., & Chen, C.-Y. (2022). Monitoring the Changing Patterns in Perceived Learning Effort, Stress, and Sleep Quality during the Sports Training Period in Elite Collegiate Triathletes: A Preliminary Research. *International Journal of Environmental Research and Public Health*, *19*(8), 4899. https://doi.org/10.3390/ijerph19084899

Lopes Dos Santos, M., Uftring, M., Stahl, C. A., Lockie, R. G., Alvar, B., Mann, J. B., & Dawes, J. J. (2020). Stress in Academic and Athletic Performance in Collegiate Athletes: A

Narrative Review of Sources and Monitoring Strategies. *Frontiers in Sports and Active Living*, *2*. https://doi.org/10.3389/fspor.2020.00042

Lundstrom, C. J., Foreman, N. A., & Biltz, G. (2023). Practices and Applications of Heart Rate Variability Monitoring in Endurance Athletes. *International Journal of Sports Medicine*, *44*(1), 9–19. https://doi.org/10.1055/a-1864-9726

Madden, E., & O'Hallarn, B. (2024). "The Game Was Ruined For Me There:" Examining the Mental Health Byproducts of the Transfer Portal and NIL on Student-Athletes. *Journal of Athlete Development and Experience*, *6*(2). https://doi.org/10.25035/jade.06.02.01

McGuigan, M. (2017). *Monitoring Training and Perfromance in Athletes*. Human Kinetics.

Meur, Y. L., Louis, J., Schaal, K., Bieuzen, F., Filliard, J.-R., Brisswalter, J., & Hausswirth, C. (2017). Whole-body cryotherapy multi exposures speed up performance supercompensation during the taper in functionally overreached endurance athletes. *Sport Performance & Science Reports*, *1*.

Montull, L., Slapšinskaitė-Dackevičienė, A., Kiely, J., Hristovski, R., & Balagué, N. (2022). Integrative Proposals of Sports Monitoring: Subjective Outperforms Objective Monitoring. *Sports Medicine - Open*, *8*(1), 41. https://doi.org/10.1186/s40798-022-00432-z

Moya-Ramon, M., Mateo-March, M., Peña-González, I., Zabala, M., & Javaloyes, A. (2022). Validity and reliability of different smartphones applications to measure HRV during short and ultra-short measurements in elite athletes. *Computer Methods and Programs in Biomedicine*, *217*, 106696. https://doi.org/10.1016/j.cmpb.2022.106696

Murray, A., Fullagar, H., Turner, A. P., & Sproule, J. (2018). Recovery practices in Division 1 collegiate athletes in North America. *Physical Therapy in Sport*, *32*, 67–73. https://doi.org/10.1016/j.ptsp.2018.05.004

Nasi, M., Bianchini, E., Lo Tartaro, D., De Biasi, S., Mattioli, M., Paolini, A., Gibellini, L., Pinti, M., De Gaetano, A., D'Alisera, R., Roli, L., Chester, J., Mattioli, A. V., Polverari, T., Maietta, P., Tripi, F., Stefani, O., Guerra, E., Savino, G., … Cossarizza, A. (2020). Effects of whole-body cryotherapy on the innate and adaptive immune response in cyclists and runners. *Immunologic Research*, *68*(6), 422–435. https://doi.org/10.1007/s12026-020-09165-1

Nicolas, M., Vacher, P., Martinent, G., & Mourot, L. (2019). Monitoring stress and recovery states: Structural and external stages of the short version of the RESTQ sport in elite swimmers before championships. *Journal of Sport and Health Science*, *8*(1), 77–88. https://doi.org/10.1016/j.jshs.2016.03.007

Pang, L., Xie, X., & Lin, Y. (2023). POMS and eye movement: Two indicators for performance in athletics. *Heliyon*, *9*(7), e17860. https://doi.org/10.1016/j.heliyon.2023.e17860

Pettersen, S. D., Aslaksen, P. M., & Pettersen, S. A. (2020). Pain Processing in Elite and High-Level Athletes Compared to Non-athletes. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01908

Pons, M. S., Hunter, S. K., & Ansdell, P. (2023). Sex differences in fatigability and recovery following a 5 km running time trial in recreationally active adults. *European Journal of Sport Science*, *23*(12), 2349–2356. https://doi.org/10.1080/17461391.2023.2233483

