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Research article

The Effects Combining Cryocompression Therapy following an Acute Bout of Resistance Exercise on Performance and Recovery

William H. DuPont [1], Brek J. Meuris [2], Vincent H. Hardesty [1], Emily C. Barnhart [1], Landon H. Tompkins [2], Morricia J.P. Golden [1], Clayton J. Usher [2], Paul A. Spence [2], Lydia K. Caldwell [1], Emily M. Post [1], Matthew K. Beeler [1] and William J. Kraemer [1] ✉
[1] Department of Human Sciences, The Ohio State University, Columbus OH, USA; [2] Aquilo Sports, Louisville KY, USA

Abstract
Compression and cold therapy used separately have shown to reduce negative effects of tissue damage. The combining compression and cold therapy (cryocompression) as a single recovery modality has yet to be fully examined. To examine the effects of cryocompression on recovery following a bout of heavy resistance exercise, recreationally resistance trained men (n =16) were recruited, matched, and randomly assigned to either a cryocompression group (CRC) or control group (CON). Testing was performed before and then immediately after exercise, 60 minutes, 24 hours, and 48 hours after a heavy resistance exercise workout (barbell back squats for 4 sets of 6 reps at 80% 1RM, 90 sec rest between sets, stiff legged deadlifts for 4 sets of 8 reps at 1.0 X body mass with 60 sec rest between sets, 4 sets of 10 eccentric Nordic hamstring curls, 45 sec rest between sets). The CRC group used the CRC system for 20-mins of cryocompression treatment immediately after exercise, 24 hours, and 48 hours after exercise. CON sat quietly for 20-mins at the same time points. Muscle damage [creatine kinase], soreness (visual analog scale, 0-100), pain (McGill Pain Q, 0-5), fatigue, sleep quality, and jump power were significantly ($p < 0.05$) improved for CRC compared to CON at 24 and 48 hours after exercise. Pain was also significantly lower for CRC compared to CON at 60-mins post exercise. These findings show that cryocompression can enhance recovery and performance following a heavy resistance exercise workout.

Key words: Muscle damage, physical performance, strength training, fatigue, resilience.

Introduction

Recovery from exercise is an important factor in the performance of successful resistance exercise training programs. Modalities have become an important part of the interventions that may assist in the recovery process from both the physiological and perceptual perspectives. The negative transient effects after exercise results in the reluctance or inability to continue or optimally perform a regular exercise program (Lee et al., 2012). Compression and contrast treatments of hot and cold have shown minimal effects on recovery from resistance exercise however contrast treatments did attenuate muscle soreness (French et al., 2008). Cold temperatures have been shown to constrict blood vessels and help flush toxins like H+ ions more rapidly from the muscles (Bailey et al., 2007; Eston and Peters, 1999), reduce inflammation (Pournot et al., 2011), reduce thermal strain (Vaile et al., 2008a), and reduce muscle soreness (Vaile et al., 2008b). However, a recent meta-analysis has shown cooling therapies effects on recovery from exercise to be minimal with only perceptual ratings showing improvements (Hohenauer et al., 2015). Thus, it appears that new cryo-technologies are needed to address the recovery processes following exercise.

The study of compression garments has increased dramatically since the early 1990s with our understanding of its effects. Compression has been shown to improve blood flow of oxygen rich blood back to the body (MacRae et al., 2011), reduced muscle vibration thereby providing stability to the muscle help prevent micro-trauma to the muscles (MacRae et al., 2011), alleviate swelling and inflammation (Kraemer et al., 1998), increase muscle support (Kraemer et al., 2010a), and enhance proprioception (Shim et al., 2001). It has also been shown that compression can enhance recovery of muscle strength after a heavy resistance exercise workout (Goto and Morishima, 2014; Kraemer et al., 2010b). Recent data indicate that compression can significantly improve recovery from exercise induced damage with higher compressions having a greater effect (Hill et al., 2017).

However, very little research has been done to determine the benefits of combining cold and compression (i.e.,cryocompression therapy) as a post exercise therapeutic intervention as most have used this for clinical/medical applications (Hoiness et al., 1998). Thus, there was a need for further work on cryocompression technologies that may assist in the recovery from exercise and allow for better day to day training performances and therefore improve the effectiveness of the training program. Thus the purpose of this study was to determine the effects of cryocompression on performance and recovery parameters following heavy resistance exercise.

Methods

Participants

Sixteen healthy recreational resistance exercise trained men were recruited to participate in the study. Subjects had been involved with resistance training for at least 6 months with regular barbell squats as part of their training 2 times per week. Each subject had to squat at least 1.0 X their body mass and groups were also matched on training status. The Ohio State University's Institutional Review Board for Human Research approved the study. The study's protocols, procedures, risks, and benefits were fully explained to each of the participants before they

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signed the approved informed consent document. Baseline measurements were obtained and used to match subject pairs for age (yrs), height (cm), body mass (kg), strength (1RM barbell back squat), body composition (7-site skin fold), power (counter movement and squat jump), reaction time (Quick Board reaction test), and physical activity (International Physical Activity Questionnaire). From the matched pair participants were then randomly assigned to either the cryocompression (CRC) or the Control (CON) treatment groups. In subsequent analyses it was then demonstrated there were no significant differences between CRC and CON groups at baseline (see Table 1).

