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Comparison of Whole-Body Cryotherapy and Other Recovery Methods for Muscle Function and Soreness in Runners

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Abstract

Background: *Cryotherapy has been widely used for post-exercise recovery for decades. Whole-body cryotherapy (WBC) is a technique that involves brief exposure to extremely cold temperatures to produce therapeutic effects. Its effectiveness in treating exercise-induced impairments is currently under investigation.*

Purpose: *This systematic review aims to assess whether WBC is more, less, or equally effective compared to other recovery interventions in reducing perceived muscle soreness and restoring muscle function after exercise-induced muscle damage (EIMD) in runners.*

Methods: *A systematic literature review was conducted using the following MeSH terms: cryotherapy, whole-body cryotherapy, exercise-induced muscle damage, muscle soreness, muscle recovery, and running. The databases searched included PubMed, CINAHL, EBSCO Host, and Google Scholar. Articles were included if they were published in the last 10 years, had a level of evidence of IIb or higher according to the Centre for Evidence-Based Medicine (CEBM), a PEDro scale score of at least 5, focused on runners, and assessed both perceived muscle soreness and muscle function recovery. Studies were excluded if they did not involve runners, used partial-body cryotherapy (PBC) instead of WBC, or failed to measure both muscle performance and perceived soreness.*

Results: *Among the four studies analyzed:*

- *Two studies found WBC significantly more effective than other interventions, such as far-infrared radiation and passive recovery, in reducing muscle soreness and restoring muscle power and endurance following simulated trail runs and high-intensity interval running.*
- *One study reported no significant difference between WBC and passive recovery in reducing muscle soreness and restoring muscle power after sprint intervals.*
- *One study indicated that WBC had a negative impact compared to cold water immersion (CWI) and passive recovery, worsening both muscle soreness and muscle strength recovery after a marathon.*

Conclusion: *The findings were inconclusive regarding WBC's effectiveness in treating exercise-induced muscle damage in runners compared to other recovery methods. However, WBC appears to have a time-dependent positive effect on muscle recovery, particularly after high-intensity interval and endurance running—though this benefit does not extend to marathon recovery. Further research is necessary to establish optimal WBC treatment protocols, including temperature, timing, duration, and frequency.*

Introduction

Running is one of the most widely practiced forms of cardiovascular exercise worldwide, appealing to individuals of all ages and fitness levels. It is highly versatile, encompassing activities such as sprinting, jogging, and marathon running. Despite its many health benefits, running can exert significant stress on the body, leading to injuries and exercise-induced muscle damage (EIMD) (Oja et al., 2015).

EIMD is a broad term describing the mechanical and metabolic effects of intense or unfamiliar exercise. These effects include muscle soreness, fatigue, weakness, swelling, impaired proprioception, and increased levels of creatine kinase and lactate in the bloodstream (Clarkson & Hubal, 2022; Proske et al., 2005). Symptoms can last from a single day to several weeks after exercise. While repeated concentric contractions can contribute to EIMD, research suggests that eccentric, or muscle-lengthening, contractions—common in running—are the primary cause (Venhorst et al., 2018).

To optimize performance and recovery, runners commonly use various pre- and post-exercise strategies. Among these, thermotherapy (heat application) and cryotherapy (cold application) are particularly popular. Cryotherapy, which dates back thousands of years, was historically used for treating wounds, inflammation, and even tumor removal. (Freiman & Bougamin, 2005). Over time, the methods of cryotherapy application have evolved, with whole-body cryotherapy (WBC) gaining popularity in sports medicine.

Whole-Body Cryotherapy (WBC)

WBC involves brief exposure to extremely cold temperatures for therapeutic purposes. It was invented by Dr. Yamaguchi of Japan in 1978 who first started using freezing treatments of short duration on his Rheumatoid Arthritis patients (Costello et al., 2015). It is currently widely used in Europe with Poland having the highest number of modern cryochambers, primarily for medical use. Unlike the U.S., where cryotherapy chambers are mainly found in sports and wellness centers, Polish rehabilitation facilities commonly incorporate WBC, often under medical supervision (Jamwal, 2017).

