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The Effectiveness of Intermittent Pneumatic Compression for Delayed Onset Muscle Soreness in Active People: A Literature Review

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ABSTRACT

Introduction: When the exercises we perform exceed the muscle endurance threshold, Delayed Onset Muscle Soreness (DOMS) often occurs. DOMS is pain that a person feels 24 to 48 hours after strenuous physical activity or heavy and intense physical activity that can lead to damage to muscles and other connective tissues in the form of small tears in the muscles, muscle spasms, overstretching, and can cause tendon and connective tissue tears. Symptoms produced by DOMS conditions are certainly alarming for daily activities. This literature review will discuss ways to reduce DOMS conditions by using Intermittent Pneumatic Compression to overcome these conditions.

Methods: The method in this study used a literature review based on the study results of data sources (including PubMed, ScienceDirect, NCBI, and Google Scholar) database with a publication period from 2017 to 2022. Keywords used in the search: ["Delayed Onset Muscle Soreness," "DOMS" or "Muscle Soreness"] and ["Intermittent Pneumatic Compression" or "Recovery Pump"].

Results: We found three related articles: two randomized controlled trials and one cross-over design based on the search result. The studies examined the effectiveness of Intermittent Pneumatic Compression on Delayed Onset Muscle Soreness. In the results of the three studies, Intermittent Pneumatic Compression offered little to no benefit in the recovery of DOMS inactive people.

Conclusion: All studies concluded Intermittent Pneumatic Compression was not effective in reducing Delayed Onset Muscle Soreness.

Keywords: Delayed Onset Muscle Soreness, Intermittent Pneumatic Compression, Pain, Recovery Pump.

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INTRODUCTION

When the exercises we perform exceed the muscle endurance threshold, Delayed Onset Muscle Soreness (DOMS) often occurs. DOMS is pain that a person feels 24 to 48 hours after strenuous physical activity or heavy and intense physical activity that can lead to damage to muscles and other connective tissues in the form of small tears in the muscles, muscle spasms, overstretching, and can cause tendon and connective tissue tears.[1] The incidence of DOMS in run events was 66,7%, jump events were 100%, and throw events were 100%.[2] In other research, all respondents (100%) had experienced DOMS, which was felt after doing the exercise; half of the overall respondents (50%) experienced mild pain, and 47% experienced moderate pain after doing the exercises.[3]

After physical exercise, the accumulation or buildup of lactic acid production will cause local muscle fatigue. This is associated with the mechanism of energy synthesis in the form of Adenosine Triphosphate (ATP) when the muscles contract; fast-twitch-type muscles play a more significant role when a person performs high-intensity activities. Fast-twitch muscle fibers experience fatigue faster because this type of fiber has a low aerobic ability, so lactic acid formation occurs faster than slow-twitch muscle fibers.[4] Symptoms/signs of DOMS are Pain; pain is one of the main features of tissue injury and inflammation. The second is edema or swelling, often associated with acute inflammation. All reported an increase in limb volume at 24, 48, and 72 hours when performing eccentric movements of the muscles. The third is stiffness or decreased Range of Motion (ROM); there is a reduction in joint range of motion during periods of severe muscle pain. Restrictions on movement that occur when experiencing DOMS appear due to loss of muscle strength and swelling in the connective tissue. Fourth is a decrease in muscle strength; this loss of strength can be attributed to irritation in muscle fibers and their connective tissue.[5]

The process of DOMS begins when muscle tissue becomes damaged, then the body automatically responds by repairing the damaged tissue and stimulating sensory nerve endings, causing a perception of pain. The damage that occurs in DOMS is damage to the Z-disc portion of the myofilaments, which damages the connective tissue. This connective tissue damage causes soreness in a person after strenuous exercise, which then stimulates nociceptors or pain receptors, resulting in an increased sensation of pain in the body. The pain will increase when doing stretching movements and when palpated.[1] Several theories explain the mechanism of DOMS. The first theory is the inflammatory theory; the theory is based on discovering an inflammatory response, namely PGE2, which directly causes pain, then swelling will occur as a result of the movement of cells and fluids from the bloodstream to the surface and contribute to pain. The second theory is the theory of connective tissue injury, resulting from muscle contraction resulting in deep tissue damage and metabolism imbalance. The third theory is the theory of muscle injury; this theory is related to muscle fiber damage resulting from structural changes in muscle fibers caused by eccentric muscle contractions. Minor injury stimulates the flow of white blood cells to the damaged area in response to acute inflammation. It ends in releasing histamine and prostaglandins responsible for facilitating nociceptors causing pain.[5] Symptoms produced by DOMS conditions can last from several days to several weeks; the symptoms are alarming to daily activities and can limit the progression of training programs.[6]

