The Use of Contrast Therapy in Soft Tissue Injury Management and Post-Exercise Recovery: A Scoping Review

Olivia Greenhalgh[a]*, Jill Alexander[b], Jim Richards[b], James Selfe[a] and Chris McCarthy[a]

[a] *Department of Health Professions, Manchester Metropolitan University, Manchester, UK;*

[b] *Allied Health Research unit, Faculty of Health and Wellbeing, University of Central Lancashire, Preston, UK*

***Corresponding author:**

Olivia Greenhalgh, PhD Student
Department of Health Professions,
Manchester Metropolitan University,
Manchester, M15 6GX
O.Greenhalgh@mmu.ac.uk

Jill Alexander, Course Lead BSc Sports Therapy
Allied Health Research unit,
Faculty of Allied Health and Wellbeing,
University of Central Lancashire,
Preston, PR1 2HE
JAlexander3@uclan.ac.uk

Jim Richards, Professor of Biomechanics
Allied Health Research unit,
Faculty of Allied Health and Wellbeing,
University of Central Lancashire,
Preston, PR1 2HE
JRichards@uclan.ac.uk

James Selfe, Professor of Physiotherapy
Department of Health Professions,
Manchester Metropolitan University,
Manchester, M15 6GX
J.Selfe@mmu.ac.uk

Chris McCarthy, Clinical Lead of the Manchester Movement Unit,
Department of Health Professions,
Manchester Metropolitan University
Manchester, M15 6GX
Chris.McCarthy@mmu.ac.uk

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Background: Contrast therapy is the alternation of thermotherapy and cryotherapy. Commonly used modalities of contrast therapy include contrast water therapy (CWT) and cold/hot packs. Despite a lack of research, it is widely used in clinical and sporting settings, particularly to aid recovery.

Objectives: The scoping review aims to provide a comprehensive overview of research surrounding the use of contrast therapy for soft tissue injury management and recovery.

Major Findings: Twenty-nine full text papers were included, following a search of the databases listed: PubMed, Cochrane, SPORTDiscus, EBSCO, CINHAL and MEDLINE (via OVID). The majority of research on contrast therapy focuses on recovery, using contrast water therapy. Despite a consensus for contrast therapy temperatures of 10-15°C (cold) and 38-40°C (hot), significant variation amongst recovery protocols still exists, with temperatures ranging from 8-15°C and 35.5-45°C and duration ranging from 6-31 minutes. Generally, beneficial effects are reported to subjective measures such as self-reported perception of recovery, fatigue and muscle soreness following contrast therapy. However, the evidence is less clear regarding the influence on physiological measures and performance.

Conclusion: Contrast therapy appears to be most commonly used in the form of contrast water therapy for post-exercise recovery purposes. There remains a significant lack of research surrounding the efficacy of contrast therapy for soft tissue injury management and the use of alternative modalities.

Keywords: contrast; cryotherapy; thermotherapy; rehabilitation; recovery

Word Count: 4,534 - including, abstract, tables, references, headings and figure captions

Introduction

With athletes often having limited time between training and competition, their ability to recover quickly is becoming increasingly important (1). Contrast therapy is a widely used rehabilitation method for soft tissue injury and post-exercise recovery, despite a lack of research in the field to support its use. Contrast therapy is the alternation of heat (thermotherapy) and cold therapy (cryotherapy) (2). Contrast water therapy (CWT) and cold/hot packs are commonly used modalities of contrast therapy. CWT, alternating hot-water immersion (HWI) and cold-water immersion (CWI), is achieved through full/partial immersion in hot and cold baths/showers in sporting settings to aid recovery. Evidence to support the use of CWT as a recovery strategy has mainly been based upon anecdotal reports (3). Separately, the therapeutic benefits of thermotherapy include an increase in blood flow, metabolism, connective tissue elasticity and pain relief (4). Cryotherapy aims to reduce tissue temperature, perceived pain, cell metabolism, nerve conduction velocity and swelling (5). Despite a general consensus within the literature of the main therapeutic effects of cryotherapy and thermotherapy separately, the physiological basis of contrast therapy is not fully understood.

The purpose of this scoping review is to provide an up-to-date overview of relevant research surrounding the use of contrast therapy for soft tissue injury management and post-exercise recovery.

