COLD WATER IMMERSION

PRACTICES, TRENDS AND AVENUES OF EFFECT

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Cold water immersion and ice baths are popular methods of recovery used by athletes. From the simple wheelie bin with water and ice, to the inflatable baths with complex water cooling units to recovery sessions in the ocean, the practice of cold water immersion is wide and varied.

Research into cold water immersion was conducted as early as 1963 when Clarke[1] examined the influence of cold water on performance recovery after a sustained handgrip exercise. Research has been conducted to understand how cold water immersion might affect the body's physiological systems and how factors such as water temperature and the duration of immersion might enhance recovery after training and/or competition.

Despite this research activity, how are we to know if research is being put into practice? In more serious situations, where guidelines and policies need to be standardised for the safe use of a product, one would expect that there is a straight forward follow-on from research into practice. Although cold water immersion may not need the rigor of testing compared to drug treatments, for example, the decision on whether to use cold water immersion in specific situations (e.g. after training or competition) may rest with one or two of the staff associated with the athlete/team. Therefore, it would be expected that these staff are well-informed on the current literature regarding cold water immersion.

WHAT THE RESEARCH SAYS

Considering that performance is the key outcome of elite sport, it should come as no surprise that the literature to date regarding cold water immersion has favoured performance. By contrast, less research has focused on the physiological foundation of using cold water immersion. In light of the findings by Broatch and colleagues[2], who suggested cold water immersion induces nothing more than a 'placebo effect', the lack of physiological research is surprising.

Performance studies have looked at various factors including both endurance and strength outcomes with cold water immersion and have produced varied results. Yamane and colleagues[3] performed several studies and found that regular cold water immersion attenuated gains in endurance and maximal strength (following handgrip training three times per week for 4 weeks), as well as endurance time, VO_2 max and ventilatory threshold (following four sessions per week for 4 weeks of cycling training). More recently, Fröhlich and colleagues[4] also reported that regular cold water immersion attenuated gains in strength (one repetition maximum (RM) and 12 RM) following 5 weeks of strength training completed twice a week.