Powers, S. K., Deminice, R., Ozdemir, M., Yoshihara, T., Bomkamp, M. P., & Hyatt, H. (2020). Exercise-induced oxidative stress: Friend or foe? *Journal of Sport and Health Science*, *9*(5), 415–425. https://doi.org/10.1016/j.jshs.2020.04.001

Reichel, T., Hacker, S., Palmowski, J., Boßlau, T. K., Frech, T., Tirekoglou, P., Weyh, C., Bothur, E., Samel, S., Walscheid, R., & Krüger, K. (2022). Neurophysiological Markers for Monitoring Exercise and Recovery Cycles in Endurance Sports. *Journal of Sports Science & Medicine*, *21*(3), 446–457. https://doi.org/10.52082/jssm.2022.446

Saw, A. E., Main, L. C., & Gastin, P. B. (2016a). Monitoring the athlete training response: Subjective self-reported measures trump commonly used objective measures: a systematic review. *British Journal of Sports Medicine*, *50*(5), 281–291. https://doi.org/10.1136/bjsports-2015-094758

Saw, A. E., Main, L. C., & Gastin, P. B. (2016b). *Monitoring the athlete training response: Subjective self-reported measures trump commonly used objective measures: a systematic review*. https://doi.org/10.1136/bjsports-2015-094758

Sekiguchi, Y., Huggins, R. A., Curtis, R. M., Benjamin, C. L., Adams, W. M., Looney, D. P., West, C. A., & Casa, D. J. (2021). Relationship Between Heart Rate Variability and Acute:Chronic Load Ratio Throughout a Season in NCAA D1 Men's Soccer Players. *The Journal of Strength & Conditioning Research*, *35*(4), 1103. https://doi.org/10.1519/JSC.0000000000002853

Shahid, A., Wilkinson, K., Marcu, S., & Shapiro, C. M. (2011). Pittsburgh Sleep Quality Index (PSQI). In A. Shahid, K. Wilkinson, S. Marcu, & C. M. Shapiro (Eds.), *STOP, THAT and One Hundred Other Sleep Scales* (pp. 279–283). Springer New York. https://doi.org/10.1007/978-1-4419-9893-4_67

Smith, M. R., Marcora, S. M., & Coutts, A. J. (2015). Mental Fatigue Impairs Intermittent Running Performance. *Medicine & Science in Sports & Exercise*, *47*(8), 1682–1690. https://doi.org/10.1249/MSS.0000000000000592

Stenson, M. C., Stenson, M. R., Matthews, T. D., & Paolone, V. J. (2017). 5000 Meter Run Performance is not Enhanced 24 Hrs After an Intense Exercise Bout and Cold Water Immersion. *Journal of Sports Science & Medicine*, *16*(2), 272–279.

Tsuda, S., & Uetani, S. (2011). Comparison of POMS Training Distress Scale and Energy Index Responses to a Training Camp in Japanese college Age Female Distance Runners: 3233: Board #196 June 4 8:00 AM - 9:30 AM. *Medicine & Science in Sports & Exercise*, *43*(5), 939. https://doi.org/10.1249/01.MSS.0000402625.09164.a5

Vyas, A. J., & Khanvilkar, D. N. P. (2024). *Role of Sports Psychology in Context to Development of Sports Performance*. *6*(3).

Weiß, M., Büttner, M., & Richlan, F. (2024). The Role of Sport Psychology in Injury Prevention and Rehabilitation in Junior Athletes. *Behavioral Sciences*, *14*(3), 254. https://doi.org/10.3390/bs14030254

Wiewelhove, T., Schneider, C., Döweling, A., Hanakam, F., Rasche, C., Meyer, T., Kellmann, M., Pfeiffer, M., & Ferrauti, A. (2018). Effects of different recovery strategies following a half-marathon on fatigue markers in recreational runners. *PLOS ONE*, *13*(11), e0207313. https://doi.org/10.1371/journal.pone.0207313

Wilson, L. J., Cockburn, E., Paice, K., Sinclair, S., Faki, T., Hills, F. A., Gondek, M. B., Wood, A., & Dimitriou, L. (2018). Recovery following a marathon: A comparison of cold water immersion, whole body cryotherapy and a placebo control. *European Journal of Applied Physiology*, *118*(1), 153–163. https://doi.org/10.1007/s00421-017-3757-z

APPENDIX I: IRB OUTCOME

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Study Modification – Expedited Review – AP0

Date: February 25, 2026 **IRB#:** 19403

Principal Investigator: Megan K Johnson **Reference No: 785300**

Study Title: Influence of Recovery Modalities on Psychological and Physiological Markers of Performance in Endurance Collegiate Athletes

Approval Date: 02/25/2026

Modification Description: We would like to add two questions to each of the Qualtrics surveys.