Methods

A scoping review was conducted using the Arksey & O'Malley (6) framework. One author (OG) searched the literature to identify studies relevant to the use of contrast therapy in soft tissue injury management. In order to identify the relevant papers, the following databases were searched: PubMed, Cochrane, SPORTDiscus, EBSCO, CINHAL and MEDLINE (via OVID). Hand searches of reference lists were also carried out. The inclusion/exclusion criteria are detailed in Figure 1.

Inclusion

- Published in a peer-review journal
- Written in English
- Includes the use of a contrast therapy modality
- Relevant to the use of contrast therapy in recovery or soft tissue injury management

Exclusion

- Not related to soft tissue injury or recovery
- Not in a peer-review journal
- Animal studies
- Written in a language other than English

Figure 1: Eligibility Criteria

The following search terms were used: ‘Contrast Therapy’ or ‘Contrast Water Therapy’ or ‘Contrast’ or ‘Thermotherapy’ or ‘Heat Therapy’ or ‘Cold Therapy’ or ‘Cryotherapy’. A wide definition of key words was adopted for search terms as suggested by Arksey & O'Malley (6) in order to offer a broad coverage of the literature available for the scoping review. Figure 2 illustrates the study selection process in order to identify the relevant sources.

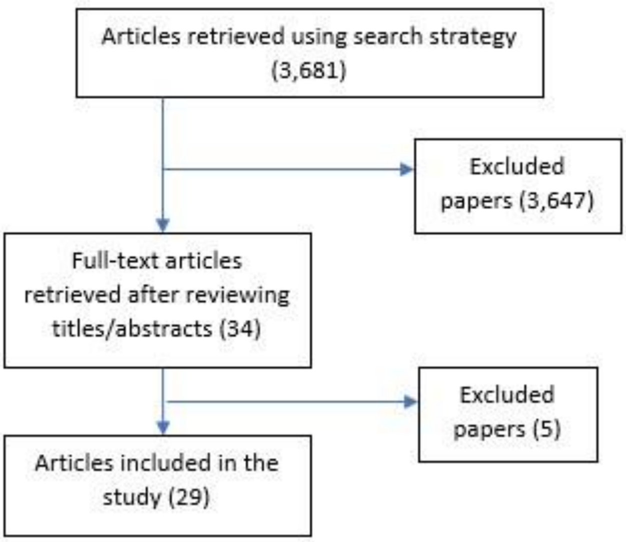

Figure 2: The Study Inclusion/Exclusion Process

Results

Twenty-nine full-text papers were included in this scoping review. This consisted of twenty-one research papers, five systematic reviews, with two of those four including a meta-analysis, and three literature reviews. Five papers were excluded following the full-text and abstract review due to duplication or not relating to the use of contrast therapy in soft tissue injury or recovery. Figure 3 provides a breakdown of the characteristics of the studies included in this review.

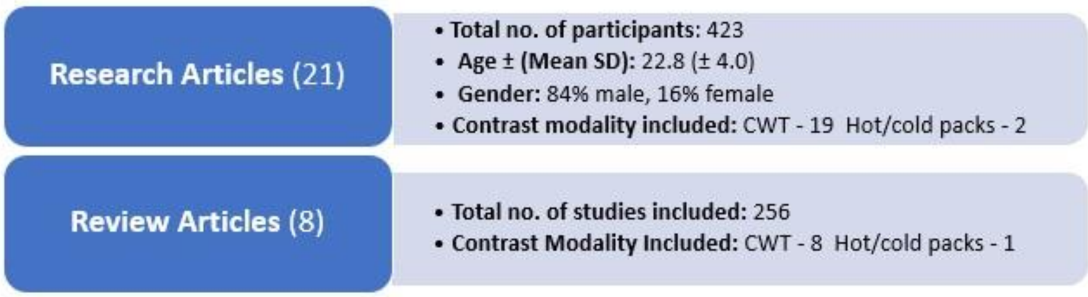

Figure 3: Paper Characteristics Summarised

The majority of the studies included in this review are original research articles. The findings of the review are documented in Table 1.

