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The Benefits of Ice Baths on Delayed Onset Muscle Soreness after high intensity training

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Abstract:

Introduction:

In the field of sports and exercise science researchers are exploring methods to enhance recovery after training sessions. One popular approach that has gained attention is the use of ice baths.

Purpose:

This review examines how ice baths impact muscle recovery time following high intensity workouts looking at both the effects and practical considerations with a focus, on Delayed Onset Muscle Soreness (DOMS). The PubMed database was used in this study. A literature review was conducted using the keywords: “cold water”, “muscle regeneration”, “muscle soreness”, “DOMS” and “ice bathing”.

State of Knowledge:

Ice baths have been found to trigger vasoconstriction reduce inflammation and alleviate muscle soreness. However, their effectiveness in reducing exercise-induced inflammation and muscle soreness remains uncertain. The impact on DOMS varies among individuals due to factors like genetics, age, gender and health conditions. This variability highlights the challenges of incorporating ice baths into workout recovery routines.

Summary:

The use of ice baths in post-exercise recovery presents a complex landscape with diverse physiological responses and variable outcomes. While practical guidelines exist for the application of ice baths in high-intensity training, debates persist regarding their efficacy on DOMS compared to active recovery. While ice baths are incorporated into holistic recovery strategies conflicting research casts doubt on their standalone effectiveness prompting further exploration of how they complement other recovery methods. Moreover, potential drawbacks and conflicting evidence regarding their influence on long-term training adaptations raise questions about the overall costs and benefits.

Key words: cold water; muscle regeneration; cryotherapy; vasoconstriction; anti-inflammatory; muscle soreness;

1. Introduction and Purpose:

In sport and exercise science, the search of the best recovery techniques after the periods of high-intensity trainings has lead to the exploration of different methods. Among them became the ice baths, which are becoming quite popular. Whether obtained through the regular high-intensity training that is known to contain extremely stressful and rigorous physical exertion or through the typical benefits of ice baths who can hasten recovery, the combination of these two factors remain intriguing. The essence of our review was to unveil the role of ice baths in the process of recovery after hard training, the physiological and hashing out of the things undergirding this interaction.

1.1. High-Intensity Training: Exploring the Regenerative Potential Field of Ice-Baths:

The basic anatomical landmarks identified from the images helped in the identification of the locations of different anatomical regions, just like they help clinicians in the pre-operative assessment. Nonetheless, the repeated exposure to muscular stress in this kind of training can trigger muscle damage, inflammation, and even DOMS (delayed onset muscle soreness) (Balnave, 1993)(1). Sportsmen employ high-performance mobilization, whether strength-training, endurance- running, and intervals, in order to stress their bodies, triggering adaptations aimed at improving performance (Laursen, 2002(2); Hughes, 2018(3); Gibala, 2019(4); MacInnis, 2017(5)). These kinds of changes are, for example, modified heart capacity, more mitochondria and skeletal muscle regeneration power, plus changes in plasma volume, stroke, muscle cation pumps, myoglobin, capillary networks and fiber types (Laursen in 2002(2); Gibala in 2019(4); MacInnis in 2017(5)). Training can suffer from muscle damage, inflammation and muscle soreness that takes place after exercise or can be delayed and becomes apparent one or two days after the exercise. The terms used for the latter are known as delayed onset muscle soreness and determine when the pain comes on. Thankfully, this muscle pain can be gradual with right preparations, but time necessary for these processes varies (Balnave, 1993)(1). A single session of low-volume high-intensity interval exercise (HIIE) and continuous exercise (CE) may be equally effective to induce mild DOMS since they tend to elicit similar responses after a single exercise bout (Farias Jr., 2017)(6). Whilst eccentric loading occurs, DOMS could be an issue, but this issue may be minimized via training.