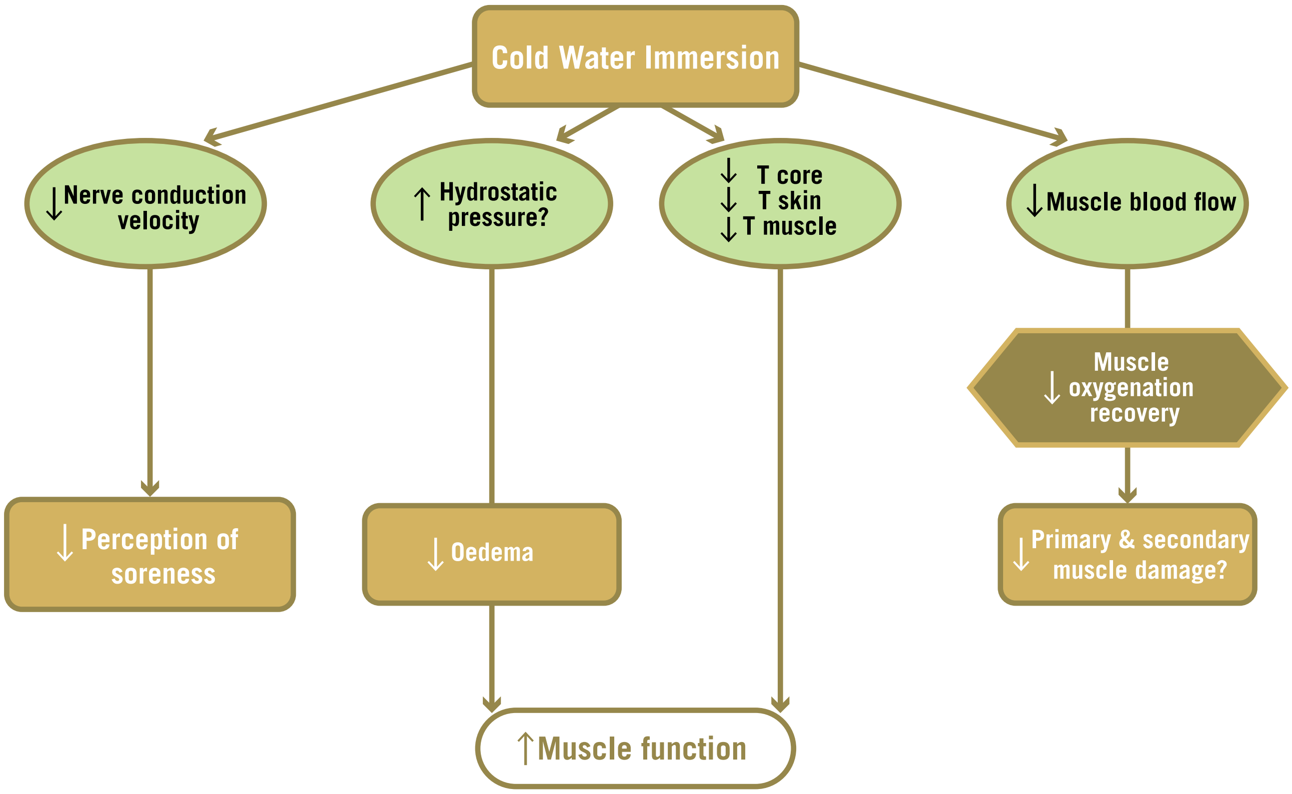

Figure 1: Physiological effects of cold water immersion. T=temperature.

In contrast with these studies, Halson and colleagues[5] found no decrement in performance (10 minute time trial, 1 second maximum mean sprint power, among others) when cold water immersion was used in conjunction with a 39-day cycling training block (which included baseline, intense and tapered training). Numerous studies have investigated the acute effects of cold water immersion on recovery of various aspects of performance in the hours and days after exercise. For a detailed summary please see Versey and colleagues[6].

Other studies completed to date have provided practitioners with some awareness of the effects of cold water immersion on various physiological parameters of the human body. Our current knowledge of the physiological basis of cold water immersion is summarised in Figure 1.

The practice of icing has long been used in sports medicine as a primary treatment to reduce pain and swelling following injury. Through the application of cold water immersion or ice baths, nerve conduction velocity will decrease leading to an increase in pain threshold and pain tolerance, which may lead to an increase in performance[7].

Additionally, Wilcock and colleagues[8] proposed that cold water immersion exerts hydrostatic pressure on the body, which may in turn limit the onset of oedema and inflammation, thereby potentially preserving muscle function. Considering that ice is a primary treatment to limit swelling and inflammation in first aid, the use of a cooling method post-exercise to limit this physiologic effect after exercise would appear logical. Obviously, cold water will cause localised and systemic effects, including a reduction in the temperature of the skin. Should immersion be sustained, the reduction in skin temperature will be followed by decreases in muscle and core temperature[9].

It has also been noted that muscular blood flow is reduced following cold water immersion, which may subsequently restrict secondary muscle damage and help maintain performance[10,11]. Some of the most interesting research in this field was reported by Takagi and colleagues[12]. In their study, they damaged rat muscle, then applied a plastic bag filled with crushed ice (surface temperature 0.3 – 1.0°C) to the injured muscle for 20 minutes. The recovery process of the muscle at the cellular level was mapped over 28 days. The major discoveries included significantly smaller regenerating muscle fibres, significantly smaller number of regenerating fibres and a slower inflammatory process for the ice group compared to the control group (which received no treatment). These basic findings support the results of exercise studies by Yamane and colleagues[3] and Fröhlich and colleagues[4] described previously.

