PERCIEVED MUSCLE SORENESS IS IMPROVED BY POST EXERCISE COMPRESSION GARMENTS: A CRITICALLY APPRAISED TOPIC

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CLINICAL SCENARIO

Muscle soreness is a recurrent complication among athletes of all activity levels. This issue can lead to reduced performance and lack of success on the field. One of the most common interventions used by clinicians to address this dilemma includes compression devices. The effects of compression devices on muscle soreness are currently unknown.

PURPOSE

The purpose of this research was to critically appraise the literature to determine the effects of compression garments on muscle soreness.

METHODS

Search Strategy
Terms Used to Guide Search Strategy (PICO)

- Patient: Athlete OR Adult
- Intervention: Compression Garment OR Clothing
- Comparison: No Intervention
- Outcomes: Muscle Soreness

Compression AND Garment AND (Creatine Kinase) AND (Muscle Soreness)

Sources of Evidence Searched

- Pubmed @ Duquesne
- CINAHL
- PEDro Database
- SportDiscus
- MedLine
- Other resources found through review of reference lists and hand search

Inclusion and Exclusion Criteria

Inclusion

- Studies measuring muscle soreness by evaluating the values of creatine kinase in the athletes
- Studies with running or sprinting as the exhaustive exercise
- Level 3 or higher
- Studies done on humans only
- Studies limited to the last 10 years (2005-2015)
- Limited to the English language
- Athletes above the ages of 18

Exclusion Criteria

- Studies with resistive training

RESULTS

The studies reviewed were identified as the "best" evidence and met the inclusion criteria (Table 1). None of the four articles meeting the inclusion criteria revealed significant improvements regarding muscle damage based on small effect sizes from all articles.[1,2,3,4] However, there were significant improvements in perceived muscle soreness for subjects wearing compression garments.

DISCUSSION AND CONCLUSIONS

Our study involved the evaluation of high quality evidence to determine the effectiveness of compression garments as a recovery tool in athletes participating in sports where running is involved. The main hypothesis was that the athletes would experience a reduction in muscle soreness with the use of a compressive garment after exhaustive exercise. While the evidence does not support the idea that compression garments positively impact physiologic markers associated with muscle soreness, the evidence does support significant reductions in muscle perceived soreness.

The studies that were reviewed displayed significant outcomes for perceived muscle soreness reduction. The results show evidence that indicated running athletes believed they were not as sore when wearing the compression garments 24 hours after workouts. Outcomes of these studies are important because it establishes that running athletes perceive less soreness after applying compression garments rather than generating a physiologic reduction in muscle soreness. Interestingly, there was no significant change in performance measures in the experimental groups as compared to the control groups in three of the studies evaluated. Furthermore, the garments did not have an effect on the blood markers for muscle damage, including creatine kinase levels.[1, 3, 4]

Each of the reviewed studies showed similar outcomes relative to perceived soreness, biomarkers and performance indicators. However, each investigation utilized slightly different interventions. Three of the four studies[1, 3, 4] utilized lower limb compression garments or tights, where one study[2] used a full body compression suit. While all of the studies utilized sprinting or running to exhaustion, each investigation chose elite athletes from different sports. In two of the studies,[1, 3] participants consisted of rugby players; another study[2] included cricket players; the final study[4] utilized marathon runners. Ultimately, similar results for soreness were documented for the contact and non-contact sports.

Figure 1: *Lower Extremity Compression Garment*[3]

Future research should explore the amount of pressure the compression garments create on the designated treatment area. Hill et al[4] noted that compression garments may not create enough pressure to enhance recovery at the cellular level. Future researchers should consider post activity compression devices that mechanically increase pressure to a desired area. These compressive devices may physiologically reduce muscle soreness. Another aspect that could be further researched is the idea of ascending pain control. This idea may affect the athlete upon utilization of compression garments. Rather than a placebo effect occurring, the compression may have some physiological effect taking place at the neural level.

Based on our findings, compression garments can be used to generate a perceived reduction in muscle soreness following activity. While compression garments may aid with perceived muscle soreness, the research revealed that compression garments do not significantly impact biomarkers of muscle soreness. Although a reduction in perceived soreness may result in improved athletic performance, more research is necessary to address muscle soreness at the cellular level.