1.2. Recovery Time: The Crucial Interval for Adaptation and Progress:

The recovery out of the door of intense training is fundamental for athletes, becouse it permits the body repair, adapt and increase performance tenor (Kellmann, 2010)(7). The length and competence of this recovery time are the essential determinants that provide a guarantee of athlete's capacity to continue the training intensity and frequency that could result to the achievement of the best results (Schoenmakers, 2019)(8).

1.3. Ice Baths as a Recovery Modality: Cooling the Flames of Exercise-Induced Stress:

The research supporting ice putting bathing for workout recovery as an effective technique has been mixed. According to Ihsan (2016)(9) and Cochrane (2004)(10), cold water therapy has a positive effect on post-exercise pain and inflammation, improving body recovery. In contrast, Jakeman (2009)(112) found no marked effects on muscle damage recovery from a solitary 10-minute ice bath. Ihsan (2021)(12) further confounds the issue by elaborating that ice baths may affect adaptations to exercise differently depending on the mode of exercise injuring resistance training but enhancing endurance.

1.4. Physiological Mechanisms of Ice Baths: Balancing the Benefits and Drawbacks:

The practice of utilizing ice baths in post-exercise recovery is a common technique among athletes, with potential advantages that include a decrease in tissue temperature, an improvement in autonomic nervous system function, and a reduction in exercise-induced muscle damage (Ihsan, 2016)(9). Although the short-term analgesic effect of ice, particularly in musculoskeletal pain, is well-documented, the evidence for its long-term effectiveness is less clear (Ernst, 1994)(13). As a result, this review will critically evaluate the dual nature of these mechanisms, taking into account the potential benefits and drawbacks, including the potential for blunted training adaptations and conflicting evidence regarding long-term effects.

1.5. Controversies and Variability in Responses: The Need for Precision:

The literature acknowledges the ongoing debate and diverse responses to ice baths. While certain studies have reported favorable outcomes, others have demonstrated limited or even detrimental effects (Ma 2022(14); Higgins 2011(15)). A variety of factors, including individual susceptibility, the timing of ice bath application, and the specific parameters of the intervention, contribute to the complex landscape of conflicting findings. The temperature of the ice bath, for example, significantly impacts pain perception, with lower temperatures causing higher levels of discomfort (Galvan, 2006)(16). Moreover, individual susceptibility plays a crucial role, and researchers have developed predictive models that take into account both external and internal risk determinants (Chashchin, 2017)(17). The timing and thickness of the ice bath can also impact hydrologic responses in Arctic lakes, which may have implications for ice bath application as a recovery strategy (Arp, 2015)(18). Finally, chemical parameters can influence freeze lining behavior, which suggests a potential avenue for further exploration in the context of ice bath interventions (Crivits, 2018)(19). Collectively, these findings emphasize the complexity of factors that contribute to the conflicting outcomes in this area. The introduction sets the stage for a nuanced exploration of these factors and underscores the importance of precision in applying ice baths as a recovery strategy (Power 1998(20); Carona 2023(21)).

2. Description of the State of Knowledge:

The current state of knowledge on the impact of ice baths on recovery time following high-intensity training is informed by a vast array of research that delves into the intricacies of this recovery method. Drawing upon an extensive range of studies that explore the physiological responses, advantages, controversies, and practical applications of ice baths, this section presents a thorough and up-to-date overview of the current understanding of ice baths as a recovery strategy post high-intensity training.