Certainly, there are some major differences between the research by Takagi et al[12] and the common practice of cold water immersion. The damage done to the rat muscle (crushed with forceps) is certainly far more severe than that caused by the typical exercise session and there are different variables at play when applying ice packs versus cold water immersion (such

Table 1: Sports included in survey

Hockey	*Netball*
Australian rules football	*Track and field*
Rugby league	*Baseball*
Soccer	*Touch football*
Swimming	*Cycling*
Kayaking	*Rugby union*
Basketball	*Skiing and snowboarding*
Water polo	*Orienteering*
BMX	*Other**

**Some respondents listed that they work with a range of sports within their place of employment.*

Table 1: List of sports included in survey responses.

as hydrostatic pressure). But when the main goal of cold therapy recovery strategies is to reduce the temperature of the target area, this research provides some important findings to consider when applying cold therapy.

Versey and colleagues[6] reviewed the effects of implementing hydrotherapy strategies (cold, thermoneutral, hot and contrast water immersion) after exercise. Cold water immersion was classified as water temperature ≤ 20°C and encompassed 36 studies from the 53 reviewed. The studies included resistance, aerobic and anaerobic exercise; various durations, temperatures and depths of cold water immersion and included a number of different outcome measures such as 5 km running performance, maximal strength, peak power output, creatine kinase levels and heart rate variability.

Their summary of these studies revealed both significant and non-significant effects of cold water immersion. The beneficial effects of cold water immersion were most evident after cycling, running and leg strength protocols, demonstrating favourable outcomes across a range of situations. The authors concluded that cold water immersion is an effective strategy when used correctly. However, due to the variability in time, depth and temperature, one would certainly have to examine the literature that would best suit their situation should they opt to use this recovery method.

Considering the wide and varied research done to date, both with a performance and physiological focus, our research was designed to investigate the current practices of cold water immersion in elite sport. An anonymous online survey was created to gauge the current methodology, such as time spent using cold water immersion, water temperature and use during various stages of the season.

THE SURVEY

We recently conducted a survey to establish how cold water immersion is currently used in elite sport. A 15-question survey was created online, including questions regarding temperature and duration, as well as targeted development of methodology, maintenance of the temperature and the equipment used to deliver cold water immersion. Most of the questions were in a multiple choice format (with the option of including further answers in select questions), whereas the last question examined the respondents' belief in cold water immersion as a recovery strategy.

A total of 32 surveys were completed. One respondent stated that they did not use cold water, one respondent stated that their sport was 'high school track' which was outside of our target population and another reported their use as not being for the purpose of exercise recovery. Subsequently, 29 responses were included for quantitative analysis.

> *The practice of icing has long been used in sports medicine as a primary treatment to reduce pain and swelling following injury*

Table 2: Water temperature and treatment duration

Temperature range (°C)	Response	Duration (minutes)	Response
0 – 5	3%	0 – 5	28 %
5 – 10	24%	5 – 10	55%
10 – 15	55%	10 – 15	7%
15 – 20	7%	15 – 20	7%
Other	14%	Other	3%

Table 2: Response rate for the duration and temperature of cold water immersion.

Table 3: Equipment used and regulation of temperature

Equipment	Response	Regulate temperature?	Response
Inflatable bath with cooling unit	15%	Yes and maintain temperature	35%
Cold water pool at set temperature	41%	Yes and do not maintain temperature	7%
Makeshift bath (e.g. wheelie bin) with cold water and ice	32%	Do not monitor temperature	28%
Other	15%	Temperature regulated automatically	34%

Table 3: Equipment used and whether the water was monitored and maintained at temperature.

The most commonly used water temperature was in the range of 10 to 15°C, while the most popular duration of immersion was 5 to 10 minutes. These practices are in agreement with the studies reviewed by Versey and colleagues[6].

