Extended Essay: SEHS

Group 4

A comparison between cryotherapy and thermotherapy for muscle recovery.

Is cryotherapy better than thermotherapy for recovery after exercise to reduce Delayed Onset Muscle Soreness (DOMS)?

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Introduction

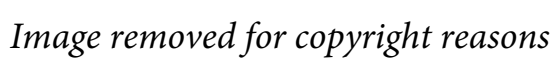
Arguably the most important aspect of a training program for elite athletes is recovery. The quicker an athlete can recover, the sooner they can have another training session or be back to peak performance. For professional sports teams, it is of utmost importance for players to be able to recover fast and fully as it not only maximises performance but decreases the risk of injury. Recovery is necessary to allow for higher intensity training programs without overtraining. Overtraining is when an athlete has trained too hard without giving themselves enough recovery time, ultimately resulting in injury or decreased performance. However, there is often dispute between different physiotherapists and fitness coaches on what the best methods for recovery are, this is mainly due to personal preference of coaches as there are various methods to choose from. One of the most common disputes is whether cryotherapy or thermotherapy treatment is better for muscle recovery to lessen the symptoms of Delayed Onset Muscle Soreness (DOMS).

Delayed Onset Muscle Soreness & Muscle Recovery

DOMS is an acute inflammatory condition that occurs after high-intensity training or competition (L, Smith). Symptoms can peak as late as two days after said exercise. These symptoms include muscle soreness, decreased range of movement and loss of maximum strength ("DOMS and What"). In the short-term, exercise is an effective analgesic for DOMS, however returning to training prematurely greatly increases the risk of injury. While there are many methods to prevent or lessen the symptoms such as stretching and self

mayo-facial release, almost all training plans include some sort of hot or cold treatment. Delayed onset muscle soreness is most often the result of eccentric training. An eccentric contraction is when the muscle lengthens under load, for example, the downward motion of a bicep curl. This is due to the mechanical breaking of myosin and actin within the muscle fibre. Thus, causing structural damage to the muscle. Eccentric training leads to biochemical and mechanical changes to the muscle, causing inflammation, stiffness and pain. Inflammation is the bodies response to injury, signalling the immune system to heal or repair the damaged tissue (Connolly et al.). However, this inflammation can cause pain, swelling and a decrease in performance, therefore, athletes aim to reduce inflammation quickly.

Muscles are made of two major protein filaments; myosin and actin. Myosin is a thick protein filament and actin is a thin filament. Both filaments are contained within the myofibril, which can be found in the muscle fibre ("MuscleContraction"). When exercising at a high-intensity, whether it is aerobic or resistance exercise, there can be a significant impairment to the skeletal muscle, not limited to the sarcolemma, contractile proteins and connective tissue (Dalleck). The skeletal muscles contract as the actin filaments are pulled across to slide past the thick myosin filaments within the sarcomere, known as the sliding filament model ("Muscle Fiber"). Putting the contractile proteins under too significant a load can cause microscopic tears which are necessary for the muscles to grow. However, it is these tears within the muscle fibre that can lead to DOMS. The muscle damage caused by



high-intensity exercise can result in diminished performance and impair transportation of blood glucose into skeletal muscle cells, in turn leading to a decreased potential to replenish glycogen storage ("Skeletal Muscle").

Cryotherapy

According to Merriam-Webster, cryotherapy is the therapeutic use of cold (*Merriam-Webster*). The use of cold to help aid muscle recovery started in the 1940s (MacAuley). Such therapy can come in several forms, namely, Whole Body Cryotherapy, Cold Water Immersion, Contrast Water Therapy and Ice Packs. In layman's terms, all cryotherapy is based on the same principle that by applying cold to sore muscles stimulates sympathetic nerve fibres. Their job is to signal blood vessels in the region, telling them to constrict. This restricts the blood flow to the affected area, returning the blood to the core of the body. This process reduces inflammation of the affected muscles. It is important for athletes to reduce inflammation caused by tears in the muscle fibres to enable them to reduce pain and allow a return to peak performance sooner.

According to a study published in the journal *Frontiers in Physiology*, one of the most prominent physiological response to cryotherapy is the release of norepinephrine into the bloodstream. It has been proven that two minutes of cryotherapy three times a week for 12 weeks can increase norepinephrine levels in the blood by 200-300% (Partridge et al.). A neurotransmitter, norepinephrine helps with focus, attention, cognition, energy and mood which can all increase an athletes performance (Partridge et al.). Additionally, during

cryotherapy treatment, the body releases proteins that are involved with metabolism of lipids, therefore, the body burns fat more easily (Partridge et al.).

