The Effects of Intermittent Pneumatic Compression on the Reduction of Exercise-Induced Muscle Damage in Endurance Athletes: A Critically Appraised Topic

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Clinical Scenario: Endurance sports require a great deal of physical training to perform well. Endurance training and racing stress the skeletal muscle, resulting in exercise-induced muscle damage (EIMD). Athletes attempt to aid their recovery in various ways, one of which is through compression. Dynamic compression consists of intermittent pneumatic compression (IPC) devices, such as the NormaTec Recovery System and Recovery Pump. **Clinical Question:** What are the effects of IPC on the reduction of EIMD in endurance athletes following prolonged exercise? **Summary of Key Findings:** The current literature was searched to identify the effects of IPC, and 3 studies were selected: 2 randomized controlled trials and 1 randomized cross-over study. Two studies investigated the effect of IPC on delayed onset muscle soreness and plasma creatine kinase in ultramarathoners. The other looked at the impact of IPC on delayed onset muscle soreness in marathoners, ultramarathoners, triathletes, and cyclists. All studies concluded IPC was not an effective means of improving the reduction of EIMD in endurance-trained athletes. **Clinical Bottom Line:** While IPC may provide short-term relief of delayed onset muscle soreness, this device does not provide continued relief from EIMD. **Strength of Recommendation:** In accordance with the Strength of Recommendation Taxonomy, the grade of B is recommended based on consistent evidence from 2 high-quality randomized controlled trials and 1 randomized cross-over study.

Keywords: delayed-onset muscle soreness, recovery, Recovery Pump, NormaTec

Clinical Scenario

Endurance sports, any single or multiple event distance 26.2 miles or longer, require extensive amounts of training to optimize performance, nutrition, and recovery. Exercise-induced muscle damage (EIMD), indicated by delayed onset muscle soreness (DOMS), occurs during long bouts of intensive exercise, such as endurance running or triathlon competition. Athletes attempt to speed their recovery following endurance events in various ways, one of which is through compression. Dynamic compression consists of intermittent pneumatic compression (IPC) devices, such as the NormaTec Recovery System and Recovery Pump. The use of IPC devices is becoming popular among endurance athletes despite the limited evidence to support whether IPC can aid athletes' recovery. Therefore, the purpose of this critically appraised topic (CAT) was to determine the effects of IPC on the reduction of EIMD in endurance athletes following prolonged exercise.

Focused Clinical Question

What are the effects of IPC on the reduction of EIMD in endurance athletes following prolonged exercise?

Search Strategy

Terms Used to Guide Search Strategy

Patient/Client group: endurance athletes or marathoner or ultra-marathon runner or triathletes

Intervention/Assessment: intermittent dynamic or pneumatic compression or dynamic compression

Comparison: none

Outcomes: reduction of EIMD or DOMS or muscle soreness

Sources of Evidence Searched

- CINAHL with full text
- MEDLINE
- EBSCO
- Additional resources obtained via review of reference lists and hand search

Inclusion Criteria

- Level 2 evidence or higher
- Studies that investigated intermittent dynamic or pneumatic compression and soreness following a running event
- Studies that investigated dynamic or pneumatic compression on recovery in athletes
- Studies that included marathon or longer distance runners or triathletes
- Studies that looked at the reduction of EIMD indicated by self-reported DOMS and plasma creatine kinase concentration
- Studies published in the last 5 years

Exclusion Criteria

- Studies that investigated the upper extremity
- Studies that investigated inducing DOMS by anaerobic methods
- Studies that did not include dynamic or IPC

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- Studies that did not include endurance runners or triathletes
- Studies that were not published in the English language

Evidence Quality Assessment

For this study, 8 articles were identified, and 3 met the inclusion criteria (Table 1). The level of evidence was assessed using the Levels of Evidence, Centre for Evidence-Based Medicine, 2011. In addition, each article was critically appraised with the Physiotherapy Evidence Database (PEDro) rating scale. The PEDro scale was selected because it is commonly used to assess the methodological quality of randomized controlled trials and other study designs that compare therapeutic interventions. Articles that scored at least 60% were classified as high-quality studies, and those that scored <60% were classified as low-quality studies.¹ All included studies were critically appraised independently by 2 reviewers (H.S. and K.A.). After an independent review, the 2 authors reviewed the completed appraisals and reached an agreement about the study quality. The highest possible score on the PEDro scale is 10. The Strength of Recommendation Taxonomy was used to assess the grade of evidence and provide a strength of recommendation.² Grade A evidence indicates that the recommendation is based on consistent, good-quality evidence.² Grade B evidence indicates that the recommendation is based on inconsistent or limited quality evidence.² Grade C evidence indicates the recommendation is based on consensus, usual practice, or expert opinion.²