To reduce DOMS symptoms, physiotherapists can use various interventions, including Intermittent Pneumatic Compression (IPC). The IPC device was a segmented compression device with a pump developed in the 1970s, they have evolved technologically to allow pressure gradients. The distal chamber has a higher pressure than in the proximal chamber, allowing a continuous sequential application pressure from the distal to the proximal.[7] IPC acts as a pneumatic massage that promotes circulation and easily relieves pain. According to the manufacturer, IPC's sequential pulse compression technology combines three distinctive massage techniques to accelerate the body's natural recovery process.[6] According to a previous study, IPC treatment can reduced the effect of DOMS after an anaerobic cycling test by lowering and reducing blood lactate levels dan reducing muscle tenderness and muscle stiffness in professional athletes from a variety of sports.[8-10] Although there is limited evidence that 810IPC can help athletes recover, IPC devices are gaining popularity among endurance athletes.To improve our evidence, this literature review will discuss the effectiveness of Intermittent Pneumatic Compression for reducing DOMS conditions.

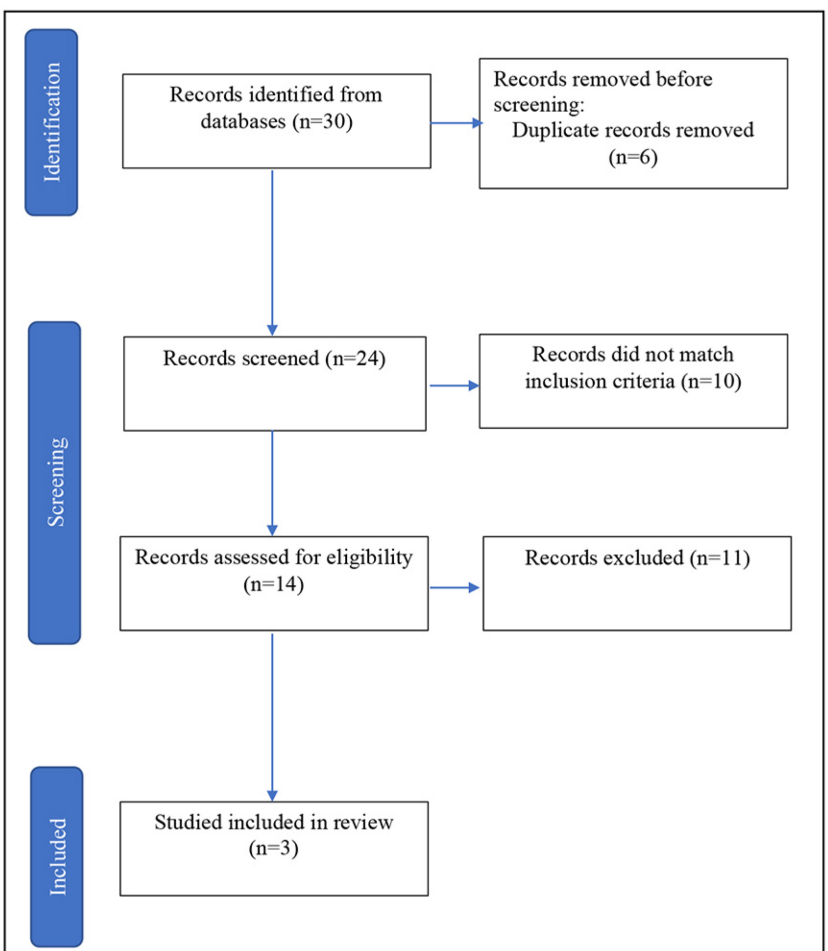

Figure 1. Flow Chart Diagram

METHODS

The method of this study used literature reviews, and sources of information obtained from research papers with a justifiable level of validity. Based on research results from data sources (including PubMed, ScienceDirect, NCBI, and Google Scholar) database, and relevant to support discussion explanation or analysis. Keywords used in the search: ["Delayed Onset Muscle Soreness", "DOMS" or "Muscle Soreness"] and ["Intermittent Pneumatic Compression" or "Recovery Pump"]. We only used text study following inclusion and exclusion criteria below:

Inclusion criteria: (1) published in English, (2) from 2017 to 2022, (3) with research design such as a randomized controlled trial, clinical trial, systemic review, experimental study, meta-analysis, observational studies, and case reports, (4) reported about Intermittent Pneumatic Compression or Recovery Pump, and (5) reported about Intermittent Pneumatic Compression or Recovery Pump for Delayed Onset Muscle Soreness.

Exclusion Criteria: (1) result and discussion of the study not reported, (2) dosage and how IPC treatment was done not reported, and (3) the study not about IPC for active people. The selected study was conducted in the flow chart below (**Figure 1**).

RESULTS

We obtained three studies related to the topic based on the search results: two randomized controlled trials and one cross-over design. The studies examined the effectiveness of IPC for reducing DOMS conditions. In the sample selection, Wiecha (2021) and Draper (2020) said that failure to obey the protocol or evaluation schedules and injuries during the trial were the exclusion criteria; samples were excluded from the study if the samples had a history of musculoskeletal, cardiovascular, circulatory, or any other health problems that would prevent them from finishing the protocol, but Heapy (2018) did not explain the exclusion criteria.[6,11,12] The summary of the studies can be seen in **Table 1**.

