2020

Does Cold Water Immersion at a Temperature below 10°c Reduce Perceived Muscle Soreness after Exercise More than a Water Temperature above 10° C?

Cara Blenke
Philadelphia College of Osteopathic Medicine

Does cold water immersion at a temperature below 10°C reduce perceived muscle soreness after exercise more than a water temperature above 10° C?

Cara Blenke, PA-S

A SELECTIVE EVIDENCE BASED MEDICINE REVIEW

In Partial Fulfillment of the Requirements For

The Degree of Master of Science

In

Health Sciences - Physician Assistant

Department of Physician Assistant Studies
Philadelphia College of Osteopathic Medicine
Suwanee, Georgia

December 13, 2019

ABSTRACT

OBJECTIVE: The objective of this selective EBM review is to determine whether or not cold water immersion at temperatures below 10°C reduce perceived muscle soreness after exercise more than water temperatures above 10°C.

STUDY DESIGN: Systematic review of three randomized controlled trials published in 2016 and 2017

DATA SOURCES: Data sources for this review were articles published in peer-reviewed journals using PubMed Database and Cochrane Collaboration

OUTCOME(S) MEASURED: The outcome measured was the patient's reduction in muscle soreness post exercise when submerged in cold water using the visual analog scale.

RESULTS: Machado et al. (*Scandinavian Journal of Medicine & Science in Sports*. 2017;27(11):1356-1363. doi:10.1111/sms.12734) found that muscle soreness was reduced immediately post recovery and 40 minutes post exercise when submerged in cold water, but no difference between groups at the 24- or 48-hour period was observed with a p-value of 0.299. Anderson et al. (Journal of Strength and Conditioning Research. 2017:1. doi:10.1519/jsc.0000000000002314) found that muscle soreness remained elevated in all trials 24 and 48 hours post exercise with a p value of 0.03 for the group submerged in 5°C water and 0.27 for the group submerged in 14°C water. Vieria et al. (*International Journal of Sports Medicine*. 2016;37(12):937-943. doi:10.1055/s-0042-111438) found that participants who were submerged in the 15°C bath had reduced muscle soreness after 24 hours compared to the group in the 5°C bath with a p value of 0.06.

CONCLUSIONS: The results of these three trials showed that submersion in a colder water bath than a warmer did not reduce perceived muscle soreness after a time period of 24-48 hours post exercise.

KEY WORDS: temperature of cold water, cold water immersion muscle soreness

INTRODUCTION

Cooling the body after an exercise regimen is widely used by individuals who participate in exercise to help accelerate the recovery process.[1] Cryotherapy, the use of cold temperature modalities, is the most commonly used modality to treat acute muscle damage.[2] The rationale for the use of it is the concept of vasoconstriction where there is an ability to reduce metabolic rates of tissues to allow undamaged tissue to survive a period of ischemia, and to protect surrounding tissue from damaging cellular reactions that accompany the inflammatory response.[2] Cold water immersion allows reduced temperatures of muscles and other tissue and demonstrates anti-inflammatory properties.[2] In sports medicine, cryotherapy as a post exercise modality has been researched to determine subjective ratings of post exercise muscle soreness and rate of perceived exertion after certain time periods of 24 to 48 hours.[3] This paper evaluates three randomized controlled trials to see if a lower temperature cold water immersion bath reduces perceived muscle soreness better than a warmer temperature bath after a time period of 24 to 48 hours.

Post exercise muscle soreness affects nearly any individual participating in the activity that caused the muscular microtrauma. Physician Assistants can work to prescribe physical therapy and even other modalities to help get the patient to return to activity. Physician Assistants can also determine more serious underlying inflammatory muscle disorders through objective measurements if needed.[4] Cost is not a factor no matter the treatment results due to resources being easily available and affordable to the patient. No reports have been made for how many healthcare visits per year post exercise muscle soreness has warranted.