WBC chambers maintain temperatures between -110°C and -140°C using liquid nitrogen. A typical session involves the participant wearing minimal clothing (such as a swimsuit, socks, and a headband) and first spending 30 seconds in a vestibule chamber at -60°C to acclimate before entering the cryochamber for a maximum of three minutes (Lombardi et al., 2017). A trained professional must always be present to ensure safety and adherence to protocols.

While numerous studies have explored the physiological effects of WBC post-exercise, the exact mechanisms underlying its therapeutic benefits remain unclear. The primary physiological response to cryotherapy is a reduction in skin temperature, leading to decreased local blood flow, swelling, metabolic activity, and nerve conduction velocity (White & Wells, 2013). These factors are believed to contribute to cryotherapy's analgesic and anti-inflammatory effects.

Research comparing local cryotherapy (ice packs, ice massage) to whole-body techniques (CWI, WBC) suggests that while ice packs are more effective at lowering skin temperature, WBC and CWI may better reduce core and deep tissue temperatures, including within muscles (White & Wells, 2013). This could explain their potential effectiveness in treating EIMD. However, WBC research remains less extensive than studies on cold water immersion (CWI).

Thus, the objective of this review is to evaluate WBC's effectiveness in alleviating muscle soreness and enhancing muscle recovery in runners.

Research Questions

- Is WBC more, less, or equally effective in reducing perceived muscle soreness after exercise-induced muscle damage in runners compared to other recovery methods?
- Is WBC more, less, or equally effective in restoring muscle function after exercise-induced muscle damage in runners compared to other recovery methods?

Hypotheses

- WBC will be more effective than alternative recovery methods in reducing perceived muscle soreness following exercise-induced muscle damage in runners.
- WBC will be more effective than alternative recovery methods in promoting muscle function recovery in runners after exercise-induced muscle damage.

Methodology

Literature Search

A systematic review was conducted to address the research questions. Databases searched included PubMed, CINAHL, EBSCO Host, and Google Scholar. The search incorporated the following MeSH terms: cryotherapy, whole-body cryotherapy, exercise-induced muscle damage, muscle soreness, muscle recovery, and running.

Inclusion Criteria

Studies were included if they

- Were randomized controlled trials with free full-text access.
- Were published in English within the last 10 years.
- Examined both short- and long-distance runners.
- Compared WBC to another recovery method or control group.
- Measured at least one outcome related to muscle function or perceived muscle soreness.
- Had a CEBM evidence level of 2b or higher.
- Scored at least 5 on the PEDro scale, ensuring methodological quality.

This structured approach ensures a high level of reliability in evaluating WBC's effectiveness for post-run recovery.

Table 1: CEBM Level of Evidence

Level	Research Design
Level 1a	Systematic Reviews of Randomized Controlled Trials (RCT)
Level 1b	Individual RCT with Narrow Confidence Interval
Level 2a	Systematic Reviews of Cohort Studies
Level 2b	Individual Cohort Study and Low Quality RCT
Level 3a	Systematic Reviews of Case-Control Studies
Level 3b	Individual Case-Control Studies
Level 4	Case-series and Poor Quality Cohort and Case-Control Studies
Level 5	Expert Opinion

Table 2: PEDro Scale

Criterium
Eligibility criteria were specified
Subjects were randomly allocated to groups
Allocation was concealed
The groups were similar at baseline regarding the most important prognostic indicators
There was a blinding of subjects
There was a blinding of the therapists who administered the therapy
There was a blinding of assessors who measured at least one key outcome
Measures of at least one key outcome were obtained by at least 85% of the subjects allocated to the group
All subjects received the treatment or control condition as allocated, or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"
Results of between-group statistical comparisons were reported for at least one key outcome
The study provides point measures and measures of variability for at least one key outcome

Exclusion Criteria

Studies were excluded if they did not involve runners, utilized partial-body cryotherapy (PBC) instead of whole-body cryotherapy (WBC), or failed to assess both muscle performance and perceived muscle soreness.

Included Studies

This systematic review identified four relevant studies (n=4). Table 3 provides details on each study, including CEBM and PEDro scores, participant demographics, the specific WBC equipment used, and the comparison intervention. All four studies examined perceived muscle soreness and muscle function recovery as key outcome measures.

