

COLD WATER IMMERSION AS A POST-EXERCISE RECOVERY STRATEGY

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Abstract

The demands of professional sport are growing rapidly, as well as the work load at practice. Applying the right way of physical therapy in a right moment and correctly specified time is a significant problem for coaches and athletes in many sports. To shorten the recovery time between practices or competitions, new ways of post-practice recovery techniques are being researched. One of them is the ice bath therapy and its beneficial effect on muscles changes induced by physical effort. Used after hard workouts or competitions, it is supposed to: support recovery, decrease the muscle pain and shorten the time for body to go back to the state before workouts. This review tries to summarize the findings of international research, as well as tries to explain the different results of those findings. This article reviews research, that shows positive impact of cold water immersion on post-exercise recovery.

Key words: *cryotherapy, exercise-induced muscle damage, post-exercise recovery strategy, ice bath, cold water immersion*

Introduction

Adequate proportions between the work load at practice and the recovery are main factors in achieving high level sport performances. By increasing the work load at practice, the recovery time also increases. Athletes and coaches very often don't devote enough time for recovery and rest, which makes the athletes tired for next workout or competitions. Preparations for the most important competitions require more intensive stimulus, few times a week, which exposes the body to training overload. By doing another hard workout, without a proper recovery, may lead to problems with getting into shape for targeted competition, or may cause serious injuries. During high level competitions, the athletes take part in many tournaments, games in a short time period. They compete many times to get to the final through rounds. Because of the fatigue accumulation in body, scientists, coaches and athletes are trying to find a new ways of post workout regeneration, which will shorten the recovery time between practices or competitions. One of the methods is the ice bath (CWI – cold water immersion), is becoming more popular and has been used during many international competitions, such as: Track & Field competitions, European and World Championships, Olympic games [1]. Applied after hard training or competitions, CWI is supposed to support recovery, reduce muscle soreness, and help the body to return to its state before exercise [2].

Cryotherapy has been shown to reduce cell necrosis, oedema and neutrophil migration, as well as

slow cell metabolism and nerve conduction velocity, which in turn reduces secondary muscle damage [3-5]. However, despite evidence for cryotherapy to lessen the inflammatory response, the effect of cryotherapy on muscle soreness and strength following eccentric exercise is unclear. Effects of immersion in ice water for post-exertion, delayed muscle soreness due to the divergence of results remains unclear [3,4]. This article attempts to summarize reports from foreign literature on immersion in ice water and an explanation of the ambiguity of the test results. The aim of this study was to review and summarize studies showing the positive effect of immersion in ice water on post workout recovery.

The formation of pain in muscles

After a hard workout, athletes feel muscle pain, which is the delayed onset muscle soreness (DOMS). These are the microdamages done to muscle fibers that cause pain, stiffness and tightness. These damages can feel like light muscle soreness, gone within hours, or can continue for several days, usually 5–7 with much more significant soreness and a reduction in joint range of motion. The microdamages are caused by high intensity workouts with many eccentric contractions [6-8]. DOMS usually forms during a hard workout that the body is not used to and not adopted to. The muscle movements have to be intense and with great force [6].

The muscle pain is caused by lactic acid buildup, local ischemia, higher muscle tightness, damages to

connective tissue and muscle inflammation. DOMS can be a significant obstacle in training through swelling, reduction in joint range of motion, and reduction in peak torque. Starting another hard workout, while experiencing the delayed onset muscle soreness can cause negative changes in ligaments and tendons, which can lead to injury eliminating the athlete from practice [7,8].

Immersion in cold water – impact, application

Immersion in cold water causes a number of physiological processes in the body: the movement of fluids within the blood and cells, decreasing in swelling, increase the capacity of cardiac output without increasing its energy cost, increase blood flow to the tissues for better nutrition and more efficient transport of waste products appears [3]. Meeusen i Lievens [9] suggested that an immersion of a limb in water baths of temperature between 42°C and 14°C for 15 minutes the blood flow is decreased, but in the water temperature below 10°C the blood flow in limb increases. 15min immersion at a temperature of 15°C will lower intramuscular temperature by ~10°C and potentially have a beneficial effect. Better blood flow through the body improves the drainage of waste products and improves the supply of oxygen and nutrients to the muscles [4].

On the body immersed in the water works the compression strength of the water causing movement of fluids. While body is immersed in the water up to the hips level, the fluids are “escaping” from the lower limbs to the chest region. Because of that phenomenon, the by-products of metabolism can escape from the muscles faster and improve post-workout recovery process [3]. Hard vessels should be used for the ice-

baths, like the clay pots used in Track & Field World Championships in Deagu in 2011 (Fig.1).