During exercise while the musculoskeletal system undergoes microtrauma, inflammation occurs and is prolonged over time.[1] Within the first day of muscle injury, the damaged area is invaded by inflammatory cells such as mononuclear cells, macrophages and T-lymphocytes.[5]

There is also secretion of growth factors and cytokines that further promote increased blood flow to the area and enhance the inflammatory process.[5] This inflammation is required to heal muscle damage but reducing this process may have beneficial effects on recovery of muscle performance.[1] While the inflammatory process is fundamental to repairing tissues, an excessive response is said to delay the regeneration process.[2] Therapeutic strategies have been used to optimize the inflammatory response and possibly accelerate muscle recovery.[2] Non-steroidal anti-inflammatory drugs like ibuprofen and naproxen as well as massage, stretching, rest and cryotherapy all are methods used to treat muscle soreness post exercise.[6] All methods mentioned are useful in minimizing symptoms. Cryotherapy, specifically cold water immersion, is being studied to determine if colder water versus a warmer water temperature bath is effective at minimizing symptoms perceived by the patient.

OBJECTIVE

The objective of this selective EBM review is to determine whether or not cold water immersion at temperatures below 10°C reduce perceived muscle soreness after exercise more than water temperatures above 10°C.

METHODS

When selecting studies to answer the specific EBM question, specific criteria was used such as certain populations, interventions, comparisons and outcomes that were measured. The types of studies, as well was taken into consideration. The population used in the studies included healthy, adult aged males who participated in an exercise regimen with post exercise induced muscle damage. The interventions that were used were cold water immersion baths below 10°C. The comparisons used were cold water immersion baths above 10°C. The outcomes

measured were patient's perceived muscle soreness post exercise when submerged in cold water and if there was any reduction in perceived muscle soreness using visual analog pain scales and self-reported pain scales. The studies used in this systematic review included three randomized controlled trials.

The online databases PubMed and Cochrane Collaboration were used to find articles suitable for this systematic review. The key words used to find the articles included "temperature of cold water", "cold water immersion" and "muscle soreness". All articles were published in peer reviewed journals and all articles were published in the English language. The articles were selected based on relevance to the clinical question as well as excluding any articles that were written as a meta-analysis. All studies selected were based on patient-oriented outcomes. The inclusion criteria consisted of studies that were published after April 2016 with a primary research design. Exclusion criteria included studies published April 2016 or before, studies with children and studies that included contrast therapies. Statistics that were reported in the articles included p-values, effect sizes (r), Kruskal Wallis Test, and effect size using partial-eta squared.

Table 1: Demographics & Characteristics of included studies

Study	Type	# of Patients	Age (Years)	Inclusion Criteria	Exclusion Criteria	W/D	Interventions
Machado, 2017[8]	RCT	60	18-25	Participants required to report absence of anemia, inflammation, DM, cardiovascular diseases and muscle injuries in the lower limbs and/or spine in the past 6 months	Athletes with any of the mentioned issues as well as athletes who have used anti-inflammatories or who have performed exercise during the study that was not part of the study	0	Cold water immersion for 15 minutes at 9°C ± 1°C and at 14°C ± 1°C after 5 submaximal eccentric contractions of knee extensions
Anderson, 2017[7]	RCT	9	21-27	Recreational team-sports players	Any participants who participated in vigorous exercise and any therapeutic treatments during the duration of testing	0	Cold water immersion (CWI) for 12 minutes at 5°C and 14°C along with a control group after a 45-minute running protocol on a treadmill.
Vieira, 2016[2]	RCT	42	18-24	Previously physically active individuals participating in mild to moderate intensity physical activity 2-3 times per week	Individuals who participated in regular strength training or plyometric exercise.	0	Cold water immersion (CWI) at 5°C and 15°C for 20 consecutive minutes after 5 sets of 20 drop jumps from a box.