Table 1: Data extraction of the included studies

	Paper Characteristics					**Key Findings**
Article Information	Studies Included	Participants	Strategies	Contrast Dose	Purpose	
(Argus et al., 2017) *Research Article*		13 male volunteers	CWI and CWT	Full-body (excluding head/neck) 38°C 1 min/15°C 1 min (14 mins total)	Recovery	- Peak torque during maximal voluntary isometric contraction of the knee extensors and jump performance were significantly decreased immediately and 4 hours post resistance-training in all conditions - CWI and CWT had no significant effect on performance or subjective measures during the 4-hour recovery period
(Bieuzen et al., 2013) *Systematic Review with Meta-Analysis*	18 RCT or crossover trials		CWT vs passive recovery (PR)		Recovery	- Evidence suggests CWT is more effective than PR or rest following muscle-damaging exercise - The benefits of CWT include reduced muscle soreness and increased muscle function (due to a decrease of muscle strength and power loss) following exercise
(Cochrane, 2004) *Literary Review*			CWT		Recovery	- Previous evidence advocates CWT for reducing injury in the acute stages, through a shunting action of vasodilation and vasoconstriction, believed to stimulate blood flow, remove metabolites, repair muscle and slow down metabolism - More research is needed to determine whether CWT influences physiological recovery post-exercise
(Crowther et al., 2017)		331 athletes	Active Recovery (AR) land-based, AR		Recovery	- Stretching was considered the most effective recovery technique - AR land-based was considered the least effective

Research Article: Survey			water-based, stretching, CWI and CWT			
(De Nardi et al., 2011) *Research Article*		18 teenage soccer players	CWI and CWT	Lower-limb immersion 15°C / 28°C alternating every 2 min (8 mins total)	Recovery	- CWI and CWT did not influence the athletes' performances negatively and did not produce changes in inflammatory and haematological markers in young soccer players - Reduced perception of fatigue was the main effect of CWI
(Dupuy et al., 2018) *Systematic Review with Meta-Analysis*	99 research articles		AR, massage, compression garments (GAR), CWI, CWT, cryotherapy		Recovery	- CWT may reduce muscle damage, due to reduced creatine kinase (CK) concentrations - CWI and GAR had a positive impact on delayed onset of muscle soreness (DOMS) and perceived fatigue but not as significantly as massage
(Elias et al., 2012) *Research Article*		14 male Australian footballers	CWI, CWT, PR	Full-body (excluding head/neck) Alternating 38°C 1 min, 12°C 1 min, (14 mins total)	Recovery	- CWI restored physical-performance and psychometric measures more effectively than CWT - PR was the least effective
(Fiscus et al., 2005) *Research Article*		24 male volunteers	HWI, CWI, CWT	Lower-leg immersion 13°C/40°C (20 mins total)	Recovery	- Contrast therapy produced fluctuations in blood flow - More research on a larger population should be carried out to determine the clinical relevance
(French et al., 2008)		26 male volunteers	CWT (Baths)	Lower-limb immersion	Recovery	- No significant differences in acute recovery from exercise-induced muscle damage with CWT, compression and PR

Research Article			Compression	8-10°C 60 seconds /37-40°C 180 seconds		- CWT may briefly reduce post-exercise soreness
(Gill et al., 2006) *Research Article*		23 elite male rugby players	CWT, GAR, low intensity AR and PR	Lower-limb immersion 8-10°C for 1 min/40-42°C for 2 mins (9 mins total)	Recovery	- Significant increases in CK activity in transdermal exudate found following rugby - An enhanced rate and magnitude of recovery was observed with AR, CWT and GAR at 37-and 84-hours post
(Higgins et al., 2017) *Systematic Review with Meta-Analysis*	23 articles		CWI and CWT		Recovery	- CWI beneficial for recovery at 24 hours (countermovement jump) and 72 hours (fatigue) post team sport - CWT beneficial for recovery at 48 hours (fatigue) and neuromuscular recovery at 24 hours post team sport - Recovery of perceptions of fatigue following team sport were improved following CWI (72 hours) and CWT (24 hours) - Neither were beneficial for recovery of perception of muscle soreness
(Higgins et al., 2013) *Research Article*		24 male rugby players	CWI and CWT (shower)	Full-body immersion 10-12°C / 38-40°C for 60 seconds alternating (10 mins total)	Recovery	- No significant difference between heart rate (HR) and blood lactate - CWT group showed significantly greater DOMS 1-hour post-intervention than the control group and at 48-hours post-intervention for the CWI group - Contrasts baths less effective for recovery than CWI and PR - Best technique observed for alleviating DOMS following exercise-induced muscle damage was 2 x 5-minute CWI
(Hing et al., 2008)	12 RCT's		CWT Hot/cold packs			- The research available regarding the efficacy of contrast therapy in sports rehabilitation/recovery is lacking quality and quantity - A consensus for temperatures used for contrast therapy (cold: 10 - 15°C hot: 38 - 40°C)