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Table 1 - Characteristics of Included Studies

	Duffield R. et al (2010)	Duffield R. et al (2007)	Hamlin MJ. et al (2012)	Hill JA. et al (2014)
Participants	11 rugby players with a mean ± S.D. age 20.9 ± 2.7 years, height 176.3 ± 5.8 cm and weight 75.4 ± 6.3 kg. All participants maintained a regulated diet.	10 male, club-level cricket players that are physically fit with a (SD) age 22.1 (1.1)years, height 185.2 (6.5)cm, and body mass 84.65 (5.90)kg utilized for this study. All had regulated diet and fitted CG.	22 trained male union rugby players (mean ± SD: age 20.1 ± 2.1 years, body mass 88.4 ± 8.8kg). Every participant had at least 3 years rugby training and same trainer.	24 subjects (female, n = 7; male, n = 17) CG Group: age 47.7 ± 10.8, height177.8 ± 10.2 cm. Non-CG Group: age 41.1 ± 10.5, height 175.3 ± 7.0 cm.
Interventions Investigated	Testing session with and without lower body CG during and 24h post-exercise. Participants performed a warm-up of 5 min. Blood was drawn to measure creatine kinase (CK) pre-, 2h and 24h post-exercise. Participants performed a 20 m sprints.	3 types of CGs were utilized to compare results. Participants were involved in a warm-up routine, 3x40m runs, stretching, and a 5 min throwing routine. They were tested on distance and accuracy throwing and then performed 30 min sprint exercises.	A full leg-length CG was utilized. Each participant completed a series of exercise circuits simulating a game of rugby followed 24 hours later by a 40-m repeated sprint test (10 sprints at30-second intervals) and a 3-km run.	Participants completed a submaximal lactate profile and a maximal exercise test on a treadmill. Subjects had to complete a 26.2 mile run outside. Assessed perceived exertion and maximal voluntary isometric contraction (MVIC) and CK.
Outcomes Measured	Peak twitch force of quadriceps, hamstrings, and knee extensors. CK values and perceived muscle soreness.	Sprint times, RPE, perceived muscle soreness for arms and legs, Analysis of [La2], pH, sO2 and pO2, and CK levels.	Perceived soreness measured 0-5, fatigue levels, and CK activity determined through the study.	Perceived muscle soreness, MVIC of knee extensors, CK and C-RP were assessed before, 1h after, and 24h-72h after.
Main Findings	A moderate ES (P = 0.08; d = 0.62) was evident for reduced muscle soreness 2h post-exercise (2.5±1.6 vs. 3.7±1.5) and low 24h post-exercise (2.8±1.3 vs. 4.9±1.4; P = 0.01; d = 1.1). No significant differences in C-reactive protein (C-RP) or CK (P=.30).	No significant difference (p>0.05 and small ES) in CGs for 10m and 20m sprints. There was no significant difference utilizing one garment over another. Control group had a higher rating of muscle soreness in arms and legs (p<0.05 and large ES). CK levels were lower in the experimental groups 24h after exercise than the control group.	Sprint times were improved with CG recovery. Differences in fatigue % (compression 7.21 ± 2.67, placebo 8.69 ± 3.21, effect size 0.51, p-value 0.08, rating: moderate) was better with CG as well. CK activity was similar in both the CG and placebo groups. Participants with CGs during recovery had a less severe case of DOMS (-42.4%; 90% CI, 26.8 to -177.1; ES= 0.34).	Muscle soreness exhibited a significant time by group effect (F(4,1) = 30.8, p , 0.001) and a significant group effect (F(1,22) = 4.451, p =0.046), with those in the CG group experiencing reduced muscle soreness. CK was elevated at 24h and 48h after exercise (692.1 ± 625.6 and 1022.3 ± 1439 U/L in compression and sham groups).
Level of Evidence; Validity Score Conclusions	Ib ; N/A Non-Significant, but data reports that the use of compression garments may not enhance the rate of recovery at the cellular level, but it may aid in the self-reported perception of recovery.	Ib ; 4/10 Compression limits swelling mechanisms. Aids in perceived muscle soreness. Limitations in nutritional intake preclude any conclusive statements on the potential recovery benefits of wearing compression garments after exercise.	IIb ; 4/10 Wearing a CG was associated with better repeated sprint and endurance performance. These results confirm the beneficial effect of wearing CGs during recovery and wearing such garments may be effective.	Ib ; 3/10 Significant findings of decreased perceived muscle soreness. However there is no significant evidence of improved recovery performance or muscle damage.