OUTCOMES MEASURED

Machado et al. looked at muscle soreness post exercise based on a visual analog scale ranging from 0 “no soreness” to 10 “extreme soreness”.[8] During the assessment of muscle soreness, the participants performed a maximal isometric contraction on an isokinetic dynamometer with the knee flexed at 60 degrees.[8] Muscle soreness was measured immediately post exercise, 40 minutes post exercise, 24, 48, 72 and 96 hours post exercise.[8] Effect size was also calculated using partial eta-squared and interpreted as small (≥0.01), medium (≥0.06) and large (≥0.14).[8] Anderson et al. also examined muscle soreness post exercise with the participants while standing.[7] The assessment used was a 10-point scale ranging from 1 (not sore) to 10 (very, very sore).[7] Muscle soreness was measured before exercise, post exercise, post recovery, 24, 48 and 72 hours post exercise.[7] Vieira et al. measured muscle soreness post exercise using a 10cm visual analog scale.[2] The scale ranged from a 0 “no soreness” to a 10 “severe soreness”.[2] Individuals rated their quadriceps soreness during two conditions: immediately after contracting their quadriceps for four seconds and doing three consecutive sit-to-stand movements from a 43 centimeter chair which was performed with constant cadence.[2]

RESULTS

Throughout all the studies, the cold water immersion therapy was well tolerated by all participants. No adverse events happened and there were no injuries reported from being immersed in cold water.

Machado et al. reported outcome data that is continuous.[8] The study contained 60 male participants ages 18-25.[8] Any participant who had medical conditions such as anemia, diabetes mellitus, current inflammation, cardiovascular diseases, and muscle injuries in the lower limbs and/or spine in the past 6 months could not participate in the study.[8] All 60 participants

completed the study with 40 making up two experimental groups and 20 making up the control group.[8] It was not possible to fully blind the participants due to the control condition.[8] One experimental group had the participants immerse themselves in a cold water bath up to the height of the iliac crests for 15 minutes at 9 ± 1 °C (CWI1) and another experimental group at the participants immerse themselves in a cold water bath for 15 minutes at 14 ± 1 °C (CWI2).[8] The control group (CG) remained seated for passive recovery.[8] Data revealed muscle soreness peaking for all three groups immediately and 48 hours post exercise.[8] CWI1 and CWI2 demonstrated reduced ratings of muscle soreness immediately post recovery and 40 minutes post exercise but no difference between groups was observed with an established p-value of 0.299 for group CWI2 and a p-value of 0.257 for group CWI1.[8] There was also a small effect size for CWI1 of 0.043 and a small effect size for CWI2 of 0.041 indicating a small treatment effect for both experimental groups.[8]

Table 2: VAS for muscle soreness presented as mean ± SD at baseline through 48 hours post exercise[8]

	Baseline	**Exercise Induced Muscle Damage**	**Recovery**	**40 minutes**	**24 hours**	**48 hours**	**p-value**
CG	1.3 ± 1.8	5.7 ± 2.5	4.5 ± 2.2	3.4 ± 2.5	3.3 ± 1.7	4.3 ± 2.9	0.001
CWI1	1.5 ± 2.2	5.5 ± 2.7	2 ± 2.5	2.6 ± 2.6	3.1 ± 1.9	4.6 ± 2.9	0.257
CWI2	1.7 ± 2.1	6.0 ± 2.7	2.7 ± 2.2	3.4 ± 2.6	3.9 ± 1.7	4.8 ± 2.4	0.299

Anderson et al. also reported data that could only be considered continuous.[7] The study only included 9 participants between the ages of 21-27.[7] Any participant who participated in vigorous exercise and any therapeutic treatments during the duration of testing had to be excluded.[7] All 9 participants completed the 45 minute intermittent running protocol on a treadmill followed by a 12 minute recovery session where the first experimental group was

immersed in a cold water bath of 14 ± 1°C ($CWI_{14°C}$), and the second experimental group was immersed in a cold water bath of 5 ± 1°C ($CWI_{5°C}$) while the control group (CON) was nonimmersed.[7] The treatment effect was calculated from perceptual data using effect sizes (r).[7] r < 0.1 is a trivial effect, 0.1-0.3 is a small effect, 0.3-0.5 is a moderate effect, 0.5-0.7 is a large effect and an r value of >0.7 is a very large effect.[7] There was no main effect trial for muscle soreness indicating a p-value of 0.89, but soreness did change over time.[7] Muscle soreness was elevated above baseline after exercise in all trials with p-values between 0.007 and 0.017 and with a r-value of 0.80-0.89, and it remained elevated in all trials 24 hours after exercise with p-values between 0.007-0.034 and with a r-value of 0.65-0.90.[7] It also was elevated 48 hours after exercise with a p-value between 0.007-0.027 and with a r-value of 0.74-0.90.[7] Muscle soreness remained higher than baseline measurements in the CWI_5 group and the CON group throughout the study, but muscle soreness was not statistically higher than baseline in the CWI_{14} group with a r-value of 0.37 and a p-value of 0.27.[7]