2.1. Physiological Responses to Ice Baths:

Ice baths or cold water immersion elicit a range of physiological responses. Research has shown that ice baths, a form of cryotherapy, can induce vasoconstriction, reduce exercise-induced muscle damage, and attenuate the inflammatory responses. During the study, a significant increase in ventilation rate, respiratory exchange ratio, shivering metabolism, and heart rate was observed during ice-water immersion, with survival time in 0°C water predicted to be 1-1.5 hours (Hayward, 1984(22)).The metabolic response to cold water immersion can be influenced by factors such as shivering thermogenesis and intermittent exercise (Stocks, 2004(23), Hesselberg, 1995(24)) and exposure to cold water can lead to increased levels of adrenocorticotropic hormone (ACTH), cortisol, norepinephrine, and epinephrine, which may enhance pain tolerance and cold tolerance (Kauppinen, 1989)(25). The metabolic response to acute cold exposure is influenced by the activation of both brown adipose tissue and skeletal muscle, with the latter playing a significant role in glucose turnover (Blondin, 2015)(26). Moreover, a study provided by Adamczyk (2016)(27) showed that both ice massage (IM) and cold-water immersion (CWI) have been shown to be effective in utilizing lactate and preventing delayed onset of muscle soreness (DOMS). In the case of vasoconstriction, Drummond (2006)(28) found that immersion of the hand in ice water could release adrenergic vasoconstrictor tone in the temple, leading to cutaneous vasoconstriction. Similarly, Gardner (1986)(29) demonstrated that cold-induced vasoconstriction is caused by increased smooth muscle responsiveness to norepinephrine. Khoshnevis (2016)(30) further supported this by showing that cryotherapy can induce persistent vasoconstriction even after the cooling period. Owing to the inflammatory response, Dugué (2000)(31) observed that regular winter swimmers had higher levels of certain cytokines, suggesting an adaptive response to cold water stress. Nemet (2009)(32) reported that local ice therapy following sprint interval training led to decreases in both pro- and anti-inflammatory cytokine levels.

2.2. Reduction of Exercise-Induced Inflammation and Muscle Soreness:

Research on the effect of ice baths on exercise-induced inflammation and muscle soreness has yielded mixed results. Howatson (2003)(33) found that ice massage reduced creatine kinase levels, a marker of muscle damage, but had no other significant effect. This was supported in subsequent studies, which found that ice massage did not reduce indirect markers of muscle damage or enhance muscle function (Howatson, 2005)(34). However, cold water immersion promoted quicker recovery of countermovement jump, with creatine kinase levels returning to baseline and remaining stable. The study suggests that cold water immersion promotes the recovery of stretch-shortening cycle performance, with warmer temperatures potentially being more effective for promoting recovery from strenuous exercise (Vieira (2016)(35); Isabell (1992)(36)).

2.3. Impact on Delayed Onset Muscle Soreness (DOMS)

Delayed Onset Muscle Soreness (DOMS) is a common condition characterized by muscle soreness, pain, reduced strength, and impaired range of motion, typically occurring 8-24 hours after strenuous or unaccustomed exercise (Mautner, 2016)(37). The primary mechanism of DOMS is ultrastructural damage of muscle cells, leading to protein degradation, apoptosis, and local inflammatory responses (Hotfiel, 2018)(38). The condition is most prevalent at the beginning of the sporting season or when athletes are introduced to new activities, and is often caused by eccentric or unfamiliar forms of exercise (Cheung, 2003)(39). Studies have reported varying degrees of effectiveness in alleviating DOMS, with some suggesting a reduction in perceived soreness and others revealing marginal effects (Sellwood, 2005)(40). Brukner (2007)(41) found that ice water immersion was ineffective in minimizing DOMS symptoms in untrained individuals. This challenges the use of ice baths as a recovery strategy in athletes. However, Demirhan (2015)(42) reported that ice massage, a form of cryotherapy, significantly reduced the DOMS levels in elite wrestlers.