The review and approval of this submission is based on the determination that the study, as amended, will continue to be conducted in a manner consistent with the requirements of 45 CFR 46.

To view the approved documents for this submission, open this study from the My Studies option, go to Submission History, go to Completed Submissions tab and then click the Details icon.

If the consent form(s) were revised as a part of this modification, discontinue use of all previous versions of the consent form.

If you have questions about this notification or using iRIS, contact the HRPP office at (405) 325-8110 or irb@ou.edu. The HRPP Administrator assigned for this submission: Kat L Braswell.

Cordially,

Eric Pennello, Ph.D.
Vice Chair, Institutional Review Board

APPENDIX II: RECRUITMENT FLYER

Participants Needed for Research Study

Recovery Modalities Impact on Performance

Looking for: male & females age 18-24 on the OU cross country team, running >40 miles (64.37 km) per week

Requires: 1 visit per week for 3-4 weeks, fully complete recovery modality protocol, and answer online questionnaires throughout duration of the study

If interested contact:

Megan Johnson megan.k.johnson-1@ou.edu

Or Rebecca Larson, PhD rdlarson@ou.edu

The University of Oklahoma is an equal opportunity institution

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/20/2026

APPENDIX III: CONSENT FORM

Signed Consent to Participate in Research
University of Oklahoma

Would you like to be involved in research at the University of Oklahoma?

I am Megan Johnson from the Health and Exercise Science Department, and I invite you to participate in my research entitled *Influence of Recovery Modalities on Psychological and Physiological Markers of Performance in Endurance Collegiate Athletes.* This research is being conducted at the University of Oklahoma in Norman. You were selected as a possible participant because you are either: 1) a male or female participating in endurance collegiate athletics at the University of Oklahoma 2) meet endurance athlete inclusion criteria; or 3) you are free from any physical injury, neuromuscular abnormalities, psychiatric and neurological disorders, and any cardiovascular diseases. You must be at least 18 years of age to participate in this study.

Please read this document and contact me to ask any questions you may have BEFORE agreeing to participate in my research.

What is the purpose of this research? This study aims to understand the impact recovery modalities have on physical and psychological components of performance.

How many participants will be in this research? About 20 participants both male and female, aged 18-24 from the University of Oklahoma's men's and women's cross country and track team are expected to take part in this research.

What will I be asked to do? If you agree to be in this research, you will be asked to:

- **Visit 1 (approximately 1h):** Consists of mostly questionnaires of both paper and online Qualtrics questionnaires, anthropometric measures (body weight, height) and treatment assignment. The questionnaires will include informed consent, a health status questionnaire (PAR-Q), baseline sleep status, and an athlete centered wellness questionnaire (REST-Q).
- **Visit 2 (approximately 1.5h):** In this visit you will perform your sport-specific workout given by the coach and complete online Qualtrics questionnaires given pre workout and post workout. You will then complete the assigned recovery modality intervention and be asked to answer online Qualtrics questionnaires and take a resting 5-minute HRV measure.
- **Visits 3 (approximately 30 minutes):** You will be asked to answer another set of questionnaires on Qualtrics following the cessation of the first treatment. After completion you will be assigned another treatment or recovery modality. You will then repeat visits 2-3.

How long will this take? Your total participation time in this study will vary depending on the length of time it takes to complete the online Qualtrics questionnaires, paper questionnaires, and undergo assigned recovery modalities. You are expected to complete all required Qualtrics online questionnaires and complete assigned recovery interventions to the full extent. Research will take place throughout the months of February and March.

What are the risks and benefits if I participate? Risks involved in this study include moderate discomfort from cold treatment. A physical risk may be due to extreme cold or due to infrared dilation of blood vessels, which may cause dizziness or lightheadedness. There are limited risks due to training status. However, mild muscle soreness is a potential risk from sport specific training. There is no medical benefit for participating in this research study. The organization hosting the data collection platform has its own privacy and security policies for keeping your information confidential. There is a risk that the external organization, which is not part of the research team, may gain access to or retain your data or your IP address which could be used to re-identify you. No assurance can be made as to their use of the data you provide for purposes other than this research. We will not share your data or use it in future research.

What are the benefits if I participate? There is no direct benefit for participating in this research study.