Wiecha (2021) found that no glaring distinction in recovery between groups after exercise-induced muscle damage in Intermittent Negative Pressure (INP) or IPC versus placebo in any measurement indicators of biochemical or functional measurement (strength, pain, or joint mobility). However, there was a significant time effect in the VAS score of muscle soreness, reduction in muscle strength, and range of active knee flexion. This research also observed peak Creatine Kinase (CK) levels after 24 hours and a slight decline afterward. Peak Lactate Dehydrogenase (LDH) levels were observed 1 hour after exercise, with a significant rise as soon as 1 hour after training.[11]

Draper (2020) compared the order effect of the first run against the second run, the results shown that no significant difference in any variables except for one of the pain ratings. as comparing the pain experienced immediately following the first run against the second run, runners shows that they feel more pain in the second run than the first run. But group analysis found no significantly differenced in C-reactive Protein (CRP) or pain among the treatment and control runs. The pain was significantly higher in post-run, day one, and day two when compared against baseline. No significantly differenced was found in pain if comparing baseline to days three, four, and five.[6]

According to Heapy (2018), compression-based manual therapy or IPC treatments produced some immediate subjective improvement in muscular tiredness, discomfort, and soreness following a prolonged running exertion. These advantages did not extend beyond the four-day treatment period, nor did they increase functional recovery as determined by 400-meter run time when compared to the control group. There was no group or interaction effect on muscle pain and soreness ratings, but there was a substantial time effect. Overall, there was no group effect and a significant time and interaction impact, but no pairwise differences were found in post-tests. In terms of the acute treatment effects, there were significant group effects for both subjective assessments. Over the course of the study, both MT and IPC produced more significant post-treatment improvements.[12]

DISCUSSION

Some IPC evaluation studies have yielded mixed outcomes. The treatment has been shown to improve performance, reduce edema and stiffness while not reducing strength loss, and improve muscular function recovery after fatigue. Even when used for three days in a row, it has no effect on a variety of performance assessments following acute eccentric exercise.[13-16] IPC treatment has also been proven to reduce blood lactate levels during anaerobic cycle testing, as well as muscle stiffness and discomfort in elite athletes from a variety of sports.[8-10]