THE EFFECTS OF HIGH INTENSITY WARMUPS ON ATHLETES WITH DIAGNOSED EXERCISE INDUCED ASTHMA: A CRITICALLY APPRAISED TOPIC

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CLINICAL SCENARIO

Exercise Induced Asthma (EIA) is prevalent throughout all levels of sport and if not properly identified can be fatal. There is no standard protocol for preventative warmups for athletes with EIA. Proper warmups can help to reduce the incidence of an exercised induced bronchospasm (EIB).[1] Current position statements for preventative warmups in athletes with EIA espouse a slow, progression of activity to optimize preventative benefits. However, consensus in the literature upon which level of warmup intensity is the most effective in preventing an EIB remains elusive.

PURPOSE

The purpose of this critically appraised topic (CAT) was to determine if performing high intensity interval warmups versus continuous moderate intensity warmups before activity reduce the incidence rate and severity of an asthma attack in athletes.

METHODS

Search Strategy
Terms Used in Search Strategy (PICO)

- Patient: athletes with exercise induced asthma
- Intervention: warm up OR preparation
- Comparison: none
- Outcomes: reduce chance of EIB during activity

(Athletes) AND (EIA OR exercised induced asthma) AND (warm up OR preparation) AND (reduce OR decrease)

Sources of Evidence Searched

- Pubmed @ Duquesne
- CINAHL
- ProQuest
- Hand Search through previously reviewed literature for topic at question

Inclusion and Exclusion Criteria

Studies that were included examined differences in warm up procedure in athletes with EIA, were of a level 2 evidence or higher, of the English language, and limited to humans. Articles excluded were those that focused on pharmacological differences in EIA preventions.

RESULTS

Four relevant studies[1,2,3,4] were located and one study was found but not included because it focused on the pharmacological differences in EIB prevention. The following studies were identified as the "best" evidence and selected for inclusion in the CAT (Table 1). The reasons for selecting these studies were because they examined the effects of different warmup procedures in athletes with EIA and they were graded with at least a level of 2 evidence or higher.

DISCUSSION AND CONCLUSIONS

Our purpose for this critically appraised topic was to determine a proper warmup procedure for athletes with EIA. We believed that a high intensity warmup would be most effective at reducing incidence and severity of an EIB. All four of our studies showed a decrease in the incidence rate and severity of EIB in athletes with EIA. de Bisschop et al[1] showed that participants that completed a long run and experienced a decrease in breathing capacity were more likely to experience a bronchoconstriction versus participants that completed an interval warmup. McKenzie et al[2] showed that those who performed a high-intensity interval warmup experienced a period of bronchodilation thus reducing the chance of experiencing EIB. Mickleborough et al[3] determined that high-intensity interval warmups improve pulmonary function to decrease the stress on the athletes' lungs from exercise. Schnall et al[4] concluded that short runs caused bronchodilation to aid in prevention of an EIB and further stressed the importance of a warmup protocol for asthmatics.

In athletics, EIA is generally ignored until an athlete begins experiencing an EIB. Instead of being proactive, athletic trainers and coaches instead deal with EIB once it presents itself. Previously, it was unknown how to effectively prevent athletes from experiencing EIB. The National Athletic Trainers Association[5] suggests the use of a warmup procedure to reduce the incidence of EIB without further explanation on the type of warmup to use. Also, the article explains in detail the procedure for how to treat an athlete experiencing an EIB but it does not go into detail on how to prevent these EIBs from occurring.[5] This reflects the general attitude toward athletes with EIA such that they are often overlooked until it becomes an emergency situation.

Athletic trainers need to educate themselves on the proper procedures for aiding in the prevention of EIB. Another problem is that the line of communication between coaching staff and medical staff has not been opened in order to create an understanding for the importance of a proper warmup technique for athletes with EIA. Therefore, clinicians need to relay this information to the coaches because the warmup procedures are generally the responsibility of the coaches. Current and common warmup procedures consist of moderate intensity for extended periods of time. As found in the studies, this type of warmup is not effective in preventing EIB.

After reviewing the findings, it can be concluded that a high-intensity warmup is needed to aid in prevention of an EIB. To summarize the type of high-intensity warmups used, we suggest completing five to ten 30-second sprints with one to two minutes rest in between sprints, depending on how the athlete responds. The athletes can complete one or two sets with a recommended 5-minute break in between sets. If coaches prefer athletes to participate in a group warmup, the asthmatic athletes should complete this high-intensity warmup prior to the group warmup. It is imperative to aid asthmatic athletes in preventing the occurrence of EIB and one way to accomplish this is to complete this type of high-intensity warmup regardless of activity the athlete will engage.