Systematic Review						
(Juliff et al., 2014) *Research Article*		10 female netballers	Passive Recovery (PR), CWT	Full-body (excluding head/neck) Alternating 1 min 3°C/ 1 min 15°C (14 mins total)	Recovery	- No significant differences on performance between the recovery conditions - Greater heat removal was observed in both water-based recovery conditions immediately to 20 minutes post recovery - Improved perceptions of recovery were observed with the water recovery conditions in comparison to PR
(King & Duffield, 2009) *Research Article*		10 female netballers	AR, CWI and CWT	Lower-limb immersion 9.7 ± 1.4 °C for 1 min and 39.1 ± 2°C shower for 2 mins (15 mins total)	Recovery	- No significant differences found in exercise performance during session 2 for all conditions - CWT significantly reduced lactate post intervention compared to AR - CWT and CWI produced the lowest decline in performance at session 2, leading to an increased self-reported perceptual recovery
(Ménétrier et al., 2015) *Research Article*		10 athletes	CWI, CWT and thermoneutral water immersion (TWI)	Lower-limb immersion 12°C 2 mins/35°C 2 mins	Recovery	- Hydrostatic pressure with CWI ~12 °C decreased femoral artery blood flow - Hydrostatic pressure with brief alternating contrasted temperatures caused no significant change in femoral artery blood flow
(Myrer et al., 1997) *Research Article*		16 volunteers	Hydrocollator pack Ice pack	Lower-limb immersion Hot-pack/ ice-pack alternating		- Contrast therapy has little effect on deep muscle temperature - If the physiological effects associated with contrast therapy are reliant on fluctuations in subcutaneous/intramuscular temperatures, it would need to be reconsidered as a viable therapeutic modality

				every 5 min (20 mins total)		
(Peeling et al., 2012) *Research Article*		8 endurance swimmers	CWT supplemental oxygen (HYP), or PR	12°C/38°C alternating 1 min for 10 mins followed by 10 mins static stretching, then a further 10 mins of CWT (20 mins total)	Recovery	- A 30-minute intervention of CWT or HYP has limited effect on the acute-phase response or on improving performance 1-day post-intervention - Acute perception of recovery is improved when an intervention is implemented compared to no recovery
(Pournot et al., 2011) *Research Article*		41 male athletes	TWI, CWI, CWT, PR	Full-body (excluding head/neck) 10°C/42°C 1 min 30s alternating (15 mins total)	Recovery	- CWI (10°C) and CWT (10-42°C) are the most effective immersion modalities for maximal anaerobic performance recovery following exhaustive exercise - A possible explanation for this could be the removal of plasma concentrations of markers of inflammation and damage
(Stanley et al., 2012) *Research Article*		18 male cyclists	CWI, CWT, PR	Full-body (excluding head/neck) 14.2°C 1 min, 35.5°C 2 mins alternating (6 mins total)	Recovery	- CWI most effective at reducing general fatigue, followed by CWT - CWT most effective at reducing leg soreness, followed by CWI - Although the effects of CWI and CWT on performance were insignificant, the improvement on perceptions of recovery provide a foundation to support the use of these recovery techniques

(Stanton et al., 2003) *Research Article (survey)*		43 therapists	CWT (Contrast Baths)		Recovery	- Contrast baths are commonly used in practice, particularly at home - Benefits of contrast baths include low cost and ease of use - Anecdotal data suggests that despite inconsistent CWT protocols, many find contrast bathing useful and report positive results
(Stanton et al., 2009) *Systematic Review*	10 articles		CWT		Hand Therapy	- Contrast baths increase superficial blood flow and skin surface temperature - Conflicting evidence exists for the effect on oedema
(Tavares et al., 2017) *Literary Review*			CWI and CWT		Recovery	- In the acute stages (<48 hours), the literature suggests that CWI and CWT can have a beneficial effect on CK clearance, DOMS and neuromuscular performance
(Vaile et al., 2008) *Research Article*		12 male cyclists	CWI, HWI, CWT, PR	Full-body (excluding head/neck) Alternating from 15°C for 1 min/ 38°C for 1 min (14 mins total)	Recovery	- CWI and CWT significantly maintained sprint performance greater than HWI and PR - CWI and CWT could be effective recovery techniques for events such as track cycling