What do I do if I am injured? If you are injured during your participation, report this to a researcher or principal investigator, Rebecca Larson immediately. Dr. Larson can be reached at 352-359-8432 (cell). Emergency medical treatment is available. However, you or your insurance company will be expected to pay the usual charge from this treatment. The University of Oklahoma Norman Campus has set aside no funds to compensate you in the event of injury.

Will I be compensated for participating? You will not be compensated for your time and participation in this research.

Who will see my information? There will be no information in research reports that will make it possible to identify you. Research records with identifiable information will be stored securely in locked file cabinets and research computers, and only approved researchers and the OU Institutional Review Board will have access to the records. You will be assigned a subject identification number, so your identifiable information will be kept confidential.

You have the right to access the research data that has been collected about you as a part of this research. However, you may not access this information until the entire research has finished and you consent to this temporary restriction.

Do I have to participate? No. If you do not participate, you will not be penalized or lose benefits or services unrelated to the research. If you decide to participate, you don't have to answer any questions and can stop participating at any time.

Will I be contacted again? The researcher might contact you to gather additional data or recruit you for new research.

I give my permission for the researcher to contact me in the future. ___Yes ___ No

Who do I contact with questions, concerns, or complaints? If you have questions, concerns or complaints about the research or have experienced a research-related injury, contact me at megan.k.johnson-1@ou.edu or my cell at 319-215-2754, or you may contact the principal investigator Rebecca Larson at rdlarson@ou.edu, or on her cell at 352-359-8432 or in her office at 405-325-6325.

You can also contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at 405-325-8110 or irb@ou.edu if you have questions about your rights as a research participant, concerns, or complaints about the research and wish to talk to someone other than the researcher(s) or if you cannot reach the researcher(s).

You will be given a copy of this document for your records. By providing information to the researcher(s), I agree to participate in this research.

Participant Signature	Print Name	Date
Signature of Researcher Obtaining Consent	Print Name	Date

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/2

APPENDIX IV: HIPPA

University of Oklahoma – Norman CampusResearch Privacy Form 1
Version 2/12/2016 PHI Research Authorization

AUTHORIZATION TO USE or SHARE
HEALTH INFORMATION[1] THAT IDENTIFIES YOU FOR RESEARCH
An Informed Consent Document for Research Participation may also be required.

Title of Research Project: **Influence of Recovery Modalities in Endurance Collegiate Athletes**

IRB Number:

Leader of Research Team: **Megan Johnson**

Address: **Department of Health and Exercise Science, 1401 Asp Avenue SJSC 117, Norman, OK 73019**

Phone Number**: 319-215-2754**

If you decide to sign this document, University of Oklahoma (OU) researchers may use or share information that identifies you (protected health information) for their research. Protected health information will be called PHI in this document.

PHI To Be Used or Shared. Federal law requires that researchers get your permission (authorization) to use or share your PHI. If you give permission, the researchers may use or share with the people identified in this Authorization any PHI related to this research from your medical records and from any test results. Information used or shared may include all information relating to any tests, procedures, surveys, or interviews as outlined in the consent form; medical records and charts; name, address, telephone number, date of birth, race, government-issued identification numbers, and can include anthropometric measurements, findings from subjective questionnaires, HRV, and sleep data.

Purposes for Using or Sharing PHI. If you give permission, the researchers may use your PHI to understand how red light and cold water immersion impact psychological and physiological measures in endurance collegiate athletes and whether perception of recovery impacts performance.

Other Use and Sharing of PHI. If you give permission, the researchers may also use your PHI to develop new procedures or commercial products. They may share your PHI with other researchers, the research sponsor and its agents, the OU Institutional Review Board, auditors and inspectors who check the research, and government agencies such as the Department of Health and Human Services (HHS), and when required by law. The researchers may also share your PHI with no one outside of the designated research team.

---

[1] **Protected Health Information includes all identifiable information relating to any aspect of an individual's health whether past, present or future, created or maintained by a Covered Entity.**

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/20/2026

Page 1 of 3

Confidentiality. Although the researchers may report their findings in scientific journals or meetings, they will not identify you in their reports. The researchers will try to keep your information confidential, but confidentiality is not guaranteed. The law does not require everyone receiving the information covered by this document to keep it confidential, so they could release it to others, and federal law may no longer protect it.

YOU UNDERSTAND THAT YOUR PROTECTED HEALTH INFORMATION MAY INCLUDE INFORMATION REGARDING A COMMUNICABLE OR NONCOMMUNICABLE DISEASE.