Study design

Participants were familiarized with the testing protocols on a familiarization day and then allowed to subsequently come in to the laboratory again and practice each test as much as they wanted until they were comfortable with the testing procedures. We have found this minimizes any potential learning effects. Baseline measurements were obtained and used for matching purposes as noted before. Additionally, participants in the CRC group were also sized for proper fit of the Cryocompression pants.

Participants reported to the laboratory on 3 consecutive days for testing (see experimental design in Figure 1). On day 1 (PERF), participants performed an acute bout of resistance exercise (AHRET) and then 20 minutes of their respective treatment immediately following exercise. Blood samples were obtained to indirectly measure muscular damage before (PRE), immediately after (IP), and +60min after exercise. Perceptual measures were obtained before (PRE), 20 minutes (+20min) after and 60 minutes (+60min) after exercise. Before all performance testing participants were taken through a simple warm-up procedure that consisted of walking on a treadmill for 5 minutes and lower body dynamic stretches. Performance tests were measured before (PRE) and 60 minutes (+60min) after the exercise bout.

Twenty-four hours and again forty-eight hours after the exercise bout participants again reported to the laboratory. Again, a blood sample and perceptual measures were obtained, 20 minutes of respective treatment was administered, and then participants warmed-up and performance testing was again conducted.

Cryocompression garment characteristics

Aquilo Sports (Louisville, KY, USA) developed a novel portable therapy system that combines cryo and compression in one recovery modality system. The system we used was comprised of a wearable 3-layer compression garment lined with polyurethane flow channels situated between an outer compression layer and a soft inner layer (skin contact), and a control unit for circulating cooled water through sealed flow channels at a regulated temperature (see Figure 2).

Table 1. Characteristics of the experimental participants. Data are means (±SD).

Variables	Control Group (n=8)	CRC Group (n=8)
Age (yrs)	21.5 (1.7	23.4 (2.2
Height (m)	1.81 (.09)	1.77 (.06)
Percent Body Fat	11.3 (3.7)	12.4 (3.5)
Relative Strength (kg/kgBW)	1.70 (.29	1.60 (.22)
Quickness Efficiency (#touches-errors/#tougches+errors)	.90 (.46	.90 (.06)
Power (W)	5066 (950)	4891 (608)

CRC = Cryocompression. No significant differences between the groups.

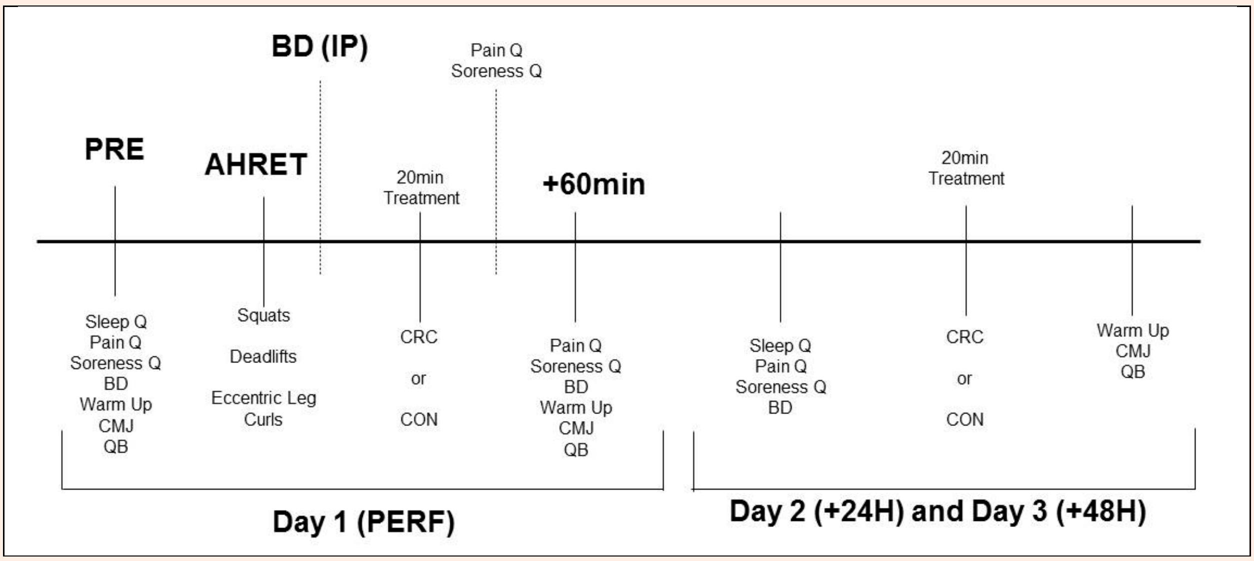

Figure 1. Study design. Q = Questionnaire, BD = Blood Draw, CMJ = Counter Movement Jump, QB = Quick Board Reaction Test, CRC = Cryocompression, CON = Control, PERF = Resistance Exercise Workout and Performance Testing Day

Figure 2. The cyrocompression system comprised of a 9L volume reservoir and control unit (A) and a lower-body garment (B) with flow channels (not shown) to circulate cooled water (10° C) across the surface area of the legs and buttocks and to provide compression.