Table 1 - Characteristics of Included Studies

	De Bisschop et al. 1999; Prospective Cohort	**McKenzie et al. 1994; Randomized Controlled Trial**	**Mickleborough et al. 2007; Randomized Controlled Trial**	**Schnall et al. 1980; Randomized Controlled Trial**
Participants	In the first study, sixteen children aged eleven years with EIA were used. Those who participated in the second study were 30 children, 21 boys and 9 girls with a mean age of 12 years, all who had EIA.	Participants were both males and females aged 12-31 that had previous history of EIB. Those excluded either had a respiratory infection at the time of the study, or those receiving long-acting xanthine or steroid therapy.	Eight moderately trained recreational young adult athletes with physician diagnosed asthma. Exclusion criteria included a past history of smoking, other lung function abnormalities, hyperlipidemia, hypertension, diabetes, bleeding disorders, and/or taking aspirin medication.	Four males and two females aged 12-31 with a history of EIB with confirmation from other laboratory studies.
Interventions	The independent variables are the short repeated warm ups at different intensities.	The independent variables were different warmup protocols.	The independent variables were not using any intervention, performing an interval warm up session, the use of an inhaler or an interval warm up session followed by the use of an inhaler.	Independent variables are the running protocols that were given to the participants.
Outcomes Measures	Time and distance of 7 minutes runs and the peak flow and blood lactate concentrations.	Peak expiratory flow rate (PEFR), forced vital capacity (FVC), forced expiratory volume in one second (FEV^{1}) and forced expiratory between 25 and 75% of vital capacity ($FEF^{25-75\%}$).	The outcome measures looked at were FEV^{1}, heart rate, expired ventilation, oxygen uptake and carbon dioxide output.	The measured outcomes were PEFR, FVC, FEV^{1}, $FEF^{25-75\%}$, and the presence of EIB.
Main Findings	For the first part of the study, an analysis of variance showed no differences in peak flow variations between the SR1, 2, and 3 or after EX 2. In the second part of the study, peak flow decreases after exercise were significantly less after EX2 than EX1. After EX2 the fall in peak flow was significantly less than after EX1, except in 6 children. The participants exhibiting a fall in peak flow during SRWU2 were less protected than the others.	The smallest fall in PEFR was seen following the series of short sprints. PEFR significantly decreased following the six minute run without prior warm up seen in tests 1 and 2. Test 3 showed the smallest decrease in PEFR, FEV1, and FEF25-75% when compared to tests 1 and 2. In test 2, performing the short sprints following a 6 minute run showed an increase in PEFR with each successive sprint performed.	There was a greater mean maximum percent difference in post-exercise FEV^{1} experienced with the control group compared to the high-intensity interval group. There was a similar difference between the groups that used the inhaler post-warmup than the group that used the inhaler without warmup. The severity of EIB was significantly less following the warm up compared to the control. Severity was much greater following the warm up and inhaler use compared to just inhaler use.	It will be noted that the falls in PEFR after the second six-minute exercise in test 2 was less than that which occurred after the second six-minute exercise in test 1. The smallest fall in PEFR was seen after the six-minute exercise in test 3. The interval running showed an improvement in PEFR when compared to continuous running. The improvement in PEFR was then in direct proportion to the degree of bronchoconstriction experienced immediately after the first sprint.
Level of Evidence; Validity Score	1b; PEDro Score 6/10	1b; PEDro Score 8/10	1b; PEDro Score 6/10	1b; PEDro Score 8/10
Conclusions	The study found that a well-tolerated period of SRWU tailored to the ability of each individual reduced the severity of post-exercise asthma in most children, 80%. There was a high correlation between the fall in peak flow after SRWU2 and that after EX2. The evidence suggests that those who bronchodilate or had no change in peak flow during the warm up were more likely to be protected against a severe bronchoconstriction. The post-exercise bronchospasm severity was in part related to the magnitude of bronchodilation during exercise.	The performance of short sprints prior to exercise can induce bronchodilation therefore, in athletes with EIA a warm up consisting of high-intensity intervals can reduce the chance of experiencing EIB.	High-intensity interval warm up protocols can improve pulmonary function to below diagnostic EIB threshold of a 10% fall in post exercise FEV1. The warm up protocol's effects are heightened when used in conjunction with an inhaler.	This study demonstrates that repeated short runs minimize the bronchoconstriction effect of subsequent exercise stress and have a bronchodilation effect on previous EIB. These observations suggest that an exercise program could be devised for asthmatics which will enable increased physical activity with less risk of bronchoconstriction.