Whole Body Cryotherapy

In recent years, the use of Cryogenic chambers for recovery has increased greatly, as top athletes and celebrities such as Cristiano Ronaldo, LeBron James and Justin Timberlake have all shared their experiences using whole body cryotherapy (WBC). Gary Barlow can be seen testing a cryotherapy chamber set at -196ºF in figure 2. WBC works on the same principle as applying ice to an inflamed, sore or overworked muscle (Shmerling). WBC requires the subject to step into a chamber wearing nothing but underwear, socks, shoes, gloves and a headband to protect your ears. The subject will spend three to four minutes in the chamber set to between -100ºC to -140ºC (Shmerling).

Image removed for copyright reasons

Promoters of WBC claim it can aid in recovering from sports injuries and arthritis, as well as helping athletes achieve better overall performance, in addition to highlighting its

apparent weight loss and anxiety-reducing benefits. However, many experiments and studies into the procedure have proven inconclusive of such benefits with one study by Joseph T Costello and Alan E Donnelly of the National Athletic Trainers' Association stating that, " Limited and equivocal evidence is available to address the effect of cryotherapy " (Costello and Donnelly) However, even after such findings, some professional athletes and trainers still claim this is the most effective method for quick muscle recovery, especially in elite athletes.

Cold Water Immersion

In addition to whole body cryotherapy, Coldwater immersion (CWI) has been widely applied as a method. CWI is when an athlete submerges their body up to their neck under cold water. Additionally, CWI is much easier to access as all it requires is a bath full of cold water and ice, as opposed to a high tech, highly-priced cryogenic chamber. There is more evidence to support the benefits of cold water immersion in comparison to whole body cryotherapy. It is said to get the best results the water should be <15ºC however, the subject must be able to withstand the temperature for up to 15 minutes (Wilcock et al.).

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In an experiment conducted and published in the Journal of Athletic Training, the effects of cold water immersion on muscle damage perceived muscle soreness and muscle power recovery were investigated. The experiment was conducted in lab and field conditions with 8 highly trained male athletes of the age of 24 +/-3.6 years and an average mass of

78.5kg (Fonseca et al.). Half the sample was randomly selected for the experimental condition of recovery using cold water immersion for 19 minutes, the other participants were allocated to passive recovery, which was the control condition. The treatments were reversed after one week for the second phase of the experiment. The experiment measured levels of creatine phosphokinase, lactate dehydrogenase (LDH), aspartate aminotransferase and alanine aminotransferase enzymes as well as perceived muscle soreness (Fonseca et al.). Additionally, limb muscle power was recorded pretraining, 24 and 48 hours post-recovery (Fonseca et al.). Athletes who underwent CWI showed significantly better post-training recovery, as there were lower LDH levels in the blood at 24 hours post-training compared to the control condition (Fonseca et al.). Estimated muscle power was higher in the cold water immersion than in the control condition for all muscle groups measured. Furthermore, it was observed that there was less perceived muscle soreness and higher perceived recovery in the cold water immersion condition as compared to the control condition at 24 hours post-recovery. The experiment concluded that cold water immersion was beneficial to the athletes as it reduces circulating level LDH, lessens perceived muscle soreness and improves muscle strength 24 hours post-recovery.

One major limitation of this study is the number of participants. Having only 8 participants could potentially limit the extent and reliability of the results. The study would be greatly improved with the use of a larger sample group as it would make the study more generalisable. Additionally, all participants in the experiment were highly trained, however, it was not specified what sport they were highly trained in. This is relevant because different sports require different areas of strength, thus some may be more accustomed to certain training regimes, causing perceived muscle soreness to differ. Furthermore, perceived muscle

soreness can be very subjective as individuals have unique pain tolerance possibly impacting the results.

Ice Packs

Possibly the most commonly used cryotherapy treatment is ice packs, as they are cheap and easily accessible. The rationale behind the use of ice packs is that the cold stimulates the sympathetic nerve fibres, which in turn respond by signalling blood vessels in the region to constrict, thus sending the blood to the core of the body to protect the vital organs (MAHONEY).

Gabe Mirkin, one of the pioneers of the term RICE (Rest, Ice, Compression and Elevation) now claims his methods are not actually beneficial to the recovery process. The use of ice helps to reduce muscle pain by reducing immune responses (Aschwanden), however, Mirkin stated in an interview with The Washington Post that "anything that reduces your immune response system will also delay muscle recovery" (Aschwanden). He believes that icing may be beneficial in the short term for reducing pain, however, will actually impair the recovery of muscle tissues.