Garment characteristics were validated for the study with skin surface area temperature (°C) during the treatment and post-treatment (20 minutes) was validated using an infrared thermometer (Nubee NUB8500H, Duarte, CA, USA). In order to determine skin temperature during the treatment, the garment was briefly opened on one leg with three measurements simultaneously recorded (front quadricep, back quadricep, and gastrocnemius). Consecutive measurements were taken on alternating legs to reduce cooling loss each time the garment was opened. Quadricep, patella (knee), and gastrocnemius (calf) compression (mmHg) was measured throughout the lower body (Microlab PicoPress, Nicolo, Italy) by compression sensors placed at each location.

The pressure-flow relationship (H-Q curve) demonstrated the ability to generate flow up to 3 $L \cdot min^{-1}$ at inlet pressure of 12 psi. The experimental garment achieved targeted compression metrics and skin temperature with uniform cooling (10-12° C) across the lower body (see Figure 3). No device failures, leaks, or deterioration occurred during endurance, durability, and robustness testing or in its use in the experimental study.

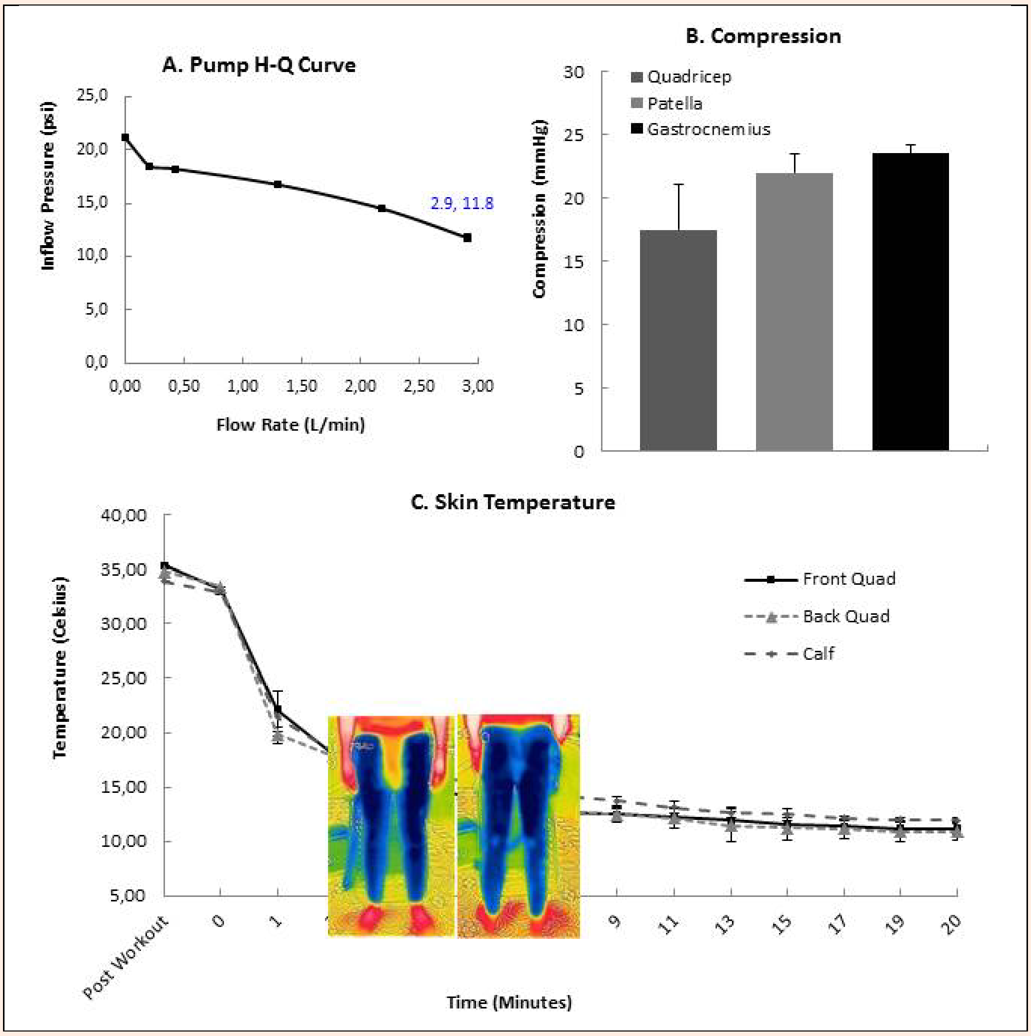

Figure 3. Equipment study on the different mechanical and engineering characteristics of the Cryocompression (CRC) System (Aquilo Sports, Louisville, KY, USA)