Forty percent of responses indicated they used a cold water pool at a set temperature. Considering that these pools are likely to be large enough to hold an entire team, this method would be the logical choice to assist with time management of recovery. A number of participants responded that they use different equipment if they are away from their main base of operations. The use of the ocean and cold showers were given as answers when participants responded with 'other'.

In regards to temperature monitoring, participants responded equally to monitoring and maintaining the temperature or that it is done automatically. It is interesting to note that ~25% of respondents did not monitor the temperature of the water. The temperature of the water could change due to transfer of body heat and other environmental factors (such as room temperature), this may alter the effectiveness of cold water immersion. In instances where the temperature is not monitored, cold water may have been used simply to influence the user's perception of recovery.

In terms of how their methodology for the cold water immersion was developed, the overwhelming response was that research was used to develop their recovery protocol (60%). Approximately 13% used trial and error, with approximately 3% stating they used both trial and error and research to build their recovery protocol. Approximately 23% stated they used other methods, which included talking to experts in the field, athlete preference and time constraints (which influence time spent utilising the recovery method).

THE PLACEBO EFFECT

The last question in the survey asked participants whether they believed cold water immersion works. When justifying their belief that cold water immersion is a beneficial recovery strategy, one common justification for their belief was in relation to the placebo effect.

Respondents commented:

- "Yes. If only to give a mental stimulus to athlete." – track and field.
- "Yes. I think so but even if it is more a psychological advancement in performance" – orienteering/athletics.
- "Yes, but only if the athlete perceives a benefit." – ski and snowboard.

The concept of the placebo effect is certainly not new and is often used in clinical trials to determine the effectiveness of a supplement or a new drug. This physiological effect has also been tested in relation to sport performance (Beedie et al[13]) and more recently, cold water immersion by Broatch and colleagues[2], who implemented a 15-minute period of either cold water immersion (~10.3°C), thermo-neutral water immersion (~34.7°C) (control condition) or the same thermo-neutral immersion with the addition of a 'recovery oil', following high-intensity cycling exercise. Participants were also given false information, indicating that the addition of this 'recovery oil' (bath soap) would benefit recovery.

Strength was the only performance variable measured and the researchers reported no difference in strength outcomes at any time point between the cold water immersion trial and the thermo-neutral water placebo trial. The authors concluded that the placebo trial was just as effective as the cold water immersion trial which gives some food for thought for the current widespread use of cold water immersion. Have athletes continued to use cold water immersions based on the evidence given to them by their coaching staff? Or have they truly tried and tested various recovery methods and found that cold water immersion promotes beneficial recovery for themselves compared with other recovery methods? And due to their current use and belief in cold water immersion, do they believe they are worse off if they haven't utilised this immersion method?

There were several limitations to our survey. The survey was designed in a mostly multi-choice format and was limited to 15 questions, to encourage participants to complete the survey. However, many more questions and more extended answer questions, could have been included to fully gauge their use of cold water immersion. Especially in regards to more specific areas of cold water research (such as modifying time and temperature based on rate of muscle temperature cooling (e.g. 1 cm muscle depth will be colder than 3 cm muscle depth at 1 minute post-immersion[14]). This survey was designed to provide an overview of current practices and thus a more rigorous, wide-spread survey would be warranted.

SUMMARY

- Both physiological and performance effects of cold water immersion have been reviewed in the literature (with substantially more focus on the latter). This research has shown both beneficial effects and no effects on recovery from exercise.
- Additional research into cold water immersion is still required to truly understand its effects in a range of

situations. As mentioned, large amounts of performance-based research exists, so future research should focus more on understanding the physiological aspects of cold water immersion. Additionally, a dose-response relationship is yet to be determined.

- Considering how much the mind can influence recovery of an individual, perhaps the best way to determine the right recovery therapy is to talk to the athlete. Ensuring the athlete is confident in the recovery therapy given to them may help to assist recovery. However, prescribers of recovery strategies should always stay up to date with the latest research to ensure their charges can maximise their recovery and not attenuate any possible training adaptations.

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