(Vaile et al., 2008)
Research Article
		38 strength-trained males	CWI, HWI, CWT, PR	Full-body (excluding head/neck)
				Alternating from 15°C for 1 min / 38°C for 1 min (14 mins total)
					Recovery	- All three hydrotherapy interventions improved isometric force recovery greater than PR
						- CWI and CWT significantly maintained performance greater than HWI and PR and were more effective in reducing the deficits associated with DOMS such as:
						  - Recovery of isometric force and dynamic power
						  - Reduction of localised swelling
						- No significant differences in rate of perceived exertion or HR for any condition

(Versey et al., 2011) *Research Article*		11 male cyclists	CWT	Full-body (excluding head/neck) Alternated 38.4°C/ 14.6°C 1 min each (6, 12 or 18 mins)	Recovery	- CWT generally improved whole-body fatigue, thermal sensation, and muscle soreness - No significant differences between conditions in HR or rating of perceived exertion - No apparent dose-response effect on CWT duration on recovery from high-intensity cycling - CWT duration up to 12 mins assisted recovery of cycling performance
(Versey et al., 2012) *Research Article*		10 male runners	CWT	Full-body (excluding head/neck) Alternated 38.4°C/ 14.6°C (6, 12 or 18 mins)	Recovery	- A 6-minute duration of CWT assisted acute recovery from high-intensity running - Algometer pain threshold during CWT for 12 minutes was higher compared with the control - No significant differences in HR or post-exercise calf/thigh circumferences between conditions - No apparent dose-response effect on CWT duration and recovery of running performance - Subjective measures of thermal sensation and muscle soreness were lower in all CWT - No consistent differences following CWT in whole-body fatigue

(Versey et al., 2013) *Review Article*	53 research articles		CWI, HWI, CWT, and TWI		Recovery	- It is unlikely that a dose-response relationship between CWT duration and recovery of exercise performance exists - CWI and CWT more likely to assist recovery of performance than HWI and TWI - It's unclear which technique is most effective
(Weerasekara et al., 2016) *Research Article*		118 volunteers with ankle sprains	Hot-fermentation heat pack Ice massage	Lower-leg immersion 0-10°C/40-50°C alternating 1 min (15 mins total)	Soft Tissue Injury	- No difference in contrast and heat therapies with ankle ROM immediately and 3 days post application - Both modalities increased swelling immediately post application - Contrast therapy reduced swelling 3 days post but heat therapy increased swelling after 3 days - Heat therapy reduced pain immediately post treatment compared to contrast but no significant difference in reduction of pain after 3 days for both modalities

Discussion

This scoping review aimed to provide a comprehensive overview of research surrounding the use of contrast therapy for soft tissue injury management and recovery. Twenty-seven (nineteen research articles and eight reviews) out of the twenty-nine studies included in this review used or included CWT as a modality. Only three studies explored alternative contrast modalities which were hot-fermentation and hydrocollator heat packs with ice massage/packs. One review article investigated both CWT and hot/cold packs (7).

Findings from this review suggest that CWT appears to be used predominately as a recovery technique by athletes' post-exercise, with twenty-six out of twenty-seven studies focussing on recovery, opposed to soft tissue injury. However, the evidence surrounding the efficacy of CWT is yet to be fully understood, with the literature reporting conflicting findings on physiological and functional effects. Despite this uncertainty, the perception of recovery is frequently improved with CWT in comparison with a passive recovery technique (8).

In comparison to passive recovery or rest, the reported enhanced therapeutic benefits of CWT include greater heat removal, increased superficial blood flow, fluctuations in blood flow, reductions in creatine kinase (CK) concentrations in the blood, lactate, muscle soreness and an increase in muscle function (9-17). However, studies within this review reported no significant differences in blood lactate, heart rate, femoral artery blood flow or post-exercise calf/thigh circumferences following CWT (18-23). No changes were observed in inflammatory and haematological markers following CWT or CWI (18).