Hausswirth et al. (2011) This study involved nine well-trained runners who completed three simulated trail runs over non-consecutive weeks. Each recovery session included one of three interventions: WBC, far-infrared radiation therapy, or passive recovery. WBC was administered using the Zimmer Elektromedizin unit, consisting of three chambers at -10°C, -60°C, and -110°C. Participants were exposed for three minutes in the coldest chamber after a brief acclimation period. Perceived muscle soreness was measured using the Mindeval questionnaire, while muscle function recovery was assessed through maximal voluntary knee extensor torque (Hausswirth et al., 2011).

Kruger et al. (2015) Eleven endurance-trained athletes were randomly assigned to either a WBC or placebo group. The exercise protocol included a treadmill ramp-test followed by high-intensity interval running. Participants in the WBC group underwent three minutes of WBC, while the placebo group performed a three-minute walk in a temperate room. Muscle soreness was evaluated through a two-part questionnaire, and muscle function recovery was measured by comparing time-to-exhaustion between the first and second ramp tests. (Kruger et al., 2015).

Russell et al. (2017) Fourteen male soccer players were divided into WBC and control groups. Participants performed sprint repetitions with rapid deceleration to induce muscle damage. The WBC group underwent treatment in a BOC Cryotherapy Chamber (-60°C for 30 seconds, then -135°C for two minutes), while the control group remained seated in a temperate room. Muscle soreness was assessed using a 7-point Likert scale, and muscle function recovery was evaluated through peak power output during a countermovement jump (Russell et al., 2017).

Wilson et al. (2018) Thirty-one endurance-trained males were allocated to a WBC, cold-water immersion (CWI), or placebo group following a marathon. WBC participants underwent alternating exposures to -80°C to -90°C cryochambers and temperate rooms. The CWI group immersed their lower limbs in 8°C water for 10 minutes, while the placebo group rested and consumed a fruit-flavored drink mislabeled as a recovery supplement. Muscle soreness was measured using a 10-point Likert scale, and muscle function recovery was assessed via knee extensor torque, maximal voluntary contraction, and reactive strength index from a drop jump test (Wilson et al., 2018).

<table>
<caption>Table 3: Articles Included in this Review</caption>
<tr><th>Article</th><th>Subjects</th><th>CEBM</th><th>PEDro</th><th>WBC Equipment</th><th>Comparison Interventions</th></tr>
<tr><td>Hausswirth et al. (2011)</td><td>n=9 (well-trained runners)</td><td>2B</td><td>7</td><td>Zimmer Elektromedizin, Germany</td><td>Far-infrared modality, passive recovery</td></tr>
<tr><td colspan="6">• In 3 non-adjoining weeks, 9 runners performed 3 repetitions of 48 minute simulated trail run on treadmill
• Each runner tested 3 different recovery modalities in random order, all given 1 hour post, 24 hours post, and 48 hours post exercise
• All outcome measures taken before, immediately after, 1 hour post, 24 hours post, and 48 hours post exercise
• Perceived soreness tested with Mindeval system questionnaire; recovery of muscle function measured with knee extensor torque assessment using isokinetic ergometer</td></tr>
<tr><td>Kruger et al. (2015)</td><td>n=11 (endurance-trained male athletes)</td><td>2B</td><td>7</td><td>Zimmer MedizinSysteme GmbH, Ulm, Germany</td><td>Placebo (3-minute walk)</td></tr>
<tr><td colspan="6">• Subjects randomly assigned to WBC or placebo group
• Two test days separated by at least 1 week; test day started with ramp-test protocol to individual exhaustion (increasing treadmill gradient every 30 seconds until exhaustion), followed by high-intensity interval running on treadmill, followed by 1 hour of passive recovery with either 3 minutes WBC or 3 minutes walking, followed by second ramp-test protocol
• PEPS and EZ Scale questionnaires given prior to first ramp-test, directly following high-intensity interval running, half-way through 1-hour rest, directly prior to second ramp-test, and directly after second ramp-test
• Perceived soreness measured with PEPS and EZ scales (both questionnaires which include adjectives about perceived physical state with associated 0-5 scales); recovery of muscle function measured by differences in time-to-exhaustion between ramp tests</td></tr>
<tr><td>Russell et al. (2017)</td><td>n=14 (male academy soccer players)</td><td>2B</td><td>7</td><td>BOC Cryotherapy Chamber, Linde, Surrey, United Kingdom</td><td>Passive recovery</td></tr>
<tr><td colspan="6">• Each subject participated in trials for both WBC modality and passive recovery modality, trials separated by 7 days
• Subjects performed short 5 minute warm-up, followed by 2 counter-movement jump attempts, followed by 10 minute dynamic warm-up and 5 minute passive rest, followed by 15 x 30 m timed sprints (each separated by 60 second rest and each requiring deceleration to a standstill within a 10 m zone), followed by either WBC or passive recovery modality that starts within 20 minutes of exercise termination
• Outcome measures taken pre-, immediately post-, 2 hours post, and 24 hours post-exercise
• 7-point Likert scale used to measure perceived muscle soreness; recovery of muscle function measured by peak power output during countermovement jumps</td></tr>
<tr><td>Wilson et al. (2018)</td><td>n=31 (endurance-trained males)</td><td>2B</td><td>7</td><td>CryoClinics, London, UK</td><td>Cold-water immersion, placebo (fruit-flavored drink/passive recovery)</td></tr>
<tr><td colspan="6">• Subjects randomly assigned into placebo (n=10), CWI (n=11), or WBC (n=11) group
• Each subject completed marathon, asked to pace run as if it were competitive, allowed to consume fluid and electrolytes during race
• Allocated treatment intervention began within 15 minutes of finishing race
• Outcome measures taken before race, 24 hours post, and 48 hours post-race
• Perceived muscle soreness measured with 11-point Likert scale during body weight squats; recovery of muscle function measured via peak knee extensor torque, maximal voluntary isometric contraction, and reactive strength index</td></tr>
</table>

