

Cryotherapy and Intermittent Pneumatic Compression for Soft Tissue Trauma

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SOFT TISSUE trauma initiates an inflammatory response that increases the local tissue temperature. Characteristics of inflammation include increased blood flow, edema accumulation, and passage of leukocytes into the tissue spaces. Leukocytes play a central

role in removal of infectious agents and tissue debris, but they can also be responsible for cellular injury and necrosis.¹ Protection, rest, ice, compression, and elevation (PRICE) therapy is a widely-accepted approach to treatment of soft tissue trauma, which modifies the inflammatory response. Research findings have con-

firmed the benefits of cryotherapy and static external compression, but the use of intermittent pneumatic compression (IPC) is a relatively new treatment for soft tissue trauma. This report discusses the potential value of combining cryotherapy with IPC for facilitation of the healing process.

Cryotherapy

Cryotherapy has long been recognized as a beneficial posttrauma treatment modality,

which provides a short-term analgesic effect, reduces metabolic activity, and decreases cellular oxygen demand (Table 1).²⁻¹¹ A marked reduction in local metabolic enzymatic activity and a profound local vasoconstriction occur in response to cold application. The analgesic effect of cryotherapy has been attributed to a combination of decreased production of pain mediators and slower propagation of neural pain signals.¹² Metabolism may be decreased by more than 50%, which facilitates oxygen diffusion into the injured tissues. Joint range of motion is improved through suppression of excitatory muscle spindle afference.¹²

Leukocytes play a central role in the inflammatory response to soft tissue injury. The application of cryotherapy has been found to decrease the number leukocytes that adhere to the endothelial surface of a capillary, which results in less leukocyte migration into the tissues.¹³ In vivo research findings suggest that cryotherapy reduces posttrauma endothelial dysfunction, which ultimately reduces the intensity of the inflammatory response.^{8,9}

Intermittent Pneumatic Compression

The utilization of IPC has been shown to be effective for prevention of edema formation, increasing blood flow, and stimulation of

KEY POINTS

- ▶ Cryotherapy and compression modify the inflammatory response to soft tissue injury.
- ▶ The therapeutic benefits of cryotherapy are enhanced by the simultaneous application of compression.
- ▶ Intermittent pneumatic compression provides therapeutic benefit that differs from that provided by static compression.

TABLE 1. THEORIZED EFFECTS OF CRYOTHERAPY ON SOFT TISSUE INJURY^{5,7-9}

- Reduces progression of microvascular injury
- Reduces leukocyte-mediated tissue damage
- Reduces secondary hypoxic tissue damage
- Reduces inflammatory symptoms
- Reduces the action of inflammatory mediators
- Reduces hemorrhage
- Helps to restore normal capillary function

tissue healing.^{4,9,14} Although static compression is an effective therapy for edema reduction, the intermittent compression optimizes lymphatic drainage.^{15,16} IPC can accelerate recovery from either intense exertion or injury, especially when the athlete is incapable of generating rhythmic muscle contractions. Improved lymphatic function accelerates healing through removal of edema from injured soft tissues.¹⁵⁻¹⁹

Lymphatic System Function

Edema is caused by protein leakage from capillaries that become hyperpermeable as a result of the action of inflammatory mediators on endothelial cells. Edema causes tissue congestion that reduces the availability of oxygen to the mitochondria, thus decreasing the availability of energy for operation of the sodium-potassium pump. The osmotic effect produced by failure of the sodium-potassium pump causes the fluid volume of the cell to increase, which damages its cytoskeleton and produces fragmentation of DNA within the cell nucleus. Reliance on anaerobic glycolysis for energy production decreases the pH of the intracellular environment, which ultimately creates clumping of nuclear chromatin. Restoration of normal lymphatic flow is essential for the healing process to progress from the acute stage to the repair stage. If lymphatic flow is optimized in injured tissues, normal metabolic processes can be restored sooner (Table 2).

The accumulation of protein-rich edema within the interstitial space can lead to the development of scar tissue, which is less elastic than normal collagenous tissue.¹⁹ IPC has been shown to be effective in reducing post-traumatic edema.¹⁹ The reduction of edema within injured tissues has been shown to improve

TABLE 2. FACTORS THAT MAXIMIZE LYMPHATIC FLOW¹⁷

- Contraction of surrounding muscles
- Movement of the extremities
- Pulsations of arteries that are adjacent to lymphatic vessels
- External compression of soft tissues

oxygen delivery.¹⁸ McGeown et al.^{15,16} concluded that lymphatic flow was directly proportional to the magnitude of intermittent compression and that pressure as low as 20 mmHg was effective in increasing lymphatic drainage.

Enhanced Blood Flow

IPC has also been shown to enhance the blood flow of the treated area through stimulation of endothelial cell production of nitric oxide. IPC increases the velocity of blood flow and creates shear stress on the walls of blood vessels, which is the probable physiologic mechanism for enhanced nitric oxide production.³ Increased nitric oxide production also inhibits platelet aggregation and neutrophil adherence, both of which play important roles in the creation of secondary hypoxic injury. Nitric oxide is also a neurotransmitter that can influence vascular tone, thereby increasing blood flow.

Tissue Healing

IPC appears to provide a therapeutic effect that enhances connective tissue healing.¹⁴ Cyclic application of external pressure results in increased arterial blood flow, decreased venous pressure, and reduced venous stasis.¹⁴ Intermittent compression has been shown to increase the ingrowth of neurovascular tissue within an Achilles tendon rupture in a rat model.¹⁴ Metabolic changes in injured tissue that reduce inflammation, limit oxidative tissue damage, restore normal osmotic balance, and restore normal capillary blood flow are also achieved through IPC.

Cryotherapy With Static Compression

The separate benefits of cryotherapy and external compression appear to be amplified when the two therapeutic modalities are used in combination.

External compression helps to restore normal physiologic processes within damaged tissue and it increases the depth of temperature reduction achieved by the application of cold to the body surface.^{1,20-24} Both the rate and magnitude of tissue cooling are increased by combined therapy, as compared to the effect of cold application without compression.²⁵ A greater magnitude of compression is associated with a shorter amount of time for a given level of tissue temperature reduction.⁵

Conclusion

The literature contains evidence that the inflammatory response in injured soft tissue is modified in a manner that promotes healing through the combined application of cryotherapy and compression. The therapeutic effect of cryotherapy is enhanced by the use of either static external compression or intermittent pneumatic compression. Further research is needed to compare the different modes of compression application in conjunction with cryotherapy. ■

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