Voluntary Choice. The choice to give OU researchers permission to use or share your PHI for their research is voluntary. It is completely up to you. No one can force you to give permission. However, you must give permission for OU researchers to use or share your PHI if you want to participate in the research and, if you cancel your authorization, you can no longer participate in this study.

Refusing to give permission will not affect your ability to get routine treatment or health care unrelated to this study from OU.

Canceling Permission. If you give the OU researchers permission to use or share your PHI, you have a right to cancel your permission whenever you want. However, canceling your permission will not apply to information that the researchers have already used, relied on, or shared or to information necessary to maintain the reliability or integrity of this research.

End of Permission. Unless you cancel it, permission for OU researchers to use or share your PHI for their research will never end.

Contacting OU: You may find out if your PHI has been shared, get a copy of your PHI, or cancel your permission at any time by writing to:

Privacy Official	or	Privacy Board
University of Oklahoma		University of Oklahoma
PO Box 26901		201 Stephenson Pkwy, Suite 4300A
Oklahoma City, OK 73190		Norman, OK 73019

If you have questions, call: (405) 271-2511 or (405) 325-8110

Access to Information. You have the right to access the medical information that has been collected about you as a part of this research study. However, you may not have access to this medical information until the entire research study is completely finished. You consent to this temporary restriction.

Giving Permission. By signing this form, you give OU and OU's researchers led by the Research Team Leader permission to share your PHI for the research project listed at the top of this form.

Participant Name (Print): _________________________

____ ______________
Signature of Participant Date
or Parent if Participant is a minor

Or

____ ______________
Signature of Legal Representative** Date

**If signed by a Legal Representative of the Participant, provide a description of the relationship to the Participant and the authority to act as Legal Representative:

____
OU may ask you to produce evidence of your relationship.

A signed copy of this form must be given to the Participant or the Legal Representative at the time this signed form is provided to the researcher or his representative.

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/20/2026

APPENDIX V: PROFILE OF MOODS QUESTIONNAIRE

POMS

Subject Number

Modality Used

Below is a list of words that describe feelings that people have. Please read each word carefully. Then click the number that best describes:

- How you have been feeling during the PAST WEEK INCLUDING TODAY
- How you feel RIGHT NOW

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/2

	Not At All - 0	A Little - 1	Moderately - 2	Quite A Bit - 3	Extremely - 4
Tense	○	○	○	○	○
Angry	○	○	○	○	○
Worn Out	○	○	○	○	○
Lively	○	○	○	○	○
Confused	○	○	○	○	○
Shaky	○	○	○	○	○
Sad	○	○	○	○	○
Active	○	○	○	○	○
Grouchy	○	○	○	○	○
Energetic	○	○	○	○	○
Unworthy	○	○	○	○	○
Uneasy	○	○	○	○	○
Fatigued	○	○	○	○	○
Annoyed	○	○	○	○	○
Discouraged	○	○	○	○	○
Nervous	○	○	○	○	○
Lonely	○	○	○	○	○
Muddled	○	○	○	○	○
Exhausted	○	○	○	○	○
Anxious	○	○	○	○	○
Gloomy	○	○	○	○	○
Sluggish	○	○	○	○	○

	Not At All - 0	A Little - 1	Moderately - 2	Quite A Bit - 3	Extremely - 4
Weary	○	○	○	○	○
Bewildered	○	○	○	○	○
Furious	○	○	○	○	○
Efficient	○	○	○	○	○
Full of Pep	○	○	○	○	○
Bad-tempered	○	○	○	○	○
Forgetful	○	○	○	○	○
Vigorous	○	○	○	○	○

APPENDIX VI: VISUAL ANALOG SCALE

VAS

Subject Number

Modality Used

Choose what represents your pain levels right now

No Pain Most Pain

0 1 2 3 4 5 6 7 8 9 10

No Pain

APPENDIX VII: ACUTE RECOVERY STRESS SCALE

Subject Number

Modality Used

Below is a list of expressions that describe different states of recovery and stress. Please rate each item and mark the number that most closely applies to you **RIGHT NOW**