When assessing subjective measures, studies reported that CWT improved self-reported perception of recovery (24, 25), perceptions of fatigue following team sport (8) and perceived reduction in muscle soreness following exercise (26). Contrastingly, Higgins et al. (8) stated that CWT and CWI were not beneficial for recovery of perception of muscle soreness following team sport. In a survey amongst athletes comparing active recovery, stretching, CWT and CWI, stretching was perceived the most effective recovery technique and active recovery was considered the least effective (27).

The literature presents a mixed response to performance following CWT. Vaile et al. (28) found that cycling sprint performance was improved following 14-minute applications of CWI and CWT compared to HWI and passive recovery. King & Duffield (24) also reported benefits to performance with CWT and CWI producing the lowest decline in performance compared to passive/active recovery strategies. However, Juliff et al. (9) reported no significant differences on performance between the three recovery conditions (passive, CWT, and contrast showers). Yet, Elias et al. (29) reported that CWT restored physical performance measures more effectively than passive recovery but less effectively than CWI. Overall, the reviewed literature implies a consensus that CWT and CWI are more effective recovery strategies than passive recovery, HWI and thermoneutral-water immersion (TWI). Albeit, despite a number of studies comparing CWT and CWI, it is still unclear as to which immersion technique (CWI or CWT) is most effective.

Versey et al. (30) suggested the optimal CWT conditions for performance recovery would consist of equal immersion between hot/cold baths lasting approximately 1 minute each, for up to 15 minutes. Nevertheless, it is still apparent that there is a lack of standardisation in CWT protocols used for post-exercise recovery (31) and the optimal protocols for other contrast therapy modalities are still unclear. Hing et al. (32) identified a consensus for the temperatures used for contrast therapy for sports recovery, across a range of modalities, as 10-15°C (cold) and 38-40°C (heat). This is in agreement with the defined therapeutic skin surface temperature range of 10-15°C used in acute injury management (33). However, Bieuzen et al. (26) noted an inconsistency in the water temperatures being used for CWT; with temperatures ranging from 8-15°C (mean: 11.1°C) and 35.5-45°C (mean 39.3°C). Immersion techniques also appear to vary; ten studies included in this review used full-body CWT immersion (excluding head/neck), seven immersed the lower-limb and two immersed the lower-leg only Hing et al. (32) also observed durations varied significantly from 6 to 31 minutes amongst the studies using contrast therapy, with ratios alternating from hot to cold ranging from 1:1 to 10:1.

Weerasekara et al. (34), the only study in this review surrounding soft tissue injury management, compared the use of contrast and heat therapy using hot fermentation heat pack (40-50°C) and ice massage (0-10°C), in subacute grade I and II lateral ankle sprains. Both interventions were applied for 15 minutes; with the contrast alternating hot/cold every minute. The authors advised that contrast therapy is more beneficial for reducing swelling in subacute grade I and II lateral ankle sprains and heat therapy offers greater pain relief initially.

Myrer et al. (2) indicated that contrast therapy using hot/cold packs was unable to produce significant physiological effects on intramuscular temperature 1cm below the subcutaneous fat following a 20-minute application. Yet, the authors reported a greater temperature gradient and heat removal, when using ice packs/hydrocollator packs compared to other studies using hydrotherapy.

Hing et al. (7) described the research available on the efficacy of contrast therapy in sports rehabilitation as lacking quality and quantity. Nineteen papers included in this review are subsequent to Hing et al. (32); three of these being systematic reviews and eighteen surrounding CWT. The majority of the studies in this review are on small sample sizes, and the majority based on a male population. This highlights that there is still a lack of research providing evidence on the efficacy and therapeutic effects of contrast therapy modalities. This also illustrates that a significant volume of the research on contrast therapy focusses on CWT and post-exercise recovery.

There remains a significant lack of research surrounding the efficacy of contrast therapy in regards to soft tissue injury management and the influence on physiological measures and performance. There is also a significant lack of research using alternative contrast modalities to CWT, which could be due to barriers such as accessibility/availability of other contrast therapy modalities/devices within sporting and clinical settings. The reviewed literature implies a consensus that CWT and CWI are the most effective water immersion recovery strategies. However, further work should aim to standardise an optimal CWT protocol for post-exercise recovery and explore whether contrast therapy could be a viable soft tissue injury treatment. Other contrast modalities should as hot/cold packs and thermal devices should also be considered.

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Declaration of interest statement

The authors report no conflicts of interest.

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