The only component that had a meaningful impact on the recovery process was time. After muscle injury induced by exercise, most studies used a single compression session. As a result, we've opted to employ therapy multiple times to maximize its potential outcomes, which is vital in many therapeutic or competitive scenarios when quick recovery is required. The subjective sense of pain is a common complaint at DOMS, and it can range from minor to excruciating.16 VAS is higher 1–4 days after activity. The discomfort normally peaks on the second day and then gradually fades. The majority of previous study had no statistically significant findings, and there were no differences after using IPC.[6,17,18] Cranston (2020) discovered that IPC was more effective than a sham technique in reducing flexor and extensor discomfort in resistance-trained athletes immediately after IPC and 24 hours later.[19]

DOMS patients' range of motion has been restricted, probably as a result of non-contractile muscle tissue shortening and edema caused by an inflammatory reaction. Only a few research have looked at the impact of IPC or INP on ROM. After IPC, Winke (2018) reported an increase in elbow flexion range of motion.[20] Perfusion is improved and recovery is accelerated when mechanical pressure is applied. Improved perfusion aids in the removal of excess lactate but has little effect on anaerobic performance. After 1 hour, acute treatment of IPC dramatically increases PGC-1α gene expression (by 77%) in muscle tissue, resulting in improved neovascularization.[17]

LIMITATIONS

However, there are some limitations to these studies. First, the intervention time of all studies is too short to yield any significant benefits, given that a max of 30 min a day is only approximately 2% of the day. This period may be too short for any meaningful impact, if the improved perfusion only occurs during the procedure. Perhaps more frequent treatment instead of increasing the duration could improve muscle recovery's effectiveness after strenuous exercises. Second, the study does not control the diet, the type of fluid ingested during the run, nor the amount of carbohydrate consumed during the run and supplement, so this might have impacted the results. Finally, the sample size is relatively small. Having a larger group of participants will provide more substantial statistical power in future studies.[6,11,12]

CONCLUSIONS

In conclusion, to help athletes recover faster there are many devices used. Unfortunately, they did not work as advertised or had not received sufficient scientific research to support their claims. To help reduce the effects of DOMS and speed of recovery from exercise and sports efforts the coaches, athletic trainers, and athletes should seek scientific support for therapeutic interventions. All studies concluded that IPC was ineffective in lowering DOMS inactive people.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest.

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AUTHOR CONTRIBUTIONS

VNC collected, compiled the study design, and drafted the manuscript; NNMS reviewed and edited the manuscript.

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Table 1. Summary of The Reviewed Studies