As applying ice directly to the skin is dangerous due to the risk of ice burns, a study by LaVelle and Snyder looked into the barrier effect. The barrier effect is the decrease in the effectiveness of ice being applied to muscles through a protective layer, such as a cloth. It is a necessary safety procedure to take, however, can cause the treatment to be less effective. The study assessed the effect of "commonly used" barriers, padded bandage, bandage, dry

washcloth and wet washcloth (LaVelle and Snyder) . The mean skin surface temperature was recorded after 30 minutes of ice application. Within the first minute the trials with no barrier decreases the temperature on average 5.2ºC which was more than any other, however, after 30 minutes the mean temperature was 30.5ºC using a padded bandage, 20.5ºC with a bandage alone, 17.8ºC with a dry washcloth and 10.8ºC with no barrier and 9.9ºC with a damp washcloth (LaVelle and Snyder). Thus concluding a damp washcloth to be the most effective protective barrier when applying ice. However, which protective barrier used will most often depend on personal preference and individual tolerance of exposure to cold. This study measured the effectiveness of ice packs on lowering skin temperature, however, will stimulate nerve fibres leading to a decrease in muscle pain.

Thermotherapy

On the opposite end of the spectrum, thermotherapy or heat therapy is another method used for muscle recovery. This can take the form of heat packs, hot water baths, ultrasound and heat therapy wraps. Firstly, heat treatment can have a positive impact on pain in muscles. During delayed onset muscle soreness (DOMS), using heat packs can lessen the pain felt in the muscle. The effect of heat on pain is effected by heat-sensitive calcium channels (Rosenbaum and Simon). These channels respond to heat by increasing calcium in the cell walls (Rosenbaum and Simon). Thus, increasing the stimulation of sensory nerves, causing the feeling of heat in the brain. The family of receptors called, TRPV, TRPV1 and TRPV2 are sensitive to harmful heat, while TRPV4 are sensitive to normal physiological heat (Rosenbaum and Simon). When activated, these receptors can inhibit pain receptors,

lessening the pain of injury. Secondly, another effect of heat treatment is that it can increase circulation, The same TRPV1 and TRPV4 receptors increase blood flow to the region in response to the heat. An increase in blood flow will aid the healing of muscles, helping to alleviate DOMS.

Heat Pack Therapy

Heat pack therapy is when a warm pack is placed on the skin to help reduce muscle soreness, inflammation and to increase recovery after exercise. Just like ice packs, heat packs are very easily accessed. The effectiveness of heat packs for reducing the symptoms of DOMS was analysed in a study conducted by JM Mayer and colleagues of the US Spine and Sports Foundation. The study was conducted on sixty-seven subjects asymptomatic of chronic back pain and of good overall health, who performed eccentric (contraction while lengthening and/or shortening the muscle) exercises utilizing the muscles in the lower back. Half the subjects were assigned a control measure of static stretching and the experimental half-used heat packs, 4, 18 and again 48 hours after exercise. The study found that pain relief was 138% greater in the group who used heat wrap recovery methods, concluding that low-level continuous heat wrap exposure had significant benefits in reducing the symptoms of DOMS (Mayer et al.).

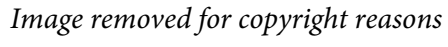
Hot Water Immersion

Very similar to Cold Water Immersion, Hot Water Immersion is when the body is submerged in water, the difference being that the water is hot. There are variations in the

length of time spent in the water and how hot the water should be, although it is thought to be between 10-15 minutes and above 35ºC. In theory, heat will help increase circulation, which will help loosen muscles. In a study published in the Journal of Clinical Medicine Research states that a limb or whole body should be submerged at temperatures of 40ºC for a duration of 20 minutes. The study highlights that this can be advantageous for pain relief. However, the study also concluded that due to the limited time period you can stay in a hot bath there may be poor heat transfer to deep tissues. As a result, for deep tissue muscle pain, Hot Water Immersion is ineffective.

Ultrasound

Ultrasound therapy is the use of soundwaves above the range of human hearing to treat DOMS and muscle strains. Ultrasound machines send waves that penetrate the skin and go into the muscle, causing the tissue to vibrate ("How Does"). These vibrations have a heating effect on the muscle, which is believed to alleviate pain and increase blood flow to the affected area. Additionally, ultrasound is a noninvasive procedure that poses very little to no risks to healthy adults. Although, the wavelengths used for muscular treatments differ from those used in pregnancy ultrasounds, therefore caution should be taken if pregnancy is expected in those using this treatment method ("How Does"). Furthermore,



ultrasound treatments may have adverse effects on malignant tumours and again caution should be taken ("How Does").