Summary of Search, “Best Evidence” Appraised, and Key Findings

- The literature was searched to identify peer-reviewed articles that investigated the effects of IPC on soreness in runners.
- The search yielded a total of 8 possible studies. After critical review, 5 studies were excluded because they did not meet the inclusion criteria for this CAT.
- Three studies met the inclusion criteria.^{3–5} Two were randomized controlled trials, and 1 was a randomized cross-over study (Table 1). The characteristics of each study are shown in Table 2.
- Two studies^{3,4} involved 3 groups: an IPC group, a massage group, and a control group. The third study only involved an IPC group and a control group.⁵ All 3 studies found there were no statistically significant differences between groups in any subjective or functional recovery outcome in 1 to 7 days postintervention.^{3–5}

Results of Evidence Quality Assessment

Of the included studies, the critical appraisal scores were all 7/10, indicating all 3 studies were categorized as high-quality evidence.¹ None of the included studies described efforts to perform blinding of subjects, therapists, or assessors to reduce the potential for bias, decreasing their scores by 3 points each.

Clinical Bottom Line

The current evidence supports that IPC devices may provide only immediate pain relief from prolonged exercise-induced DOMS. However, the immediate pain relief from IPC was no more than what the massage interventions achieved,^{3,4} nor did pain relief continue over the 1- to 2-week recovery period.^{3,4} Therefore, the use of IPC for a single treatment following an endurance event is not effective for providing extended subjective pain relief or functional recovery from EIMD in endurance runners and triathletes. In accordance with the Strength of Recommendation Taxonomy, the grade of B is recommended based on consistent evidence from 2 high-quality randomized controlled trials and 1 randomized cross-over study.

Implications for Practice, Education, and Future Research

The purpose of this CAT was to determine the effects of IPC on the reduction of EIMD in endurance athletes following prolonged exercise. However, the results revealed there is no evidence that a single treatment of IPC provides extended subjective relief or functional recovery from EIMD in endurance runners and triathletes. For optimal athletic performance, athletes must recover fully between endurance races. Static compression is generally accepted as a beneficial form of recovery and is used frequently in the endurance athlete population. Dynamic compression is becoming popular in the endurance athlete population, but minimal research on its effectiveness is available. While some research suggests IPC may aid in recovery,^{6–8} all 3 of the studies appraised concluded IPC was not an effective intervention for the reduction of EIMD in the endurance athlete population.^{3–5} Although 2 of the appraised studies^{3,4} reported immediate relief of soreness, that relief was not extended in the subsequent days following the IPC intervention.

The studies appraised^{3–5} varied only slightly in their population and outcome measures. Two studies^{3,4} investigated the effect of IPC on ultramarathoners' subjective and functional recovery, indicated by lower body muscle pain and soreness, the overall muscle fatigue score, and plasma creatine kinase concentration. The other study⁵ included marathoners, ultramarathoners, cyclists, and triathletes and investigated the effects on DOMS ratings and C-reactive protein. The 2 studies investigating ultramarathoners were randomized control trials, had higher participant numbers, and compared IPC with a massage group, as well as a control group.^{3,4} The other study had a smaller population and used their participants as their own controls by doing 2 running trials.⁵

While all 3 studies used IPC as their primary intervention, the brand of compression device and parameters of use differed. Two articles used the Recovery Pump (Recovery Pump LLC, Concordville, PA) for a 20-minute session at 80 mm Hg of pressure immediately following an ultramarathon race.^{3,4} The other study⁵ used The NormaTec Recovery System (The NormaTec PULSE

Table 1 Summary of Study Designs of Articles Retrieved

Level of evidence	Study design/methodology of article retrieved	Number located	Study
2	Randomized controlled trial	2	Hoffman et al ⁴ Heapy et al ³
2	Randomized cross-over study	1	Draper et al ⁵