Acute bout of resistance exercise

The acute bout of heavy resistance exercise was designed to create muscular fatigue and moderate muscle tissue damage in the lower body musculature. It was a heavy resistance exercise protocol that many healthy recreationally resistance trained adults may perform during a typical workout. Therefore, participants performed barbell back squats for 4 sets of 6 repetitions at 80% of their one repetition maximum with 90 seconds rest between sets, followed by stiff legged deadlifts for 4 sets of 8 repetitions using 1.0 X body mass with 60 seconds rest between sets, followed by eccentric legs curls (Nordic hamstring curls) for 4 sets of 10 repetitions with 45 seconds rest between sets.

Blood draws and muscle damage biomarker

A trained phlebotomist collected blood from the antecubital vein in the arm at PRE, IP, +60min, +24H, and +48H into serum 10ml vacutainers. Blood was allowed to sit at room temperature between 30-60 minutes to clot and then centrifuged using a Sorvall Legend XT centrifuge (Thermo Fisher Scientific Inc., Waltham, MA, USA) at 3000 rpm for 10 minutes and aliquoted into labeled 1.5ml micro centrifuge tubes. Samples were immediately placed in –80° C freezers for storage. After all testing was complete, frozen samples were thawed once and analyzed.

Total serum creatine kinase (CK) concentrations were used as an indirect biochemical marker of muscle fatigue and damage (Brancaccio et al., 2010). Creatine kinase concentrations were determined using Sekusui's creatine kinase-SL enzymatic assay (Sekisui Diagnostics, Lexington, MA, USA). All samples were measured in duplicate for absorbance at 340nm in a Biotek Synergy H1 monochromatic multi-mode plate reader (Biotek, Winooski, VT, USA). Intra-and inter-assay coefficients of variations for creatine kinase were < 10%.

Perceptual measures

Questionnaires were used at specific time points (see Figure 1) to measure participants sleep quality, soreness, pain, and mood states. The sleep quality visual analog scale (Wewers and Lowe, 1990) was administered at PRE, +24H, and +48H.: The soreness visual analog scale (Huskisson, 1974), McGill pain questionnaire (Melzack, 1975; Shacham, 1983), and the shortened profile of mood states (Shacham, 1983) were administered at PRE, +20min, +60min, +24H, and +48H.

Countermovement jump power performance

Maximal-effort countermovement jumps were performed to measure jump power (W). Participants performed 3 sets of 3 consecutive counter movement jumps (CMJ). Participants were instructed to begin in the upright position with their hands on their hips, begin with a downward movement by flexing at the knees and hips (eccentric phase) until their knee angle was approximately 90°, and then immediately extend their knees and hips to jump up in the air with maximal effort as high, hard and fast as they could. Upon landing participants were instructed to immediately repeat the procedure for the second jump without a pause, and then again upon landing repeat the procedure for the third jump without a pause. Jump power data was collected using an Advanced Mechanical Technology Inc. (AMTI) force plate (Watertown, MA) with a sample rate of 200 Hz. Only the jump with the highest power output was selected for analysis. Jump power was analyzed using Accupower 2.0 software (AMTI, Watertown, MA, USA). Force plate analysis of power was based on the following methods. Power is calculated as the product of the resultant force signal and the resultant center of mass (CoM) velocity, Power = Force x Velocity where velocity is the resultant center of mass velocity. Center of mass velocity was calculated using the impulse-momentum relation. AccuPower calculates center of mass (CoM) velocity using the impulse-momentum relation, $F\Delta t = m\Delta v$, which when rearranged is $\Delta V = F\Delta t/m$ where F = net force, Δt = change in time, m = body mass, ΔV= change in velocity. Thus, for a given time interval (based upon sample rate), the change in CoM velocity equals the net force times the length of the time interval divided by the body mass.

Reaction time

Reaction time was measured using the Quick Board reaction test. The Quick Board system (The Quick Board, Memphis, TN, USA) is comprised of a footpad with 5 sensors placed equidistant from each other with two at the front of the footpad, two at the back of the footpad, and one in the middle of the footpad. In addition, there is an iPad (Apple Inc., Cupertino, CA) Quick Board application that presents the visual stimulus. The iPad is placed at eyelevel in front of the participant and connected to the footpad by a QBiAd interface cord. The footpad is replicated on the iPad and the sensors light up in a random order. Once the correct corresponding sensor is touched on the footpad the next sensor immediately lights up.

Participants began by standing on the footpad with their feet between the sensors, not touching any (operational defined as base) while looking at the iPad. Participants were instructed to the touch the corresponding sensor of the footpad that lit up on the iPad and then return to base before touching the next sensor that lit up. In addition, they had to touch the sensors on the left side footpad with their left foot and the sensors on the right side of the footpad with their right foot, but they could touch the middle sensor with either foot. Participants were also instructed to keep their eyes on the iPad rather than looking up and down between the iPad and their feet. Participants performed 3 sets of 20 touches with 30 seconds between each set. In this measure, the average of all trials was used for analysis.

