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A COMPARISON OF THE EFFICIACY OF THREE DIFFERENT CRYOTHERAPY TREATMENTS USED IN THE ATHLETIC RECOVERY OF SPORTSPEOPLE – LITERATURE REVIEW

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Abstract

It has been assumed that cryotherapy treatments improve athletic recovery and prevent the negative effects of strain caused by training. Body response to low temperatures is reflected in many changes in the hormonal, blood, nervous and immune systems, which may significantly influence tissue regeneration mechanisms. The use of ice or other forms of local cooling is a popular method for the treatment of sports-related injuries. This method is widely used by athletes and allows for fast return to sports activities shortly after injury.

The purpose of this paper was to compare the literature reports on three different cryotherapy treatments (ice massage, whole-body cryotherapy, and cold water immersion) and to demonstrate the efficacy of these methods in the athletic recovery.

Key words: *ice massage, cold water immersion, whole body cryotherapy, athletes*

Introduction

The concept of cryotherapy was developed in the 1970s by Toshiro Yamauchi, a Japanese scientist who, together with his team, constructed the first cryogenic chamber in 1978. The Polish school of cryotherapy was established in Wrocław in 1983, at the Department of Physiotherapy, Academy of Physical Education, managed by Professor Zdzisław Zagrobelny. The first cryoapplicator was installed there, and it was used to provide cryotherapy treatments to patients with rheumatoid disease and post-traumatic injuries. In 1989 the first cryogenic chamber in Poland, and the third in the world, was constructed and put into use in Kamienna Góra [1].

It has been assumed that cryotherapy treatments improve athletic recovery and prevent the negative effects of strain caused by training [2]. Body response to low temperatures is reflected in positive changes in the hormonal, blood, nervous and immune systems, which may significantly influence tissue regeneration mechanisms [3]. The use of ice or other forms of local cooling is a popular method for the treatment of sports-related injuries. This method is widely used by athletes and allows for fast return to sports activities shortly after injury [4].

The purpose of this paper was to compare the literature reports on three different cryotherapy treatments (ice massage, whole-body cryotherapy, and cold water immersion) and to demonstrate the efficacy of these methods in the athletic recovery of sportspeople.

Ice packs and ice massage

In their research carried out on 24 healthy men aged 18-24 years Richendollar et al. [5] found that the application of ice bags on the anterior thigh 20 minutes before warming-up (incorporating a 3 minute jog, 3 minute stretching and 10 double-legged vertical jumps) had negative effects on maximum performance during 3 functional tests, which included: single-leg vertical jump, shuttle run, and 40m sprint. They also found that active warm-up and time necessary to increase muscle temperature after the application of the ice bag can reduce the negative effects of muscle cooling. The researchers also recommend warming-up before the return to activity after the application of ice packs on large muscle groups.

On the other hand, Howatson et al. [6] examined 12 male volunteers who performed damaging exercises. The protocol consisted of 10 maximal eccentric repetitions of the elbow flexors using isokinetic dyna-

mometry. Subjects received ice massage immediately post-exercise, and 24 and 48h post-exercise. Muscle function (maximal isometric, slow and fast isokinetic contractions), creatine kinase, myoglobin, muscle soreness, limb girth and range of motion were measured pre, immediately post, 24, 48, 72 and 96 h post-exercise. Ice massage was found to be ineffective in reducing the indirect markers associated with exercise-induced muscle damage and enhancing recovery of muscle function in male exercisers unaccustomed to eccentric-biased exercise.

Verducci [7] reported that interval cryotherapy applied to athletes (10 volunteers, members of an athletic club) who weight lift is associated with increased work, velocity, and power. Local cryotherapy (bags filled with ice cubes) was applied for 3 minutes on the arms and shoulders during one day. Ice bags were applied after each of 3 sets of exercises. Researchers found that the athletes' velocity was significantly faster for the first to the fourth sets, matched sets, and all sets when subjects received cryotherapy. Power was also significantly greater when subjects received cryotherapy.

Herrera et al. [8] found that ice massage, ice packs, and cold water immersion were effective in reducing skin temperature and changing sensory conduction at a physiological level that is sufficient to induce hypoalgesic effects. However, cold water immersion was the most effective modality in changing nerve conduction parameters. The study was carried out on 36 healthy subjects. Each subject received 1 of the 3 modalities (ice massage, ice pack, cold water immersion) applied for 15 minutes. Skin temperature and nerve conduction parameters were measured before and immediately after cooling. In another study Herrera et al. [9] also confirmed cold water immersion as the most effective modality for maintaining reduced sensory nerve conduction after cooling.

