Practical Aspects of Precooling for Competition in the Heat

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ABSTRACT
ENVIRONMENTAL CONDITIONS, PARTICULARLY HEAT, CAN HAVE AN IMPACT ON PERFORMANCE. PRECOOLING AS A MEANS OF IMPROVING PERFORMANCE IN HOT AND HUMID ENVIRONMENTS HAS BECOME POPULAR IN BOTH TEAM AND ENDURANCE SPORTS. ALTHOUGH A VARIETY OF PRE-COOLING METHODS HAVE BEEN RESEARCHED AND USED IN THE FIELD, THERE IS VERY LITTLE RESEARCH ON THE PRACTICALITIES OF USING THE VARIOUS COOLING METHODS WITH TEAMS OR INDIVIDUAL ATHLETES. THIS ARTICLE WILL DISCUSS THE PRACTICAL ASPECTS OF IMPLEMENTING A PRECOOLING REGIME.

COLD TUBS
Immersion in cold water has been used in several studies as a means of precooling (3,4,15). The rate of heat loss to water is 2–4 times greater than to cold air, making it a faster means of decreasing temperature pre-exercise (22,37). Performance studies using water immersion have found increases in running distance of 4% over 30 minutes (3) and increases of 2.7% for average power output after a 70-second bike sprint (19). Several studies have examined the effects of cooling between bouts of repeat sprint exercise (39,40) and found that 15 minutes of whole-body immersion maintained performance in subsequent bouts of sprint exercise more effectively than active recovery. Although these studies show that cooling between bouts of exercise can be effective, they used repeat cycling performance as their intervention as such results may not be applicable to team sports involving running-based repeat sprints.

In a comparison of cold water immersion and ice slurry ingestion, Siegel et al. (35) found similar improvements in run times to exhaustion for both experimental conditions compared with controls (water immersion: 56.8 ± 5.6 minutes, ice slurry: 52.7 ± 8.4 minutes, control: 46.7 ± 7.2 minutes). Although the differences between the water immersion trial and the slurry ingestion trial were not statistically significant, the 4-minute greater time to exhaustion between the groups could result in real-world competition differences. The cold-water immersion resulted in significantly
lower core temperature at 15 and 20 minutes into exercise than control or ice slurry ingestion and tended toward lower core temperature even at 40 minutes of exercise.

Many colleges and professional sports teams make use of cold tubs during recovery and have them available in their home facilities. Portable cold tubs are available but require a source of electricity and are still notoriously unreliable and prohibitively expensive for many individuals. An inexpensive alternate is an inflatable pool that could be purchased at many big box general merchandise stores and bags or blocks of ice. Regardless of the method used, time and space are still issues if water immersion is to be used.

To avoid acute responses to cold stress, such as shivering and increased metabolic rate, the recommended protocol for water immersion cooling is to start with water at 29°C and decrease the temperature by 1–2°C every 10 minutes for about an hour (18). With large groups of athletes, the size of most cooling tubs makes it difficult to cool a whole team. The first group cooled risks having lost the benefits of precooling by the time a second or third group have finished their session. A significant drawback of water immersion is that muscles are also cooled, potentially increasing the time required to warm-up before competition. To date, there is no research on the effects of combining warm-up and water immersion.

**COLD AIR**

Several studies have used cold air at temperatures between 0°C and 5°C to improve endurance performances by 4–16% in cycling and running, as measured by time to exhaustion at various percentages of \( \dot{V}_{O_2} \text{max} \) (12,16,28). Cooling protocols have typically used repeated and alternating periods of cooling of up to 15 minutes followed by periods of rewarming of up to 20 minutes for a total time of 100–130 minutes (12,28). During air cooling, core temperature has been shown to increase significantly during the cooling period, probably due to warm blood from the periphery moving to the core, but there is a spontaneous decrease in core temperature during the rewarming period (29,41) as the cooler peripheral tissues continue to extract heat from the warmer core.

Cold air exposure, while showing performance benefits, is one of the least practical methods of precooling before a sporting event. Air cooling to temperatures low enough to create a change in core temperature that would result in improved performance requires some sort of refrigerated chamber, which can be very expensive and is not practical for travel to competition sites. Portable air-conditioned tents have been marketed for precooling but have never been scientifically evaluated. Additionally, the amount of time to achieve significant cooling, 100–130 minutes, can become difficult to fit into a pre-event routine and warm-up schedule.

**MISTING FANS/COLD SHOWERS**

Misting fans have become quite popular and are frequently seen on the sidelines at football games and other sporting events. In the only study to examine the effects of misting fans, Mitchell et al. (21) found that the evaporative effect of combining moving air and water resulted in a decrease in skin temperature of 6°C and a decrease of esophageal temperature of 0.5°C. Unfortunately, there was also a decrease in running performance at \( \dot{V}_{O_2} \text{max} \) of 8%. Whether this is due to the cooling or the limited warm-up used in this study is unclear.

Only 1 study has examined the use of a shower as a precooling strategy (9). Water temperature of the shower was decreased from 28 to 24°C over a 60-minute period. Rectal temperature was decreased by 0.6°C, but there were no changes in performance, physiological, or psychological outcomes as a result of the intervention. More work is needed to determine the performance impact of these interventions as they are potentially easier to administer to larger groups of athletes and in the case of a cold shower, is available at most sporting events.