Results

Perceived Muscle Soreness

As summarized in Table 4, two studies demonstrated a statistically significant advantage of whole-body cryotherapy (WBC) in reducing perceived muscle soreness following exercise-induced muscle damage from running.

In (Hausswirth et al., 2011) WBC significantly reduced perceived muscle pain/soreness ($p < .05$) within the first hour post-exercise compared to soreness levels immediately after exercise. In contrast, far-infrared radiation (FIR) only led to a reduction at the 48-hour mark, while passive recovery showed no significant effect (Hausswirth et al., 2011).

Kruger et al. reported a significant improvement in perceived muscle recovery following WBC ($p < .01$, $d = 0.95$), whereas the placebo group exhibited no improvement (Krüger et al., 2015).

Russell et al. (2017) found no significant reduction in perceived muscle soreness in either the WBC or passive recovery groups (Russell et al., 2017).

Wilson et al. (2018) observed no significant difference between WBC and cold-water immersion (CWI) in reducing muscle soreness. However, WBC appeared to have a potentially beneficial effect compared to the placebo group after 48 hours (Wilson et al., 2018).

Table 4: Perceived Muscle Soreness

Article (Year)	Outcome Measure	WBC	Control Interventions	Confidence Interval	Comments
Hausswirth et al. (2011)	Mindeval System	Pre: 0.2 +/- 0.7 Post: 60.6 +/- 20.7 Post 1 h: 31.7 +/- 23.8 Post 24 h: 33.3 +/- 26.1 Post 48 h: 39.0 +/- 24.0	(FIR) Pre: 1.6 +/- 3.2 Post: 61.9 +/- 19.0 Post 1 h: 58.3 +/- 18.4 Post 24 h: 49.3 +/- 29.1 Post 48 h: 45.2 +/- 29.1 (PAS) Pre: 0.1 +/- 0.3 Post: 55.7 +/- 18.2 Post 1 h: 44.3 +/- 23.7 Post 24 h: 53.9 +/- 25.5 Post 48 h: 58.9 +/- 19.0	95%	WBC>FIR WBC>PAS The Mindeval questionnaire consists of 3 categories of questions related to pain, tiredness, and well-being. The data displayed in this table represents the results from the questions related to perceived pain, as it most closely correlates to muscle soreness.
Kruger et al. (2015)	PEPS and EZ Scale	$R1_{pre}$: 3.3 +/- 1.1 $R1_{post}$: 2.8 +/- 1.2 $Rest_{30\ min}$: 3.0 +/- 1.1 $R2_{pre}$: 3.3 +/- 1.0 $R2_{post}$: 2.3 +/- 1.0	(PBO) $R1_{pre}$: 3.3 +/- 0.5 $R1_{post}$: 2.6 +/- 1.1 $Rest_{30\ min}$: 2.0 +/- 0.7 $R2_{pre}$: 2.3 +/- 1.0 $R2_{post}$: 2.0 +/- 1.1	95%	WBC>PBO The PEPS and EZ scales contain questions pertaining to perceived physical state. The data displayed in this table represent the results from the questions within the category of "perceived sensation of recovery," as it most closely correlates with muscle soreness.
Russell et al. (2017)	7-point Likert Scale	Pre: 1+/- 1 Post: 3 +/- 2 Post 2 h: 1 +/- 1 Post 24 h: 2 +/- 2	(CON) Pre: 1+/- 1 Post: 3 +/- 2 Post 2 h: 2 +/- 1 Post 24 h: 2 +/- 2	95%	WBC=CON
Wilson et al. (2018)	11-point Likert Scale	B-24 h: 1 +/- 1 B-48 h: 0 +/- 1	(PL) B-24 h: 2 +/- 1 B-48 h: 1 +/- 1 (CWI) B-24 h: 2 +/- 1 B-48 h: 0 +/- 0	*90%	It is unclear whether WBC has a positive effect on perceived muscle soreness compared to a placebo 24 hours post intervention, but WBC has a possibly beneficial effect on perceived muscle soreness compared to a placebo 48 hours post intervention. It is unclear whether WBC has a positive effect on perceived muscle soreness compared to a CWI 24 hours post intervention. WBC has a possibly trivial effect on perceived muscle soreness compared to CWI 48 hours post intervention.