A different study, carried out by Isabell et al. [10] on a group of 22 healthy men, demonstrated that ice massage was not effective in significantly reducing the symptoms of delayed onset muscle soreness (DOMS). Subjects performed up to 300 concentric or eccentric contractions of the elbow flexors to induce muscle soreness. The researchers suggested that the use of ice in the treatment of DOMS may be contraindicated. However, ice massage resulted in faster muscle cooling than the ice pack [11].

Merrick et al. [12] suggested that the use of ice packs combined with compression wraps is more effective in cooling tissues. They concluded that ice combined with compression should be more effective than ice alone in reducing the metabolism of injured tissues.

Another study evaluated the effect of ice pack application following brief sprint-interval training in 12 junior handball players. Analysis of blood samples demonstrated that local ice therapy was associated with many changes, such as: significant reduction in the level of proinflammatory interleukin IL-1β, and anti- inflammatory interleukin receptor 1 (IL-1ra). The researchers also found reduction in the level of anabolic insulin-like growth factor (IGF) and IGF-binding protein-3 (IGFBP-3), and a significant increase in the level of a catabolic marker - IGF-binding protein-1 (IGFBP-1) during recovery after exercise. Nemet et al. concluded that the use of ice packs can reduce the anabolic effect of previous training and have a negative influence on athletic performance [13].

Oakley et al. [14] investigated 33 subjects who performed repeated isokinetic eccentric contractions of the right hamstring muscle group. Ice packs were applied to 23 subjects, and 10 other subjects were the control group who received no treatment. Ice packs were applied 3 times a day for 20 minutes immediately after exercise, and then up to 72 hours after exercise. The cryotherapy group had lower creatine kinase (CK) and aspartate aminotransferase (AST) levels at 72 hours after exercise compared to the control group.

Whole-body cryotherapy

Hausswirth et al. [15] found that three sessions of whole body cryotherapy performed within 48 hours after damaging exercise had no effect on plasma levels of creatine kinase (CK). Also, it seems that repeated whole-body cryotherapy (from 5 to 10 sessions) is required to stimulate recovery from muscle fibre damage induced by physical exercise. When the efficacy of three different modalities for athletic recovery were compared (cryotherapy, far infrared, passive recovery), whole-body cryotherapy was found to provide the best effects in the regeneration of muscles after eccentric work.

Whole-body cryotherapy applied immediately after exercise also accelerates athletic recovery in athletes. This conclusion was reached by Pournot et al. [16], who investigated the effects of whole-body cryotherapy (at -110°C, for 3 minutes) in professional runners. Multi-exposure to cryostimulation can accelerate body recovery by inhibiting the acute inflammatory process. A single session of cryotherapy increases the activity of anti-inflammatory IL-1ra, limiting the inflammatory response by reducing the levels of interleukin IL-1β and C-reactive protein (CRP).

Other researchers found that 23 cryotherapy sessions performed in a group of 6 professional rowers resulted in better circulatory and metabolic tolerance to physical work and delayed the onset of fatigue during exercising. This results from reduced systolic frequency and lactate levels in the blood during gradual exercise. Cryotherapy can also significantly reduce

stress reactions to progressive physical work caused by decreased hormonal response after applied treatments. However, no changes were found in rest levels of growth hormone, testosterone or cortisol [17].

Repeated cryotherapy sessions applied between physical exercise also reduce the levels of creatine kinase (CK), lactate dehydrogenase (LDH) and synthesis of pro-inflammatory cytokines (IL-2, IL-8), at the same time increasing the level of circulating pro-inflammatory cytokines (IL-10), and improving recovery from muscle injury induced by damaging exercise [18].

Whole-body exposure to cryogenic temperatures has positive effects on the lipid profile in healthy subjects. Cryotherapy results in the increase of HDL cholesterol and decrease of LDL cholesterol and triglyceride levels. Therefore, systemic cryostimulation seems to be useful in preventing hyperlipidaemia. Lubkowska et al. suggest that a minimum of 10 one-day sessions are required to achieve positive effects, with 20 sessions as the optimum number [19].

Cold water immersion

Bailey et al. [20] applied cold water immersion to subjects with exercise-induced muscle injury who had increased plasma levels of myoglobin and creatine kinase (CK). Twenty healthy men were included in the study (10 subjects were assigned to the control group and 10 to receive cryotherapy). All subjects completed a 90-min intermittent shuttle run. After exercise participants received cold water immersion of the legs (temperature: 10°C, time: 10 minutes). Cryotherapy administered immediately after exercise was found to reduce muscle soreness at 1, 24, and 48 h after exercise. However, cold water immersion had no effect on creatine kinase response, but reduced myoglobin plasma level 1 h after exercise. The results suggest that cold water immersion immediately after exercise can be effective in eliminating the symptoms of exercise-induced muscle damage.