At the moment I feel / I am

	Does not apply at all - 1	2	3	4	5	6	Fully Applies - 7
1. recovered	○	○	○	○	○	○	○

	Does not apply at all - 1	2	3	4	5	6	Fully Applies - 7
2. muscle relaxation	○	○	○	○	○	○	○
3. pleased	○	○	○	○	○	○	○
4. unmotivated	○	○	○	○	○	○	○
5. attentive	○	○	○	○	○	○	○
6. feeling down	○	○	○	○	○	○	○
7. strong	○	○	○	○	○	○	○
8. tired	○	○	○	○	○	○	○
9. rested	○	○	○	○	○	○	○
10. muscle fatigue	○	○	○	○	○	○	○
11. stable	○	○	○	○	○	○	○
12. sluggish	○	○	○	○	○	○	○
13. receptive	○	○	○	○	○	○	○
14. stressed	○	○	○	○	○	○	○
15. physically capable	○	○	○	○	○	○	○
16. worn - out	○	○	○	○	○	○	○
17. muscle activation	○	○	○	○	○	○	○
18. unenthusiastic	○	○	○	○	○	○	○
19. in a good mood	○	○	○	○	○	○	○
20. annoyed	○	○	○	○	○	○	○
21. mentally alert	○	○	○	○	○	○	○

	Does not apply at all - 1	2	3	4	5	6	Fully Applies - 7
22. muscle soreness	○	○	○	○	○	○	○
23. energetic	○	○	○	○	○	○	○
24. overloaded	○	○	○	○	○	○	○
25. physically relaxed	○	○	○	○	○	○	○
26. muscle stiffness	○	○	○	○	○	○	○
27. having everything under control	○	○	○	○	○	○	○
28. lacking energy	○	○	○	○	○	○	○
29. concentrated	○	○	○	○	○	○	○
30. short-tempered	○	○	○	○	○	○	○
31. full of power	○	○	○	○	○	○	○
32. physically exhausted	○	○	○	○	○	○	○

APPENDIX VIII: RECOVERY – STRESS QUESTIONNAIRE SPORT – 76

Number/Modality

Subject Number

Modality Used

RESTQ-Sport

The questionnaire consists of a series of statements. These statements possibly describe your physic or physical well-being or your activities in the past three days and nights.

Please select the answer that most accurately reflects your thoughts and activities. Indicate how how each statement was right in your case the past three days and nights.

APPENDIX X: PITTSBURG SLEEP QUALITY INDEX

PSQI

Subject Number

Modality Used

The following questions relate to your actual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions

☐ During the past month, what time have you usually gone to bed at night?

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/25/2026

☐ During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

☐ During the past month, what time have you usually gotten up in the morning?

☐ During the past month, how many hours of actual sleep did you get at night? (this may be different than the number of hours you spent in bed)

For each of the following remaining questions, check the one best response. Please answer all questions

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Cannot get to sleep within 30 minutes	○	○	○	○
Wake up in the middle of the night or early morning	○	○	○	○
Have to get up to use the bathroom	○	○	○	○
Cannot breathe comfortably	○	○	○	○
Cough or snore loudly	○	○	○	○
Feel too cold	○	○	○	○

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
Feel too hot	○	○	○	○
Had bad dreams	○	○	○	○
Have pain	○	○	○	○
Other reason(s) please describe	○	○	○	○

How often during the past month have you had trouble sleeping because of this?

- ○ Not during the past month
- ○ Less than once a week
- ○ Once or twice a week
- ○ Three or more time a week

During the past month, how would you rate your sleep quality

- ○ Very good
- ○ Fairly good
- ○ Fairly bad
- ○ Very bad

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/25/2026

For each of the following remaining questions, check the one best response. Please answer all questions

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
During the past month, how often have you taken medicine to help you sleep? (prescribed or "over the counter"	○	○	○	○
During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	○	○	○	○

During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

- ○ No problem at all
- ○ Only a very slight problem
- ○ Somewhat of a problem
- ○ A very big problem

Do you have a bed partner or a roommate?

- ◯ No bed partner or roommate
- ◯ Partner/roommate in other room
- ◯ Partner in same room, but not same bed
- ◯ Partner in same bed

If you have a roommate or bed partner, ask him/her how often in the past month you have had...

	Not during the past month	Less than once a week	Once of twice a week	Three or more times a week
Loud snoring	◯	◯	◯	◯
Long pauses between breaths while asleep	◯	◯	◯	◯
Legs twitching or jerking while you sleep	◯	◯	◯	◯
Episodes of disorientation or confusion during sleep	◯	◯	◯	◯
Other restlessness while you sleep, please describe [ ]	◯	◯	◯	◯

Powered by Qualtrics

IRB NUMBER: 19403
IRB APPROVAL DATE: 02/25/2026