Study controls to reduce confounding variables

Participants were asked a series of compliance questions each day before testing to verify compliance with all study controls. All participants were in compliance for all testing days. Having experience with other muscle damage and soreness studies we used the same interview and log patterns for subjects to adhere to our out of laboratory guidelines (Kraemer et al., 2010c). Before performance and recovery testing began, urine specific gravity (USG) was measured before using a handheld refractometer

(Reichert, New York, NY, USA) to ensure that participants were at a minimum level of hydration, USG ≤ 1.020. If USG was > 1.020 participants sipped water and were periodically retested until USG ≤ 1.020. Participants arrived at the lab having fasted for at least 8 hours. In addition, participants recorded their diet, intake of all food and fluids, the 24 hours before day 1 of testing and replicated that diet on day 1 and day 2 after all testing was completed for that day. Participants were counseled and given specific instructions for recording their diets to help ensure accuracy and completeness of diet records. Participants were restricted from engaging in any exercise for the 72 hours prior to day 1 testing. In addition, they were restricted from engaging in any exercise outside of the study's exercise until after day 3 testing was completed. Participants were prohibited from using any recovery methods other than the experimental cryocompression treatment garment. Specifically, participants were restricted from the use of baths, hot tubs, showers > 10 minutes, ice, compression, aspirin, or any other medication, drug, device or modality that might help with recovery remained in place until after completion of day 3 of testing. Twenty-four hours prior to day 1 testing and up until all testing was completed, participants were restricted from using alcohol and drugs. In addition, participants were screened and excluded if they had any injury or condition that could prevent them from full participation in all the study's procedures and protocols.

Skin temperature: To ensure that the experimental Cryocompression pants were working properly, lower body skin temperature of CRC group was measured at the beginning, + 10 minutes into, and right before the end of each 20-minute treatment. Using a FLIR ONE thermal camera attached to an iPhone, iPod or Android phone, thermal images with temperature readings were taken of participants' front and back. Any areas of the lower body garment outside the range of 10-12 °C were adjusted as needed to bring them back within range.

Statistical analyses

Data are presented as means and standard deviations (M±SD). Data were first tested for linear statistics assumptions. nQuery Advisor® software (Statistical Solutions, Saugus, MA) was used to determine that a group size of n = 8 would be adequate to defend the 0.05 alpha level of significance with a Cohen probability level of at least 0.80. Assumptions for linear statistics were generally met, and when kurtosis or skewness was significantly greater than zero, data were re-analyzed after $\log_{10}$ transformation. If a similar outcome was found, the analysis on transformed data was disregarded. When Levene's test for equality of variance did not allow for the assumption of equal variance, analyses were conducted on adjusted data (via Levene's adjustment procedure). Variables not meeting those assumptions were logarithmically ($\log_{10}$) corrected and re-tested. Demographic characteristics between experimental groups were analyzed using an independent t-test. No significant differences were observed between the matched groups. Two-way ANOVA (group x time) with repeated measures was used to analyze all other experimental data. Where appropriate, Fisher's LSD post hoc tests were used to determine pairwise differences. Prior testing showed that ICCR test retest reliabilities for experimental tests were ≥ 0.93. Statistical significance was *a priori* defined as $p \leq 0.05$.

Results

Examination of the countermovement vertical jump power (Figure 4A) demonstrated significant main treatment effects for time and experimental intervention. For the main effect for time all of the post workout values were significantly lower than their pre-exercise values. Subsequent post hoc analyses for treatment effects and interactions showed there were significant pairwise differences for jump power for CRC group which was significantly greater than CON at 24 and 48 hours after resistance.

Serum creatine kinase (CK) concentrations as an indirect measure of muscle tissue damage also demonstrated significant main effects for time and treatment. Significant increases were observed for time at all of the measurement time points from pre-exercise values for both experimental conditions (Figure 4B). Subsequent post hoc analyses treatment and interaction effects showed that there were significant pairwise comparisons showing significantly lower values for the CRC group 24 and 48 hours after exercise. For the McGill Pain measure, significant main effects for time and treatment were observed (Figure 4C). The main effect of time showed that all of the values for both treatment groups were significantly higher than the pre-values reported. Subsequent post hoc analyses for treatment and interaction effects demonstrated pairwise comparisons showing significantly lower values for the CRC group 60 minutes post exercise and at 24 hours, and 48 hours after the exercise session.

Muscle soreness using a visual analog scale showed significant main effects for time and treatment (Figure 4D). Both the 24 and 48 hr time points showed significant increases from the pre-exercise time point values. Treatment and interaction effects with observed at both the 24 and 48 hr time points with significantly lower soreness ratings for the CRC group being reported.