Cold water immersion can also improve antioxidative protection. Siems et al. [21] examined a group of 36 volunteers who took a cold water bath (temperature 1-4°C) for 5-10 minutes. The researchers suggest that the improvement in the antioxidative defence system results from the higher baseline glutathione level (GSH) and increased activities of erythrocytic superoxide dismutase (SOD) and catalase (Cat) in winter swimmers.

Other studies demonstrated that post-exercise cold water immersion resulted in reduced CK and LDH levels, hypoalgesia (measured by the Visual Analogue Scale, VAS), lower body temperature and greater preservation of isometric strength endurance of the upper extremities. Nine jiu-jitsu fighters were subjected to two 90-minute training sessions. After the first session

Table 1. *Comparison of the efficacy of selected cryotherapeutic modalities used in athletic recovery*

Ice massage/ ice packs	Cold water immersion	Whole-body cryotherapy
Ice massage: – used before warm-up has a negative effect on athletic performance; – ineffective in reducing the levels of indirect markers reflecting muscle damage and symptoms of DOMS. **Ice packs:** – cause significant increase in work, velocity and power (used for 3 minutes post-exercise); – combined with compression improve the efficacy of ice in tissue cooling; – reduce the activity of interleukin IL-1, IL-1ra receptor, insulin-like growth factor (IGF) and binding protein 3 (IGFBP-3); – increase the level of binding protein 1 (IGFBP-1); – reduce the level of creatine kinase (CK) and aspartate aminotransferase (AST).	– reduces exercise-induced muscle soreness; – reduces the myoglobin level;- increases glutathione level (GSH) and increases the activity of erythrocytic superoxide dismutase (SOD) and catalase (Cat); – reduces CK and LDH levels; – has no effect on the activity of creatine kinase (CK), muscle soreness and maximal voluntary contraction (MVC); – does not enhance recovery after damaging exercise.	– accelerates muscle regeneration after eccentric work; – increases the levels of IL- 1ra antagonist, decreases levels of interleukin IL-1β and C-reactive protein CRP; – improves circulatory and metabolic tolerance to physical work; – delays the onset of fatigue during exercise; – reduces the levels of creatine kinase (CK), lactate dehydrogenase (LDH) and synthesis of pro-inflammatory cytokines (IL-2, IL-8); – increases the level of circulating pro--inflammatory cytokines (IL-10); – increases HDL cholesterol level and reduces the levels of LDL cholesterol and triglycerides.

5 subjects were immersed in a pool with ice (5±1°C) for 19 minutes, and the remaining fighters were allocated to the control group [25].

In contrast to these results Goodall and Howatson [22] concluded that cold water immersions are not efficient in muscle regeneration following eccentric exercise. In the study 18 volunteers experienced 12-minute immersions in water (15°C) immediately post-exercise. Cryotherapy was repeated for the following 3 days. No changes were observed in the values of the tested parameters, i.e. creatine kinase activity (CK), muscle soreness or maximal voluntary contraction (MVC). The researchers suggested that cold water immersion, despite being a popular modality for athletic recovery, should be used with care by athletes and coaches [23].

Similar conclusions were drawn by Jakeman et al. [24], who investigated the influence of cold water immersion on recovery after exercise-induced muscle damage. Eighteen female subjects were given a single 10-minute cold water immersion at 10°C following damage-inducing exercise (10 sets of 10 counter-movement jumps). It was found that a single cryotherapy treatment had no effect on indicators of muscle damage (muscle soreness, CK, MVC), and therefore has no beneficial effect on recovery from exercise-induced muscle damage.

Summarizing, the analysed scientific reports present inconclusive results on the efficacy of the above-listed cryotherapeutic treatments used in athletic recovery. The efficacy of three cryotherapy treatments (ice massage, cold water immersion, and whole-body cryotherapy) is compared in Table 1.

Further well-designed controlled studies on the effects of cryotherapy on the human body are necessary because of the growing interest and improved availability of cryotherapy treatments. In particular, researchers should focus their investigations on cryotherapy modalities providing the most beneficial effects, and should specify such parameters as treatment duration, temperature range and number of treatment sessions.

Declaration of interest

The author reports no conflicts of interest.

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