Table 3: Visual Analog Scale for perceived muscle soreness[7]

	Baseline	**Post Exercise**	**Post Recovery**	**24 Hours Post Exercise**	**48 Hours Post Exercise**
CON	2 (0-3)	4 (1-6)	3 (1-5)	5 (3-8)	6 (3-6)
$CWI_{5°C}$	2 (1-5)	5 (3-7)	3 (1-5)	5 (1-7)	5 (1-8)
$CWI_{14°C}$	2 (0-5)	5 (1-9)	3 (1-5)	4 (1-6)	5 (3-7)

Vieira et al. published a study with continuous data that also could not be converted to dichotomous data.[2] In this study, 42 male participants ages 18-24 participated in an exercise protocol where 5 sets of 20 drop downs from a box along with a maximally explosive vertical jump was performed.[2] To be excluded from this study, the individual could not be one who regularly participated in strength training or plyometric exercises.[2] It is assumed in the article

that all 42 participants completed the study.[2] Blinding was achieved as participants were split into a control group (GC), a group that was immersed in water at 5°C, and a group that was immersed in water at 15°C.[2] The control group sat quietly at room temperature for the same 20 minute duration as the CWI groups.[2] The researchers admitted a lack of substantial effect in the current study which might be explained by the fact that a single cold water immersion application was used in both cold water immersion groups.[2] A Kruskal Wallis Test was done to determine possible between-group differences for post exercise muscle soreness data, but no range of measures was stated or given.[2] Exact data was only given 24 hours post exercise for the control group and the G15 group.[2] The median muscle soreness measured during the seat-to-stand task was rated in 4.6 for G15 vs 5.8 for GC with a p-value of 0.07.[2] During muscle contraction, muscle soreness was rated 3.3 for G15 vs 4.9 for GC with a p-value of 0.06.[2]

Table 4: Median muscle soreness using the VAS at 24 hours[2]

	24 Hours Post Exercise-Seat to Stand	**24 Hours Post Exercise-Muscle Contraction**
Control Group (GC)	5.8	4.9
$CWI_{15°C}$ Group (G15)	4.6	3.3
p-value	0.07	0.06

DISCUSSION

The objective of this EBM systematic review was to determine if a colder water temperature bath reduced muscle soreness post exercise better than a warmer temperature bath. Each study evaluated this objective by using a visual analog scale as well as different methods to obtain muscle contractions to determine soreness. In the study by Vieira et al., a trend towards lower muscle soreness was only observed 24 hours post exercise with the $CWI_{15°C}$ group instead of the $CWI_{5°C}$ group.[2] Anderson et al. reported perceived muscle soreness remained higher than baseline in the $CWI_{5°C}$ group and the control group and did not return to baseline in any of the

three trials.[7] An improvement in perceived muscle soreness was not observed in this study with both cold water immersion groups.[7] Machado et al. reported ratings of soreness increasing post exercise and peaking at 48 hours.[8] An analgesic effect was noted immediately post exercise from a time period of 3 minutes to 3 hours but not in the time period of 24-48 hours.[8] As stated before, even though the cold water immersion was well tolerated by all the participants throughout the studies, cold water immersion can elicit a dangerous response called "cold shock".[9] In serious cases, it can lead to drowning and cardiovascular problems.[9]