Body in that kind of vessel, is affected better by the hydrostatic pressure of water. It was observed that with increasing depth of water, the stress of water on the body increases: on the depth of 1 meter the pressure is 981Pa, and on the depth of 0,1 meter the pressure is only 98,1Pa. The pressure difference causes fluid movement from the legs to the chest region. Since our bodies are composed mostly of water, which is not compressed, when the external pressure increases the gases and liquids in our bodies move to the area of lower pressure. As a result of centralization of circulation, fluids from the intercellular space pass into the blood, and further along with the venous return to the upper body. It is possible that in this journey also participate liquid waste products, which speeds up the transport of metabolites, thus regeneration after training, and return of the body to homeostasis [3,4,10].

Body immersed in the water is less affected by gravity. Skeletal-muscular system is relieved. This phenomenon, combined with a slowdown muscle-nervous conduction, are considered as main factors contributing to the feeling of less fatigue muscles after immersion in ice water [3,4].

The influence of cryotherapy on post workout muscle inflammation

Post-workout muscle fibers micro trauma initiates immune responses. This leads to local inflammation, which initiates tissue healing [2]. Pournot and others [1] are using the cryotherapy with a lower temperature than the temperature used in ice-baths. Based on their results, they assume that using the cryotherapy



Fig.1. Clay pots used in Track & Field World Championships in Deagu in 2011

(-110°C) will speed up the post workout recovery by limiting the inflammation. The authors think that shortening and reducing the period of acute inflammation, protects the body against excessive immune response, which then shortens the recovery time after workouts [1,2]. Excessive inflammation caused by the muscle fibers micro trauma can lead to lack of muscle recovery on time, tissue damage and dysfunction leading to affect athletic performance [11].

The influence of cryotherapy on post workout muscle pain and stiffness

Edema occurs as a result of acute inflammation induced by muscle fibers micro trauma. After that, the vascular permeability increases, this in combination with the extracellular concentration of proteins and congestion gives the swelling. Increase of water in the extracellular space due to edema causes pressure on pain receptors. Eston and Peaters [5] observed that with increasing swelling of muscle, the muscle pain also increases. According to the authors, the increased muscle soreness and swelling may contribute to post-workout tissue stiffness.

Immersion in cold water also influences the nervous system. Cooling inhibits conduction of pain [3]. Decrease of the temperature of superficial tissues of the lower limbs causes a reduction of nerve conduction due to decreased production of acetylcholine. Immersion in ice bath also affects the reduction of muscle spindle activity. Reduced activity of muscle spindle inhibits the response to stretching, which results in less muscle spasticity. The mentioned above mechanisms reduce the vicious cycle of pain and tension, which likely causes the decrease in muscle soreness [3,5]. However, according to Hjortskov and others [12] increase in the parasympathetic system activity and decrease in sympathetic system activity is responsible for the analgesic effect of immersion in ice water.

Based on the results in Table 1, we can assume that immersion in cold water reduces muscle soreness [10,13], pain [2,5,10,13-15] and stiffness [5,10]. In control groups, which were resting in a passive way or using other ways of recovery, there was an increase in muscle soreness [10,13], pain [10,13] and stiffness [5,10].

Table 1. *Studies showing the positive effect of immersion in ice water on post workout recovery*

Author	Test group	Exertion	Recovery methods	Test methods	More important results
Ascensao et al. 2011	20 soccer players	Soccer match	1gr. 10min., 10°C, to iliac crest 2gr. 10min., 35°C, to iliac crest	(CK, Mb, CRP, jump, sprint, MIVC quadriceps, muscle soreness) before, after, 24h, 48h after the game	Gr. CWI: ↓muscle soreness, faster recovery of strength, lower increase in CK activity, ↓Mb concentration, ↓CRP
Eston i Peaters 1999	15 male	Eccentric elbow flexor work on a dynamometer	Control gr., group CWI 15min., 15°C forearm	Muscle tension, CK, relaxed arm angle, MIVC, swelling, for three days	↑relaxed arm angle, lower increase in CK
Ingram et al. 2009	11 male, 3-day testing trials	Shuttle run test, 80min. simulated team sports exercises	CWT gr., CWI gr. 10°C to umbilicus, 2x5min. break 2,5 min., Control gr.	(MIVC, sprint test, muscle soreness, CK, CRP) before, after and for 2 days	Gr. CWI: ↓muscle soreness ↓decrease in strength ↑increase in sprint performances, ↓increase in CK and CRP activity
Montgomery et al. 2008	29 male basketball players	3-day long basketball tournament – 3 games	1st gr. Stretching and carbs 2nd gr. CWI 5x1min. up to neck 11°C break 2min. 3rd gr. full leg compression garments	Lower leg girth, muscle soreness, vertical jump, sit-and-reach test, 20m. acceleration	↓decrease in speed, flexibility, and jump performances, ↓muscle soreness and swelling
Pournot et al. 2011	11 endurance trained males	45min. running uphill	1st group 3min. WBC -110°C every 24th for 96h 2nd group passive recovery	Pro-inflammatory and anti-inflammatory cytokines activity,	↑anti-inflammatory cytokines activity, ↓pro-inflammatory cytokines activity,