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INTERVAL CRYOTHERAPY HAS A POSITIVE EFFECT ON OVERHEAD KINETIC ACTIVITIES IN ADULT MALES : A CRITICALLY APPRAISED TOPIC

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CLINICAL SCENARIO

Cryotherapy is typically used as a recovery method after activity to relieve soreness and assist in performance the next day. However, recent research shows positive effects of using cryotherapy intermittently throughout activity. Baseball pitchers recently have been utilizing interval cryotherapy, which is thought to improve throwing performance. This new approach of using cryotherapy intermittently can also be applied to other overhead kinetic activities to increase performance.

PURPOSE

To determine the effect of interval cryotherapy on overhead kinetic activity in adult males.

METHODS

Search Strategy

Terms Used to Guide Search Strategy (PICO)

Patient/Client group: adult males

Intervention (or Assessment): cryotherapy OR cold therapy OR ice

Comparison: no intervention

Outcome: performance OR velocity

(cryotherapy OR cold therapy OR ice) AND (performance OR velocity) AND (baseball pitchers OR throwing athletes)

Sources of Evidence Searched

- PubMed
- The Cochrane Library
- Sport Discus
- CINAHL
- Additional resources obtained via review of reference lists and hand search

Inclusion and Exclusion Criteria

Inclusion

- Studies investigating cryotherapy on shoulder joint to measure performance
- Level 1 evidence
- Limited to English language
- Limited to humans
- Limited to the last 15 years (2000-2013)

Exclusion

- Injuries to the shoulder
- Physical health, arm, or shoulder problems that could influence the results of performance

RESULTS

Three relevant studies were located and categorized in Table 1 (based upon Centre of Evidence-Based Medicine). Two of the studies[1,2] demonstrated the effects of interval cryotherapy in baseball pitching. The third study[3] demonstrated the effect of interval cryotherapy in weight lifting.

DISCUSSION AND CONCLUSIONS

The main purpose of this study was to determine the effect of interval cryotherapy on the overhead kinetic activity in adult males. The studies had significant results supporting the effects of cryotherapy when applying ice to the shoulder intermittently. The outcomes of these studies suggest that interval cryotherapy has a positive effect on performance.

Cryotherapy is a cold application that results in conductive heat loss and reduces muscle temperature.[2, 3] The duration of intermittent cooling of the shoulder decreases tissue temperature, but does not penetrate deep enough to effect muscular functioning. The use of interval cryotherapy has been shown to benefit in repeated performance.[1] In the second Verducci study it states, baseball pitchers typically use cold therapy after activity to decrease recovery time.[3] Clinicians can implement the use of interval cryotherapy in the treatment of overhead athletes involved in kinetic activity who strive to increase their performance.

Performance is affected by velocity, accuracy, work, power, and soreness. The shoulder joint is subjected to high stress as a result of repetitive overhead activities,[1] causing a decrease in performance. All three studies had a common variable of velocity, which increased after intermittent cryotherapy. Intermittent cryotherapy showed an overall increase in performance.

Due to the lack of research of interval cryotherapy on specifically throwing performance, the third article replicated a baseball study[2] to determine if similar results would be acquired by increasing the weight of a baseball to seventy five percent of the one-repetition maximum arm pull. Similar results were obtained, increasing work, velocity, and power when using interval cryotherapy between weight-pulling sets. Therefore, interval cryotherapy can be applied to increase performance in other upper body sports specific activities.

Future research should investigate the effect on recurrent trials of intermittent cooling by manipulating various shoulder motions. Future investigation should also explore how temperature influences muscle fatigue. In addition, further research containing overhead athletes in other sports can be utilized to examine the effect of interval cryotherapy.