In a survey published by the Journal of Physical Therapy conducted by Townsend and associates asked 457 orthopaedic certified physical therapists their opinions on the use and perceived clinical importance of ultrasound for the treatment of common orthopaedic impairments (Wong et al.). The results showed that 83.6% of respondents were likely to use ultrasound to decrease soft tissue inflammation, 70.9% to increase tissue extensibility, 68.8% to enhance scar tissue remodeling, 52.5% to increase soft tissue healing, 49.3% to decrease pain and 35.1% for reducing swelling in soft tissue (Wong et al.). The survey concluded that ultrasound is a popular choice amongst orthopaedic certified physical therapists to aid treatment in common orthopedic injuries. There were some significant limitations of this survey, firstly, only 207 of the 457 surveys sent out were usable. Additionally, all 207 respondents were located in the Northeast and Midatlantic region of the United States, meaning there were possible regional differences that were not captured. Furthermore, physiotherapists did not have to confirm their answers to the survey with actual documentation or prior treatment logs, therefore relied on respondents being honest with their answers.

In theory, ultrasound is a forward-thinking recovery method to help alleviate DOMS, however, aside from the opinions of professionals, there is very little scientific evidence to show that ultrasound has any real effects for the recovery of DOMS. Thus, posing the question, are there true benefits of ultrasound or is it an expensive and unproven treatment option.

Contrast Water Therapy

Contrast Water Therapy (CWT) is the use of both cryotherapy and thermotherapy in one specific treatment method CWT is when the body is placed in warm water for between 6-12 minutes and then directly transferred to an ice bath otherwise known as cold water immersion for the same period of time. Experts say warm water should be >35ºC and cold water should be between 10-15ºC (Varsey et al.). Once again, the colder the water temperature the more beneficial the treatment will be, as long as the participant can withstand it for the necessary amount of time.

In an experiment published in the Journal of Science and Medicine in Sport, the effects of CWT were analysed and compared to the effects of CWI. Repeated sprint ability, strength, muscle soreness and inflammatory markers were the components measured throughout the 48 hour post-exercise recovery period. The subjects of this experiment were all male athletes competing in varying team sports. Baseline performance measurements were taken of 10 and 20 meter sprints and the isometric strength of the quadriceps, hamstrings and hip flexors. Isometric contractions target a specific muscle or muscle group, in which there is tension applied to the muscle continuously without a change in muscle length nor any joint movement (Laskowski). Following baseline testing, participants were subject to 80 minutes of team sports, followed by 20 meter shuttle runs until exhaustion. Immediately following the exercise, each participant performed either CWI or CWT and then again 24 hours post-exercise. Finally, at 48 hours post-exercise the performance measurements were retaken. The results showed that CWI caused a significant decrease in perceived muscle soreness, as well as a reduced decrease in isometric leg extension and flexion strength compared to CWT.

Additionally, CWI lead to a faster return to baseline performance. However, CWT showed a significant reduction in muscle soreness 24 hours post exercise. The study concluded that Cold Water Immersion offers greater recovery benefits over Contrast Water Therapy.

Conclusion

Overall, it can be said that there are benefits to both cryotherapy and thermotherapy when it comes to recovery after exercise to reduce Delayed Onset Muscle Soreness. Studies have indicated such positives and negatives. On one hand, it can be seen that cryotherapy is beneficial by lowering the levels of blood lactate. This is very beneficial to top-level athletes, as it will allow them to return to training sooner. It can also be said that cryotherapy is beneficial for reducing muscle pain. However, such a reduction in pain is caused by the ice reducing the immune response time, which can hinder the healing process. On the other hand, thermotherapy can increase blood circulation through the TRPV1 and TRPV4 pain receptors. This can help alleviate muscle soreness, one of the most prominent symptoms of DOMS. However, this may not benefit deep tissue as it takes time for the heat to reach it. Additionally, there are also large differences in rates of recovery between each individual inconsequential to whether it is thermotherapy or cryotherapy. Despite this, it can be said that overall cryotherapy is generally better for reducing Delayed Onset Muscle Soreness. This is due to its ability to decrease perceived pain and lower blood lactate levels.

However, which recovery method used can also depend on the goals of the athlete and what they personally want from their recovery, for example whether they would rather more pain relief than to regain peak performance.. Some of the referred to studies use pain level as an indicator of effectiveness. Since this is subjective and immeasurable such studies may require further research. Athletes can also be very superstitious and as a result will choose a treatment method based on what they believe works best for them.

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