2.4. Timing and Duration of Ice Bath Application: Critical Considerations:

The state of knowledge acknowledges the significance of timing and duration in the application of ice baths. Research on the optimal time window for ice bath intervention post-exercise has yielded varying recommendations. Vanderlei (2017)(43) found that 15 minutes at 14°C was the most effective intervention for creatine kinase concentration and long-term recovery perception. However, Bleakley (2010)(44) highlighted the difficulty in achieving optimal tissue cooling with cryotherapy, suggesting that the clinical effectiveness of inducing modest reductions in deep-tissue temperature should be explored. Adamczyk (2016)(27) and Almeida (2016)(45) recommended ice massage for localized muscle fatigue and cold-water immersion for global or generalized muscle injury or fatigue, respectively. These studies collectively suggest that the optimal time window for ice bath intervention may depend on the specific recovery needs of the individual, and the duration of immersion has been a point of investigation, with studies examining the effects of short-term and prolonged exposure. Research on the effects of ice baths has explored the impact of different immersion durations. Golden (1988)(46) found that repeated resting exposure to cold was more effective in producing adaptation, whereas exercise during exposure prevented this adaptation. Willis (1973)(47) observed intense subacute dermatitis in skin exposed to water for 72-144 hours, suggesting potential skin issues with prolonged immersion. Smith (1990)(48) noted hormonal and metabolic changes during prolonged whole-body immersion in cold water, similar to short-duration exposure. O'Hare (1985)(49) found significant diuresis, natriuresis, hemodilution, and increased cardiac index in subjects immersed in mineral water, indicating potential physiological responses to prolonged immersion.

2.5. Interindividual Variability in Response: Challenges and Implications:

The existing body of research recognizes interindividual variability in responses to ice baths, and individual differences in response to physical activity and training are influenced by a range of factors. Bouchard (2001)(50) found that age, sex, and race have little impact, whereas pretraining phenotypes and familial factors play a significant role. This is supported by Mann (2014)(51), who highlighted the influence of genetic factors, autonomic activity, and homeostatic stress. Baird (2018)(52) further emphasized the role of disease characteristics and disabilities in individuals with multiple sclerosis. These findings underscore the use of ice baths for recovery after high-intensity training is a complex issue, with the need for personalized approaches and caution against a one-size-fits-all mentality (Murray, 2015(53); Stephens, 2017(54); Minett, 2015(55)). Current evidence for the benefits of ice baths in adolescent athletes is limited, and more research is needed in this area (Murray, 2015)(53). The effectiveness of ice baths for recovery varies among individuals, and factors such as body temperature, cardiovascular responses, physique traits, and exercise type must be considered when optimizing protocols (Stephens, 2017)(54). The specificity of exercise prescription and training, as well as the impact of factors such as illness, sleep, and psychology, further underscore the need for personalized approaches (Minett, 2015)(55). There is a gap in mechanistic knowledge and a need for improved knowledge transfer between scientific and applied practice communities (Allan, 2021)(56).

2.6. Practical Applications and Guidelines:

According to research, there are practical guidelines available for the application of ice baths in high-intensity training. These guidelines suggest optimal protocols for water temperature, immersion duration, and frequency (Allan, 2016)(57). Nevertheless, the efficacy of ice baths as a recovery strategy continues to be a subject of debate, with some studies indicating that they may not be more effective than active recovery (Lateef, 2010(58); O'Brien, 2000(59)).

2.7. Integration with Other Recovery Modalities: Holistic Approaches:

The current state of knowledge highlights the significance of incorporating ice baths within holistic recovery approaches. Burke (2014)(60) and Pastre (2009)(61) underscore the importance of comprehensive recovery strategies, including ice baths, as they emphasize the need for cost-benefit analyses and better control of variables in recovery methods. However, the efficacy of ice baths has been called into question by Allan (2021)(57), who notes the lack of mechanistic knowledge and alignment with scientific recommendations. Allan (2016)(58) further supports this by finding that cold-water immersion is no more effective than active recovery in reducing inflammatory cellular stress.

3. Summary:

The use of ice baths in post-exercise recovery presents a complex landscape with diverse physiological responses and variable outcomes. While ice baths show potential in reducing exercise-induced inflammation and DOMS, their effectiveness remains inconclusive, with conflicting evidence and individual variability playing significant roles. Optimal timing, duration, and integration with other recovery modalities pose challenges, emphasizing the need for personalized approaches. Recognizing potential drawbacks and gaps in mechanistic knowledge, further research is crucial to clarify the practical applications and overall impact of ice baths in holistic recovery strategies.

Disclosure:

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