Table 1 - Characteristics of Included Studies

	Bishop et al (2013)[1] Prospective Cohort	Verducci (2001)[2] Prospective Cohort	Verducci (2000)[3] Prospective Cohort
Participants	Eight trained amateur male baseball pitchers with no previous history of elbow or shoulder injury were recruited and participated in this study (n = 8, 21 ± 1 yr; 180 ± 7 cm).	Six university NCAA Division II level non-scholarship baseball pitchers (*M* age = 22.3 years, *SD* = 5.84, *M* weight = 84.7 kg, *SD* = 9.48, *M* experience pitching college-level baseball = 2.8 years, *SD* = 1.2, and *M* total years pitching baseball = 15.5 years, *SD* = 2.07) participated in this study.	Ten male volunteers of a private athletic club, (age= 29.0± 2.8 years); height= 174.8± 7.1cm; weight= 72.0± 2.0 kg; weight-training experience = 5.5 ± 1.1 years.
Interventions	Threw fastballs at a target at the rate of one pitch every 20 seconds. 12 pitches per inning with 6 minutes of rest in between. 3 sessions. First trial was to adapt to the protocol, followed by 2 simulated game trials. 2 randomly selected treatments were used, intermittent ice bag cooling of the shoulder and forearm (AC) and no treatment (NC). Maximum of 60 pitches thrown to replicate the first 5-innings of a baseball game.	Interval cryotherapy (CT) treatment consisted of 3 plastic bags (11 x 17 inches) one-third full with chipped ice to the surface of the shoulder and arm and applying two ice bags covering the arm and elbow for 3 min. New bags of ice were used after every third inning. The traditional placebo (TP) treatment consisted of wrapping the shoulder, arm, and elbow with 5 towels for 3 min. At the end of the 3 min, the ice bags or towels were removed; warm-up jackets were used for the next 5 min.	Interval cryotherapy treatment consisted of applying 5 plastic bags (28 x 46cm) one-third filed with ice cubes (1.9 x 2.5 x 1cm each) for 3 minutes: 3 on the shoulder and arm and 2 covering the arm and elbow. New ice bags were used after each 3 sets. The towel treatment consisted of covering the shoulder and elbow with 1 towel each for 3 minutes. The participants did not lift for 1 week before testing, and the treatments were 7 days apart.
Outcomes Measures	Velocity, differences in treatment, and subjective ratings	Innings pitched, velocity, accuracy, and arm and shoulder soreness	Work, velocity, and power
Main Findings	Shoulder and forearm cooling between innings had an increase in pitching velocity when compared to NC. AC treatment significantly improved perceived recovery between innings. Comparison of treatments resulted in 35% reduction ($p = 0.01$) in perceived exertion. A comparison of pitch velocity by inning between the two treatments revealed a significant increased in mean pitch speed ($p = 0.04$) in the 4th inning and 5th inning with AC treatment when compared to NC.	For innings pitched, the CT significantly, $F(1, 4) = 12.88$, $p = .011$, delays the onset of fatigue, using (ANCOVA) with air temperature as the covariate. For velocity, using MANCOVA with the first inning, significantly higher velocities resulted for pitches during CT for the second-to-fourth innings, $F(1, 4) = 50.80$, $p = .002$, all $F(1, 4) = 116.07$, $p = .000$, and matched, $F(1, 4) = 70.89$, $p= .001$, innings. For accuracy using MANCOVA the CT means were consistently closer to the target than the TP means by a range of-0.6-14.7%, with the mean distance being 7.84%. For arm and shoulder soreness, the CT second-to-fourth, matched, and all innings percentages of 89, 79, and 63%, respectively, were greater than the TP percentages of 56, 46, and 42%, respectively.	Participants performed 14.1% more total work ($F1,9 = 19.02$, $P= .002$) and 14.5% more arm pulls ($F1,9 = 22.22$, $P= .001$) during the interval-cryotherapy sets. Velocities for the first to fourth sets ($F1,8 = 7.45$, $P = .03$), matched sets ($F1.8 = 12.35$, $P = .008$), and all sets ($F1,8 = 6.25$, $P = .04$) were higher with cryotherapy. No significant difference in the base sets were seen ($F1,9 = 0.07$, $P = .79$). Participants performed higher power values for the first to fourth sets ($F1,8 = 6.73$, $P = .03$) and matched sets ($F1,8 = 8.41$, $P = .02$) when treated with cryotherapy. However, there were no differences for all sets. ($F1,8 = 3.23$, $P = .11$) or base sets ($F1,9 = 0.09$, $P = .77$).
Level of Evidence/Validity	Level 1b. Validity: N/A	Level 1b. Validity: N/A	Level 1b. Validity: N/A
Conclusions	Intermittent cooling of the shoulder and forearm provided a positive effect on perceived recovery, perceived exertion and pitching velocity during baseball pitching in a temperate environment. Potential positive effects of cryotherapy include improved pitching performance by an increase in pitch velocity, improved subjective recovery and reduced subjective exertion.	Three minutes of interval cryotherapy between innings significantly delayed the onset of fatigue and generally increased velocity, while no differences occurred in accuracy. Icing reduced next-day arm soreness.	Interval cryotherapy between weight-pulling sets is associated with increased work, velocity, and power.

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