Limitations with Anderson et al. and Vieira et al. include only one session of cold water immersion application for both groups instead of having participants return 24, 48 and 72 hours post exercise to repeat the cold water immersion.[2,7] Vieira et al. also reported data in plot form on different graphs which was difficult to read.[2] No numerical data was reported in the graphs.[2]. Another limitation throughout all the used articles was the fact of each article not focusing on the same time period post exercise for reduced muscle soreness. Different exercise regimens and exercise induced muscle damage strategies were used throughout the studies which means different muscle fibers were recruited and ultimately could elicit different pain responses. Each article also focused on a different time period instead of directing the study toward a time period of 24 hours post exercise or 48 hours post exercise. The articles had different durations of time for the recovery period as well. Machado et al. required participants to fulfill a 15 minute recovery session, Vieira et al. required a 20 minute recovery session, and Anderson et al. required a 12 minute recovery session.[2,7,8] The cohort size for Machado et al. and Vieira et al. were significant enough with group sizes of 60 and 42.[2,8] The cohort size for Anderson et al., however, was very limited in size with only 9 participants in the study.[7] With all of these limitations and differences compiled, there are some significant shortcomings which could have

swayed the results of the three articles to be different if the articles all followed the same protocols.

CONCLUSION

The result of all three studies indicates that a colder temperature bath does not have a greater reduction in perceived muscle soreness than a warmer temperature bath. Due to the limitations of these studies, further research needs to be done to provide more specific information. For individuals who participate in any exercise regimen and are looking for certain recovery strategies, reviewing these articles is encouraged to understand what may or may not benefit the individual. These individuals, after reviewing the articles, can decide on the most effective use of recovery time whether cold water immersion is still desired, or other recovery strategies such as physical therapy, nutrition and NSAIDs are desired.

REFERENCES

1. Abaidia A, Lamblin J, Delecroix B, et al. Recovery from exercise-induced muscle damage: Cold-water immersion versus whole-body cryotherapy. *International Journal of Sports Physiology and Performance*. 2017 Mar;12(3):402-409. doi: 10.1123/ijspp.2016-0186.
2. Vieira A, Siqueira A, Ferreira-Junior J, et al. The effect of water temperature during cold-water immersion on recovery from exercise-induced muscle damage. *International Journal of Sports Medicine*. 2016;37(12):937-943. doi:10.1055/s-0042-111438.
3. Hohenauer E, Taeymans J. The effect of post-exercise cryotherapy on recovery characteristics: A systematic review and meta-analysis. *PLoS One*. 2015;10(9). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4586380/. Accessed October 6, 2019.
4. Myositis: Causes, Diagnosis, and Treatment. Hospital for Special Surgery. https://www.hss.edu/conditions_inflammatory-muscle-disorders-diagnosis-treatment.asp. Accessed October 6, 2019.
5. Ambrosio F, Kadi F, Lexell J, Fitzgerald GK, Boninger ML, Huard J. The effect of muscle loading on skeletal muscle regenerative potential: An update of current research findings relating to aging and neuromuscular pathology. *American Journal of Physical Medicine & Rehabilitation*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4872620/. Published February 2009. Accessed December 7, 2019.
6. Cheung K, Hume P, Maxwell L. Delayed onset muscle soreness: Treatment strategies and performance factors. Sports medicine (Auckland, N.Z.). https://www.ncbi.nlm.nih.gov/pubmed/12617692. Published 2003. Accessed October 6, 2019.
7. Anderson D, Nunn J, Tyler CJ. The effect of cold (14 °C) versus ice (5°C) water immersion on recovery from intermittent running exercise. *Journal of Strength and Conditioning Research*. 2017:1. doi:10.1519/jsc.0000000000002314
8. Machado AF, Almeida AC, Micheletti JK, et al. Dosages of cold-water immersion post exercise on functional and clinical responses: A randomized controlled trial. *Scandinavian Journal of Medicine & Science in Sports*. 2017;27(11):1356-1363. doi:10.1111/sms.12734
9. Datta A, Tipton M. Respiratory responses to cold water immersion: Neural pathways, interactions, and clinical consequences awake and asleep. *J Appl Physiol* 100: 2057–2064, 2006; doi:10.1152/japplphysiol.01201.2005.