For quality of sleep the Sleep Scale ratings both showed significant main effects for time and treatment (Figure 4E). For the 24 and 48 hrs time points a significant reduction in sleep quality was observed in both groups. Treatment and interaction effects were observed with pairwise differences showing that CRC group reported significantly better sleep than the CON group at both time points after the exercise session.

The fatigue rating using the profile of Mood State (Figure 4 F) showed a significant main effect for time and treatments. For time significant increases above the pre value were observed in the CRC group for the post-exercise and 24 hrs but not 48 hrs after the exercise session. For the CON group, significant increases were observed above the pre exercise values only 24 and 48 hrs after the exercise session. The treatment effects and interactions were observed with pairwise comparisons seen at post exercise with the CRC group being higher than the CON group but lower than the CON at both the 24 and 48 hrs measurement time points.

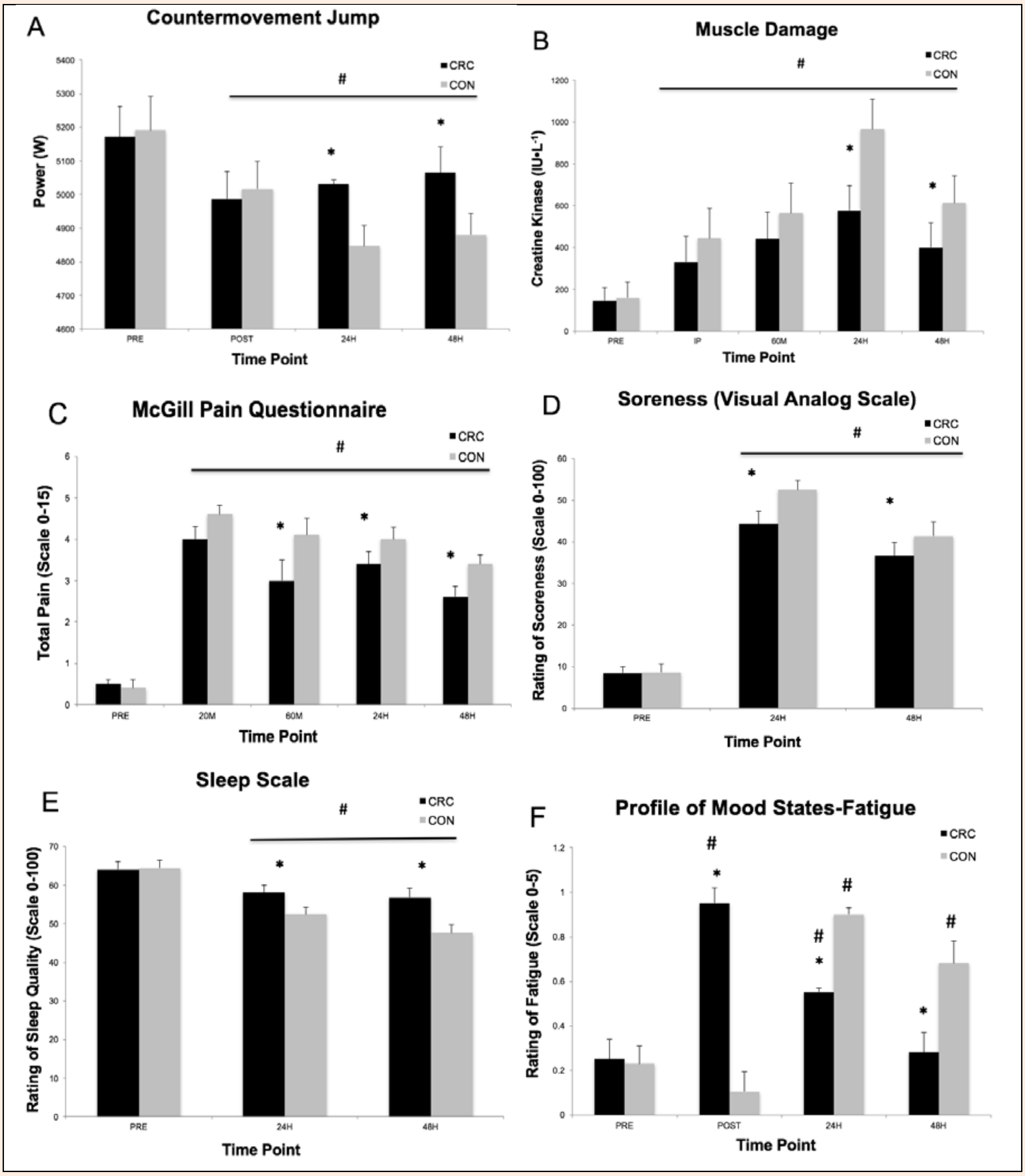

Figure 4. Experimental values for jump performance, muscle damage, muscle soreness, pain, sleep quality and mood states (Means ± SD) # = P ≤ 0.05 from corresponding pre- values; * = P ≤ 0.05 from corresponding CON treatment condition.