= signifies there is no significant difference between WBC and control intervention at reducing levels of perceived muscle soreness; > signifies that WBC was significantly more effective at reducing perceived levels of muscle soreness than the control intervention; < signifies the control intervention was significantly more effective at reducing perceived levels of muscle soreness than WBC

WBC: whole-body cryotherapy
FIR: far-infrared radiation
PAS: passive recovery (seated in armchair for 30 minutes)
PBO: placebo (3-minute walk)
CON: seated for approximately 110 minutes
PL: placebo (10 minutes of quiet rest after marathon combined with consumption of fruit-flavored drink which did not contain any anti-oxidants or phytonutrients 2 times per day for 5 days before the run, day of the run, and 2 days after the run)
CWI: cold-water immersion
*A 90% confidence interval combined with magnitude-based inferences were calculated for changes in perceived muscle soreness between baseline and 24 hours-post marathon and baseline and 48-hours post-marathon. The methods utilized are further described by (https://pubmed.ncbi.nlm.nih.gov/19114737/).

Recovery of Muscle Function

As outlined in Table 5, two of the four studies demonstrated a statistically significant benefit of whole-body cryotherapy (WBC) in enhancing muscle function recovery after exercise-induced muscle damage from running.

In Hausswirth et al. (2011) maximal voluntary contraction capacity significantly improved ($p < .05$) within the first hour post-exercise following WBC. In comparison, recovery took 24 hours with far-infrared radiation (FIR) and did not occur at all with passive recovery (Hausswirth et al., 2011).

In Kruger et al. (2015) the difference in time-to-exhaustion between the first and second ramp tests was significantly lower ($p < .05$, effect size $d = 1.13$) in the WBC group (36.5 ± 18.8 s) compared to the placebo group (66.7 ± 32.8 s), indicating faster recovery (Kruger et al., 2015).

Russell et al. (2017) found that peak power output returned to pre-exercise levels at both the 2-hour and 24-hour marks in both the WBC and passive recovery groups. However, no significant differences were observed between the two groups (Russell et al., 2017).

In Wilson et al. (2018) peak torque declined from baseline in all groups at both the 24-hour and 48-hour marks, with WBC having a more detrimental effect than both cold-water immersion (CWI) and the placebo intervention. Similarly, WBC negatively impacted maximal voluntary isometric contraction force at both time points compared to CWI and the placebo group. While it was unclear whether CWI and passive recovery had a harmful effect on contraction force, WBC was shown to have a clear negative impact overall. Reactive strength index (RSI) decreased across all groups at the 24-hour mark, but by 48 hours, WBC had a more pronounced negative effect compared to CWI and passive recovery, which had unclear or trivial effects (Wilson et al., 2018).