Author	Type of Study and Sample Size	Objective and Outcome Measures	Protocol	Results
Wiecha, et al., 2021	RCT (45 healthy males were recruited: IPC (n=15), INP (n=15), Sham Microcurrent (n=15))	To evaluate whether IPC and INP alleviate the adverse muscle effects of eccentric exercise. S-Monovette clotting tubes to collected blood samples (6 ml). VAS was used to assess pain. Handheld 360° range–14 inch metal goniometer to evaluate knee joint's ROM. Isokinetic dynamometer to evaluate isokinetic muscle strength.	Participants performed (1) IPC or (2) INP or (3) sham microcurrent therapy (PT) for lower body (legs and pelvis) after eccentric exercises, after 24 and 48 h for 30 minutes duration. INP, program number 2 was used, the program consisted of 5 repetitions, 6 minutes stages. IPC group, the "sports massage" program was set, pressure was 80 mmHg, 10 treatment cycles, with 3 minutes duration. Microcurrent therapy was stimulated using the Sonicator Plus 940. Two current circuits were used (both lower extremities). Self-adhesive electrodes are placed on the quadriceps muscle. The device are not turning on for 30 minutes.	LDH: Pre-1 h and 24-48 h after the intervention, there were significant differences ($P < 0.05$). CK: substantial increase from baseline to 24 hours ($P < 0,001$) and 48 hours ($P < 0,001$), as well as a decrease from 24 to 48 hours ($P < 0,040$). VAS: substantial temporal effect increase in all groups after exercise ($P < 0.001$), Pre 1 hour ($P < 0.001$), pre 24 hours ($P < 0.001$), pre 48 hours ($P < 0.001$), and 1-24 hours ($P < 0.001$), 1-48 hours ($P < 0.001$), with no difference between 24 and 48 hours ($P < 0.996$). Pre 1 h ($P < 0.001$), pre 24 h ($P < 0.001$), and pre 48 h ($P < 0.001$), with no significant differences in ROM between 1 and 24 h ($P < 0.528$), 1-48 h ($P < 0.817$), and 24-48 h ($P < 0.964$). QPT: There was a significant drop pre-1 h ($P < 0,001$), pre 24 h ($P < 0,001$), and pre 48 h ($P < 0,001$), but no change in 1-24 h ($P < 0,335$), 1-48 h ($P < 0,785$), and 24-48 h ($P < 0,877$). H:Q ratio: Pre 24 h ($P < 0.001$), pre 48 h ($P < 0.001$), 1-24 h ($P < 0.001$), and 1-48 h ($P < 0.033$) showed substantial increases, but pre 1 h ($P < 0.166$) and 24-48 h ($P < 0.630$) showed no significant difference.
Draper, et al., 2020	A Cross Over Design (10 atheletes: No Treatment vs IPC Treatment)	To observe the effect of IPC in reducing CRP and DOMS after long distance running. Blood samples were obtained by venipuncture of the antecubital vein using a collection tube (3.5 mL). The Management of Cancer Pain Scale test was use to asses the perception of pain.	All treatment participants received the same IPC for one hour at the intensity setting of 10 (90 mmHg for cell 1 and 5 and 100 mmHg for cell 2-4) with a compression time of 30 seconds and simultaneously, the intensity setting is 10. In the control runs, the participants received no treatment.	CRP: no difference between pre- and post-run, but a substantial increase on day one ($p = 0.04$, $d = 0.9$), but no difference on days two ($p = 0.28$), three ($p = 0.99$), four ($p = 1.0$), and five ($p = 1.0$). When comparing pre-run to post-run ($p < 0.01$, $d = 1.1$), day one ($p = 0.002$, $d = 0.8$), and day two ($p = 0.02$, $d = 0.4$), there was a significant increase in pain. When comparing pre-run to days three ($p = 0.23$), four ($p = 0.72$), and five ($p = 1.0$), there was no difference.

Heapy, et al., 2018	RCT (57 ultramarathoners competing in the 2016 Tarawera Ultramarathon: IPC Group (n=18), Control Group (n=19) and Massage Group (n=19))	To evaluate the efficacy of 4 daily post-race treatments of a specific MT and IPC protocol versus supine rest during recovery from a ultramarathon.	MT: effleurage strokes massage with balm was used with the manual therapy protocol. Each MT intervention was 25.12 min.	There was no group ($p = 0.3$) or interaction ($p = 0.1$) influence on muscle pain and soreness ratings, but there was a substantial (p 0.0001) time effect.
		10-point scale with anchor used to rate pain and soreness in lower body muscles.	IPC: Participants were seated with their legs extended on a treatment table for 20 minutes, full length pneumatic boots were placed on both legs, and the pump was programmed to deliver up to 80 mmHg of compression.	Overall, there was no group effect ($p = 0.5$) and a significant time ($p < 0.0001$) and interaction ($p = 0.008$) effect, but no pairwise differences were found in post-tests.
		13 cm visual analogue scale with anchors used to measure overall muscle fatigue.	The four circumferential chambers are inflated for about 8-10 seconds.	Improvement in muscle pain and soreness rating had no significant time ($p = 0.7$) or interaction ($p = 0.9$) effects.
			Control group: sit on the treatment table for 20 minutes with legs extended.	Overall, there was no time ($p = 0.2$) or interaction ($p = 0.3$) effects on muscle tiredness, but there was a significant ($p = 0.03$) time effect when the control group was excluded from the analysis.

IPC: Intermittent Pneumatic Compression; INP: Intermittent Negative Compression; VAS: Visual Analog Scale; ROM: Range of Motion; CK: Creatine Kinase; QPT: Quadriceps Peak Torque; H:Q Ratio: Hamstring : Quadriceps Ratio; CRP: C-reactive Protein; MT: Manual Therapy.