Table 2. The Quick Board parameters for reaction times to the visual light signals and the number of touches and errors in picking the wrong foot pad to touch. Data are means (±SD).

	Touches		Errors	
	CRC	CON	CRC	CON
Pre	29.0 (3.5)	29.3 (1.3)	1.0 (1.1)	1.3 (1.6)
Plus60min	28.6 (3.2)	28.5 (2.4)	1.2 (1.2)	1.3 (1.9)
Plus24H	29.0 (3.0)	29.5 (1.9)	1.0 (1.0)	.8 (1.0)
Plus48H	28.9 (3.5)	29.8 (2.0)	.5 (1.0)	.5 (.8)

No significant differences between the treatment conditions.

No significant main effects were observed in visual reactions or correct responses as measured by the Quick Board technology between experimental conditions (Table 2).

Discussion

The primary finding of this study was that using the combination of cold and compression therapy, was an effective method to help recovery from an acute bout of intense resistance exercise. Recovery plays an important role in the type and quality of subsequent workouts and can influence the training progression (Kamandulis et al., 2012). It may also impact the psychological factors related to the ability to engage or continue regular exercise. Thus, the perceptual feeling of pain and soreness may play big roles in exercise recovery that may limit one's ability to train optimally in a training progression needed to achieve performance training goals (Hill et al., 2017).

Participants using the CRC treatment group experienced less soreness than CON group as early as 24 hours after exercise and continued to experience less soreness than CON group 48 hours after the heavy resistance exercise workout. Interestingly, this coincided with the observation that the CRC treatment group also experienced less pain than CON group as early as 60 minutes after exercise and again continued to experience less pain 24 hours and 48 hours after the workout. This may have been mediated by less muscle damage, as measured indirectly using serum creatine kinase concentrations, in the CRC group when compared to the CON group. Ultimately, these factors most likely combined to produce less muscle fatigue in the CRC group than in the CON group from the heavy resistance workout. These effects were observed for the CRC group as early as 24 hours after the exercise session and continued at 48 hour time point. Taken together, cryocompression appears to reduce the less dramatic symptoms of DOMS (delayed onset muscle soreness). Thus in this study the mediating mechanisms appear to be the combination of compression and cooling undertaken simultaneously after a workout. As noted before, cooling may only provide some type of positive perceptual or in essence an analgesic aspect in the recovery process (Hohenauer et al., 2015). Again, muscle damage markers and other measures of recovery have seen few dramatic effects from typical cooling methods (Hohenauer et al., 2015). And while beyond the scope of this study, it points to an attractive hypothesis that cooling with is perceptual analgesic effects concomitant with an effective amount of compression might mediate the outcomes we observed with this combination technology. Interestingly, when compression is used alone in a damage model, initial 24 to 48 hour measurements show significantly elevated pain scores (Kraemer et al., 2001a; 2001b). This is thought to occur due inhibition by the mechanical compression of swelling in the muscle resulting in pushing fluid into the vascular beds to protect sarcolemma membrane integrity (i.e., less muscle fiber damage). Thus the potential importance of cooling as an analgesic may play a vital role in this synergy.

While DOMS is a common term used to describe the perceptual and underlying effects on skeletal muscle, the experimental protocols used and the magnitude of damage was dramatically different from conventional DOMS exercise models (Clarkson and Hubal, 2002; Clarkson and Sayers, 1999; Kraemer et al., 2010c). Such predominately eccentric mediated stressors used in damage protocols would dramatically inhibit normal function for days and reflect a type of nonfunctional overreaching condition. Nevertheless, from the DOMS body of literature, perceptual measures and tissue damage markers play an important role in helping to understand the recovery responses to more conventional exercise stressors. Using that conceptual approach, compression has been shown to be effective in decreasing the magnitude of perceptual and muscle tissue markers with more conventional heavy resistance exercise stress (Kraemer et al., 2010b). Other physiological attributes observe with compression might also enhance the recovery process from enhancing tissue oxygenation (Coza et al., 2012), reduced swelling and inflammation (Kraemer et al., 1998;(Kraemer et al., 2001) and aid in recovery (Goto and Morishima, 2014). Interestingly in this study lower body limb movement and reaction times in response to visual stimuli were not influenced by the CRC intervention. This may be due to the limited range of motion required in the task and the lack of enough skeletal muscle damage to produce severe neurological and contractile deficits in such low power motor control movements.

Per the exercise adherence and continuation of a workout sequence, many of these common characteristics along with fatigue are often reasons people give for why they either stop or are more reluctant to continue exercising regularly (Vanden Auweele et al., 1997). The CRC group experienced less fatigue at 24 hour and 48 hours after exercise. Reducing the magnitude of and time these characteristics last also may contribute to the quality of the workout and enhance the sequencing of different periodized loading patterns thus having an enhanced positive effect on targeted performance outcomes.