Table 5 : Recovery of Muscle Function

Article (Year)	Outcome Measure(s)	WBC	Control Interventions	Confidence Interval	Comments
Hausswirth et al. (2011)	Peak Torque Assessment Using Isokinetic Ergometer	Raw data not available	(FIR) Raw data not available (PAS) Raw data not available	95%	WBC>FIR WBC>PAS Though there is a figure that depicts these findings, raw data points for % differences in MVC between separate time points for each intervention were not made available.
Kruger et al. (2015)	Time to Exhaustion (ttim, in seconds) Differences in Ramp Test Protocol	(t_{tim} ramp 1 - t_{tim} ramp 2) = 36.5 +/- 18.8 s	(PBO) (t_{tim} ramp 1 - t_{tim} ramp 2) = 66.7 +/- 32.8 s	95%	WBC>PBO

Russell et al. (2017)	Peak Power Output (W) During Countermovement Jump	Pre: 4,092 +/- 466 Post: 3,971 +/- 482 Post 2 h: 4,009 +/- 406 Post 24 h: 4,127 +/- 468	(CON) Pre: 4,151 +/- 494 Post: 4,004 +/- 443 Post 2 h: 4,055 +/- 489 Post 24 h: 4,089 +/- 459	95%	WBC=CON
Wilson et al. (2018)	Peak Torque and Maximal Voluntary Isometric Contraction (MVIC) Assessment with Isokinetic Dynamometer, Reactive Strength Index (RSI) during Drop Jump (DJ)	Baseline (B) Values Peak Torque: 203.72 +/- 39.47 Nm MVIC: 228.60 +/- 54.68 N RSI: 1.03 +/- 0.29 m/s Percent Differences at 24 and 48 h Peak Torque (%) B-24 h: -10.7 +/- 4.0 B-48 h: -5.3 +/- 4.7 MVIC (%) B-24 h: -10.1 +/- 3.3 B-48 h: -8.0 +/- 6.5 RSI (%) B-24 h: -13.7 +/- 10.1 B-48 h: -5.8 +/- 9.9	PL Baseline (B) Values Peak Torque: 178.24 +/- 28.41 Nm MVIC: 197.85 +/- 51.15 N RSI: 0.88 +/- 0.21 m/s PL Percent Differences at 24 and 48 h Peak Torque (%) B-24 h: -3.7 +/- 4.3 B-48 h: -1.6 +/- 4.0 MVIC (%) B-24 h: 17 +/- 5.5 B-48 h: 3.4 +/- 8.5 RSI B-24 h: 4.9 +/- 9.3 B-48 h: 2.9 +/- 12.5 CWI Baseline (B) Values Peak Torque: 195.33 +/- 29.92 Nm MVIC: 221.81 +/- 37.48 N RSI: 0.89 +/- 0.30 m/s CWI Percent Differences at 24 and 48 h Peak Torque (%) B-24 h: -4.1 +/- 5.5 B-48 h: -1.7 +/- 6.5 MVIC (%) B-24 h: -0.7 +/- 5.2 B-48 h: 1.1 +/- 5.5 RSI B-24 h: -4.8 +/- 13.0 B-48 h: 2.6 +/- 12.3	*90%	WBC has a likely harmful effect on peak knee extensor torque compared to a placebo 24 hours post intervention, and a possibly harmful effect on peak knee extensor torque compared to a placebo 48 hours post intervention. WBC very likely has a harmful effect on MVIC compared to a placebo 24 hours post intervention, and a likely harmful effect on MVIC compared to a placebo 48 hours post intervention. WBC has a possibly harmful effect on RSI compared to a placebo both 24 hours and 48 hours post intervention. WBC likely has a harmful effect on peak knee extensor torque compared to CWI 24 hours post intervention, and a possibly harmful effect on peak knee extensor torque compared to CWI 48 hours post intervention. WBC has a likely harmful effect on MVIC compared to CWI both 24 hours and 48 hours post intervention. WBC has a possibly harmful effect on RSI compared to CWI both 24 hours and 48 hours post intervention.