Rowell et al. 2011	13 soccer players	4-day long soccer tour- nament – 4 games	1st gr. 6 soccer players CWI 5x1min. in 10°C break 1min up to neck 2nd gr. 7 soccer players TWI 5x1min. in 34°C break 1min. up to knees	Muscle soreness, distance covered, HR	Gr. CWI: ↓muscle soreness., ↓less dis- tance covered, could run further on higher HR
Vaile et al. 2008	38 male in two tests for 8 months	7 series with 10 repetitions eccentric repetitions of leg work	1st gr. CWI 12 male 2nd gr. HWI 11 male 3rd gr. CWT 15 male 4th gr. control group	Weighted squat jump, isometric squat, blood markers, muscle soreness and thigh girth	CWI gr. ↓muscle soreness and swelling., improved recovery of isometric force and dynamic power,

Gr.- group; CK- creatine kinase; Mb- myoglobin; CRP- C-reactive protein MIVC- maximal voluntary isometric contraction; CWI- cold water immersion; CWT- contrast water therapy; WBC- whole body cryotherapy, TWI- thermoneutral water immersion; HR- heart rate, HWI- hot water immersion, CWT- contrast water therapy

The influence of immersion in ice bath on creatine kinase activity

The enzyme used to indicate muscle damage is the level of creatine kinase (CK). Due to heavy exertion, CK emerges from damaged muscle cells into the extracellular space. Effect of immersion in ice water on the level of creatine kinase remains unknown. Eton and Peters [5] suggest that creatine kinase flows from muscles to the lymphatic vessels. It is possible that the reduction of vascular permeability due to cryotherapy slows creatine kinase runoff from muscles to the lymphatic vessels. According to the author, it is also likely that cold therapy slows the flow of lymph.

Based on the data in table 1, it can be conducted that immersion in ice water after exercise reduces the activity of CK. The group using cryotherapy had a smaller increase in CK compared with the control group which rested passively or used other forms of treatments [2,5,14].

Discussion

In studies on immersion in ice water all of the results are not clear. Despite the widespread use of these procedures in sport, most studies show no effect of cooling with ice to recover after exercise. The only effect of CWI, which the researchers describe is as an analgesic. This article summarizes research on immersion in ice water, which show a decrease in post-exercise soreness, stiffness, swelling and a decrease in creatine kinase levels in muscles. According to the authors dealing with the problem, the ambiguity of the results may correspond to the variety of research procedures. Studies vary in time during which the test was subjected to immersion (1-15min), depth of immersion (partial / overall), water temperature (10-15°C), a research protocol, ratios tested (CK, CRP, Mb, MIVC, ROM, girth) and the kind of effort to induce damage in the muscle (running on an enve-

lope, Cyklo Ergometr, jumps, squats, football match, swimming competitions, etc.).

Despite the use of this method by well-known teams and clubs there are not many articles describing the impact of CWI for recovery after training. The reasons for the ambiguity of research results can be many. However, some important details should be noted. Most studies used eccentric exercise or effort on ergometer instead of effort in terms of training specific to each discipline. Specialized training involves many muscle groups and has a systemic effect, which is not possible to reproduce in the laboratory. Therefore, research should be conducted during training or competitions. Another important factor is the temperature and immersion time. This research procedure has the most differences. The effectiveness of treatment determines the water temperature should be within the range of 10°C to 15°C and immersion time which should not be less than 10 minutes. Probably very important in this research is the immersion time, which if too short can cause the body's recovery process will not commence or their effect will not be significant. The importance of temperature and time of immersion appear to be crucial. Thus, their effects on the body should be particularly examined.

Significant influence on the effects of this research has, also the position of person taking the test. For the pressure difference causing fluids to move from legs to chest region to take place, the person cannot stay in sitting position simply, or be immersed in ice water up to knees. Important to that the pressure difference is also the hardness of the vessel. The vessel should not be deformed during research.

There is no doubt that the explanation of effect of post workout immersion in ice water on the body requires more research. Analgesic effect is known and proven. However, noting the popularity of this procedure (the Olympic Games, European Champion-

ships, World Athletics) there should be an attempt to determine its effect on the body.

Declaration of interest

The author declares no conflicts of interest.

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Accepted: March 15, 2013

Published: March 27, 2013

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