The CRC treatment group also reported better sleep quality than CON group at both 24 hours and 48 hours after exercise. The obvious mechanism appears to be that the CON group may have suffered an acute disruption in sleep quality due to the increased soreness, pain, and muscle damage they experienced with the workout which has been observed in soccer athletes as playing an important role in sleep quality (Thorpe and Sunderland, 2012). This appears to be another important finding for using such a simultaneous dual therapeutic intervention after a workout. It is well known that a lack of sleep, even acutely, can negatively affect mood, personality, cognitive and physical performance, and overall health (Orzel-Gryglewska, 2010). Cryocompression may help prevent acute disruptions in sleep resulting from pain and soreness following exercise over a training cycle and be especially important with training load/volume transitions. Cryocompression may also help prevent acute or chronic sleep deprivation of those that experience pain and soreness on a daily basis from such conditions as osteoarthritis even experienced by athletes (Salzmann et al., 2017; Smith et al., 2017).

Interestingly, the CRC treatment group recovered from the decreases in performance resulting from the acute bout of resistance exercise more quickly than CON group. Vertical jump power was higher for CRC treatment group at 24 hours and 48 hours after exercise when compared to the CON group. In fact vertical jump power for CRC treatment group had almost returned to baseline levels 48 hours after the intense heavy resistance exercise workout while CON group's vertical jump power remained far below baseline levels as far as 48 hours after exercise. Compression has been previously shown to improve the recovery of jump performances after resistance exercise (Kraemer et al., 2010b) and after high intensity plyometric exercise (Jakeman et al., 2010b). Interestingly, massage therapy in combination with compression has also been shown to enhance jump power performances (Jakeman et al., 2010a). Therefore, cryocompression can help individuals recover decrements in performance more quickly than rest alone.

Conclusion

In summary, this initial investigation into the use of the combined cryocompression therapeutic modality resulted in an enhanced recovery process in recreationally resistance trained men. The combination of compression and circulating ice cold water was more effective in helping the recovery process from a conventional heavy resistance workout for the lower body musculature than compared to no therapeutic intervention. This initial study now sets up other experimental studies and hypotheses which may partial out the individual roles of each therapeutic modality or modulate their intensities and expand on the exercise stressors (e.g., combination training stressors). Yet, the combined cooling-compression model used in this study appears to have internal validity from prior research as it relates to perceptual and structural aspects of recovery. Finally, cryocompression systems may help people recover more quickly and improve the resilience for more optimal resistance training day to day.

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Declarations of interest

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Key points

- The combination of circulatory cooling and compression technology enhances recovery from heavy resistance exercise.
- Sleep quality is enhanced following the use of cyo-compression when compared to typical no intervention control conditions following heavy resistance exercise.
- Muscle damage markers, pain and soreness markers are improved with cryocompression when compared to no interventional control conditions following heavy resistance exercise.

AUTHOR BIOGRAPHY

William H. DUPONT
Employment
Doctoral Fellow, The Ohio State University
Degree
M.S.
Research interest
Aging, Neuroscience, and Recovery Processes

Brek J. MEURIS
Employment
Research Engineer, Aquilo Sports
Degree
MEng **Research interest**
Materials and Systems Engineering

Vincent H. HARDESTY
Employment
Graduate Research Assistant
The Ohio State University
Degree
B.S.
Research interest
Exercise Physiology and Physical Therapy

Emily C. BARNHART
Employment
Graduate Research Assistant
The Ohio State University
Degree
B.S.
Research interest
Sports Nutrition, Resistance Training

Landon H. TOMPKINS
Employment
Development Engineer, Aquilo Sports
Degree
MEng
Research interest
Co-inventor of the Aquilo cryo-compression therapy system

Morricia J.P. GOLDEN
Employment
Research Assistant
The Ohio State University
Degree
B.S.
Research interest
Exercise Science

Clayton J. USHER
Employment
Field Engineer with Aquilo Sports
Degree

BEng
Research interest
Co-inventor of the Aquilo cryo-compression therapy

Paul A. SPENCE
Employment
Founder and President of Aquilo Sports
Degree
M.D.
Research interest
Translation of medical devices into clinical practice

Lydia K. CALDWELL
Employment
Doctoral Fellow, The Ohio State University
Degree
M.S.
Research interest
Recovery, Neuroscience, Exercise Stress Physiology

Emily M. POST
Employment
Doctoral Fellow, The Ohio State University
Degree
M.S.
Research interest
Exercise Physiology, Developmental Biology and Neurobiology

Matthew K. BEELER
Employment
Doctoral Fellow, The Ohio State University
Degree
M.A.
Research interest
Exercise Physiology, Neuromuscular Biology and Resistance Training

William J. KRAEMER
Employment
Professor, The Ohio State University
Degree
Ph.D.
Research interest
Physiological and Neurobiological Basis of Recovery , Resistance Training
E-mail: kraemer.44@osu.edu

✉ **William J. Kraemer, PhD**
Department of Human Sciences , The Ohio State University, A054 PAES Building, 305 Annie & John Glenn Avenue, Columbus, OH 43210, USA