Table 2 Characteristics of Included Studies

	Heapy et al ³	Hoffman et al ⁴	Draper et al ⁵
Study design	Randomized control trial	Randomized control trial	Randomized crossover study
Participants	57 ultramarathoners competing in the 2016 Tarawera Ultramarathon. Inclusion criteria: (1) completed the race or withdrew after running >5 h and at least 39 km; (2) available postrace for treatment and follow-up 400-m runs; (3) signed written consent; (4) completed prerace questionnaire and initial data. Exclusion criteria: not reported. Of 1091 race entrants, 61 enrolled. Fifty-nine fulfilled the prerace requirements. Fifty-seven completed the study.	72 ultramarathoners competing in the 2015 Western States Endurance Run. Inclusion and exclusion criteria were not indicated. Of 388 race entries, 108 individuals enrolled. Seventy-three completed the race (74.5%) and were randomized (24 in control, 24 in IPC, and 25 in massage). One participant dropped out of the control group.	10 endurance-trained athletes (5 males, 5 females) who were marathoners, ultramarathoners, ironman triathletes, or college athletes. Inclusion criteria: completion of health risk factor screening questionnaire. Exclusion criteria: (1) history of musculoskeletal, cardiovascular, circulatory, or other health problems; (2) current bacterial or viral infections.
Intervention investigated	Following the race, participants were allocated to one of 3 groups. Arrival time, sex, and the race distances of 62.7 km, 87.4 km, and 102.8 km were balanced covariates. The IPC group used the Recovery Pump LLC for a 20-min treatment at 80 mm Hg of pressure. Participants received this treatment for the next 3 d. The MT group received a 25.12-min massage by one of 3 massage therapists after the race and for the next 3 d. Massage strokes were applied according to a pre-scripted protocol. The control group sat with legs extended for 20 min.	After the race, participants presented for data collection and group allocation. Participants were randomly assigned into one of 3 groups, with sex and finishing time as balanced covariates. Allocation was concealed until intervention. The IPC group used the Recovery Pump LLC for 20 min at 80 mm Hg of pressure. The massage group received a 20-min massage by one of 3 massage therapists following a prerecorded script. The control group rested supine for 20 min.	Participants performed two 20-mile runs spaced 3 to 4 wk apart. Participants were randomly assigned to the treatment or control run for their first run and the opposite group for their second run. The IPC group received 1 h of IPC using the NormaTec at 90 mm Hg to 100 mm Hg pressure. The control group received no intervention.
Outcome measures	1. Lower body muscle pain and soreness rating. 2. Overall muscle fatigue score. 3. Plasma CK. 4. 400-m timed run.	1. Lower body muscle pain and soreness rating. 2. Overall muscle fatigue score. 3. Plasma CK. 4. 400-m timed run.	1. CRP 2. Perceived pain rated on a scale of 0 to 10.
Main findings	Significant time effect for muscle pain and soreness rating ($P < .0001$). There was a significant difference immediately posttreatment for the muscle pain and soreness rating and overall muscular fatigue for IPC compared with control ($P < .05$). There was a significant difference immediately posttreatment for both subjective outcomes for massage compared with control ($P < .05$). No significant differences over 2 wk for any outcome measure.	No significant differences between groups, but there was a significant time effect ($P < .0001$). There was statistical significance for acute muscle pain and soreness rating ($P < .0001$) and muscular fatigue scores ($P < .00001$) between the massage and control group. There was statistical significance for acute overall muscular fatigue score between IPC and control ($P < .01$).	For CRP, there were no significant main effects for treatment group ($P = .48$) or between treatment and time ($P = .33$), but there was a main effect of time ($P < .01$). For perceived pain, there was no significant main effect for the treatment group ($P = .89$) or between intervention and time ($P = .72$), but there was a main effect for time ($P < .01$).
Level of evidence	2	2	2
Validity score	PEDro 7/10	PEDro 7/10	PEDro 7/10
Conclusion	While there was immediate subjective relief following IPC and massage, IPC did not significantly improve long-term functional or subjective recovery. There is no evidence that IPC or massage improves functional recovery or long-term subjective benefits.	While there was immediate subjective relief of muscle soreness and fatigue following IPC and massage, neither treatment provided extended relief or functional benefits of recovery.	While both CRP and perceived pain were higher on day 1 compared with the baseline, both decreased over 5 d regardless of intervention. IPC does not benefit recovery following prolonged running.

Abbreviations: CK, creatine kinase; CRP, C-reactive protein; IPC, intermittent pneumatic compression; MT, manual therapy; PEDro, Physiotherapy Evidence Database.

Recovery Systems, NormaTec, Watertown, MA). Draper et al⁵ used the IPC for 1 hour at 90 to 100 mm Hg following a 20-mile run.⁵

Both of the IPC devices investigated are commercially available. They are commonly used on an individual basis by endurance athletes, as well as in a clinic setting by athletic trainers and clinicians. Both IPC systems claim to improve recovery in athletes. While patient and athlete preference has its role in the selection of recovery methods, it is essential to educate clients on the evidence behind possible recovery devices. Given the much higher cost of IPC devices, it may be more practical for athletes to purchase static compression garments, such as sleeves or stockings, as the literature provides support of their efficacy, and the cost is lower.

Some limitations of this study need to be addressed. First, the studies appraised did not use consistent parameters of pneumatic pressure or duration of treatment when implementing the IPC devices. Investigating consistent parameters will help clinicians identify if there are certain parameters that are more effective for the recovery of EIMD. Second, the included studies did not utilize the same outcome measure. Future studies that investigate the recovery of EIMD with consistent treatment parameters and the same outcome measure will help answer this clinical question.

In conclusion, the literature does not yet support a single treatment of IPC as an effective intervention for providing extended relief of subjective pain or functional recovery from EIMD in endurance runners and triathletes. For this reason, clinical decisions must be made on a study-by-study basis until strong evidence is available in favor of IPC for improving recovery in endurance athletes. To better solidify the current knowledge, future research should address the existing evidence with a more consistent study design to further identify the efficacy of IPC use following endurance events. This CAT should be reassessed in 2 years to determine

whether additional evidence supports IPC as an effective intervention for the reduction of EIMD.

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