= signifies there is no significant difference between WBC and control intervention at reducing levels of perceived muscle soreness; > signifies that WBC was significantly more effective at reducing perceived levels of muscle soreness than the control intervention; < signifies the control intervention was significantly more effective at reducing perceived levels of muscle soreness than WBC

WBC: whole-body cryotherapy
FIR: far-infrared radiation
PAS: passive recovery (seated in armchair for 30 minutes)
PBO: placebo (3-minute walk)
CON: seated for approximately 110 minutes
PL: placebo (10 minutes of quiet rest after marathon combined with consumption of fruit-flavored drink which did not contain any anti-oxidants or phytonutrients 2 times per day for 5 days before the run, day of the run, and 2 days after the run)
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*A 90% confidence interval combined with magnitude-based inferences were calculated for changes in perceived muscle soreness between baseline and 24 hours-post marathon and baseline and 48-hours post-marathon. The methods utilized are further described by (https://pubmed.ncbi.nlm.nih.gov/19114737/).

Discussion

Summary of Evidence

This systematic review aimed to evaluate whether whole-body cryotherapy (WBC) is more effective than alternative recovery methods in reducing perceived muscle soreness and restoring muscle function following exercise-induced muscle damage from running. Four randomized controlled trials (one parallel study and three crossover studies) were analyzed, each examining markers of muscle damage in endurance-trained individuals.

The studies varied in several key aspects, including WBC protocols (chamber temperature, duration, timing, and frequency of treatment), comparison interventions (cold-water immersion [CWI], far-infrared radiation [FIR], and passive recovery or placebo), methods of inducing muscle damage (e.g., simulated trail running, high-intensity interval training, repeated sprints, and a marathon), and assessment tools for muscle soreness and recovery (Likert scales, questionnaires, isokinetic ergometers, and functional movement tests). Additionally, muscle function was evaluated through different components, including strength (maximal voluntary isometric contraction force), power (peak torque, peak power output during a countermovement jump, and reactive strength index), and endurance (time-to-exhaustion differences).

Overall, findings across the four studies were inconsistent. The hypothesis that WBC would be more effective than other recovery interventions at reducing muscle soreness was supported by Hausswirth et al. (2011) and Kruger et al. (2015) where WBC significantly decreased muscle soreness compared to FIR and passive recovery. However, Russell et al. (2017) and Wilson et al. (2018) contradicted this hypothesis, as WBC was found to be no more effective than passive recovery in Russell et al. (2017) and even detrimental compared to CWI and passive recovery in Wilson et al. (2018)

Similarly, the hypothesis that WBC would enhance muscle function recovery was supported by Hausswirth et al. (2011) and Kruger et al. (2015) where WBC was superior to FIR and passive recovery in restoring maximal voluntary contraction force and endurance. However, Russell et al. (2017) and Wilson et al. (2018) found no significant advantage of WBC over passive recovery, and in the case of Wilson et al. (2018) WBC was actually harmful, impairing recovery of peak torque, maximal voluntary contraction force, and reactive strength.

Limitations

A key limitation of this review is the small number of studies meeting the inclusion criteria (n=4), which limits the generalizability of the findings. Additionally, all studies focused on endurance-trained athletes, who may experience less muscle soreness and recover faster than the general population. This further reduces the applicability of the results to broader populations.

The inconsistency in study methodologies—such as variations in WBC treatment protocols, assessment tools, and exercise modalities—also affects the reliability of the findings. Furthermore, due to the nature of WBC interventions, blinding participants to their treatment group was not possible, increasing the risk of bias in all included studies.

Conclusions

Given the mixed results across studies, no definitive conclusions can be drawn regarding the overall effectiveness of WBC for reducing muscle soreness and enhancing muscle function recovery compared to other interventions. However, findings suggest that WBC may be beneficial under certain conditions. Notably, WBC was effective following shorter-duration exercise (e.g., a simulated trail run [48 minutes] and high-intensity interval training [45 minutes]), showed mild effectiveness after repeated sprints (~25 minutes), but was detrimental following prolonged exertion (e.g., a marathon [~4.5 hours]). This suggests that the effectiveness of WBC may depend on exercise duration or the timing of its administration post-exercise.

Future research should investigate the optimal timing, frequency, temperature, and duration of WBC to maximize its benefits. Standardized methodologies, including consistent skin, core, and deep tissue temperature measurements, would enhance comparability between studies. Additionally, further studies should clarify whether WBC or CWI provides distinct physiological and therapeutic benefits beyond localized cryotherapy.

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