**COLD GARMENTS**

Vests containing ice or a silica-based gel have been found to be effective at controlling core temperature during endurance sports (1,36). They can be worn while an athlete goes through their pre-competition routine, provided the added weight of the vest does not interfere with movement patterns. Cold garments are most effective when used during warm-up, absorbing excess heat produced during the warm-up by cooling the skin and blood, which is then transported throughout the body (30).

Although there is a body of research that suggests that ice garments can improve endurance performance in sports such as rowing (27), cycling (37), and running (1), the research on cooling garments and repeat sprint activities is equivocal. This may be due to the different cooling methods used. Castle et al. (6) saw a 4% improvement in peak power output in 34°C and 52% relative humidity after precooling with ice packs on the upper legs compared with no precooling. In contrast, Duffield et al. (10) found no significant benefit of using an ice jacket before and during repeat sprint exercise in 30°C and 60% relative humidity. It may be that for improvements in repeat sprint activity, cold must be applied over a larger surface area or directly to the working muscles. Minett et al. (20) compared the effects of head, head and hand, and whole-body cooling on intermittent sprint exercise. Head cooling involved an iced towel placed on the head and neck, head and hand involved the iced towel plus hands in ice water, and whole body involved the same as the head and hands plus an ice vest and ice packs applied to the thighs. The whole-body cooling resulted in significantly greater running distances than the other 2 interventions or the control group.

Ice vests are simple to use and are affordable for individual athletes, typically costing in the hundreds of dollars, but can become a major expense for
<table>
<thead>
<tr>
<th>Cooling method</th>
<th>Effective for (based on current research)</th>
<th>Practical for</th>
<th>Ease of setup and use</th>
<th>Portability</th>
<th>Cost</th>
<th>Other requirements</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold tubs</td>
<td>Endurance sports</td>
<td>Endurance sports</td>
<td>Not easy</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Water source, drain, electricity</td>
<td>60 min immediately before warm-up decrease H2O by 1–2°C every 10 min</td>
</tr>
<tr>
<td>Misting fans</td>
<td>Not yet shown to be effective for performance enhancement</td>
<td>Team sports</td>
<td>Not easy</td>
<td>Low</td>
<td>High</td>
<td>Water source, electricity</td>
<td>20 min standing with fans front and back and water spraying 50 mL/min</td>
</tr>
<tr>
<td>Cold showers</td>
<td>Not yet shown to be effective for performance enhancement</td>
<td>Team sports, endurance sports</td>
<td>Very easy</td>
<td>Not portable but often readily available</td>
<td>Very low</td>
<td>Shower facilities</td>
<td>60 min immediately before warm-up decrease water temperature by 4°C</td>
</tr>
<tr>
<td>Cold air</td>
<td>Endurance sports</td>
<td>Not practical</td>
<td>Not easy</td>
<td>Very low</td>
<td>Very high</td>
<td>Specialized chamber</td>
<td>Alternate 15-min cooling and 20-min warming periods for 100–130 min</td>
</tr>
<tr>
<td>Ice vests</td>
<td>Endurance sports</td>
<td>Endurance sports</td>
<td>Easy</td>
<td>High</td>
<td>Moderate</td>
<td>Portable cooler or freezer</td>
<td>Worn for 15–65 min before event, during warm-up</td>
</tr>
<tr>
<td>Ice packs</td>
<td>Repeat sprint sports</td>
<td>Repeat sprint sports</td>
<td>Easy</td>
<td>High</td>
<td>Low to very low</td>
<td>Portable cooler or freezer</td>
<td>20 min immediately before warm-up on muscles to be used</td>
</tr>
<tr>
<td>Ice towels</td>
<td>Repeat sprint and endurance sports</td>
<td>Repeat sprint and endurance sports</td>
<td>Easy</td>
<td>High</td>
<td>Very low</td>
<td>Portable cooler or freezer, water</td>
<td>20 min before event worn during warm-up</td>
</tr>
<tr>
<td>Ice slurries</td>
<td>Endurance sports</td>
<td>Team sports, endurance sports</td>
<td>Moderately easy</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Slush machine or a cooler for transporting premade slurry</td>
<td>500 mL 20–30 min before the start of competition</td>
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</table>
large teams. The vests can typically be frozen in 4–6 hours in a standard freezer and transported in a cooler. Cooling garments and ice packs seem to be most effective when used for periods of 15–65 minutes in hot environmental conditions and close to competition time (4,19,27,37). Currently, ice packs are the only precooling method shown to be effective in repeat sprint sports, making them the best option for many team sports.

An alternate to ice vests that work on the same premise is cooling using a neck collar or frozen towels. The head and neck are areas that are highly thermosensitive (8) and when cooled have been shown to alleviate heat strain more effectively than cooling the same surface area on the trunk (33). Performance improvements have been seen in rowers (26) and runners, including a 7.3% improvement in a 15-minute running time trial performance in the heat (38). Neck collars or frozen towels are simple to use and relatively inexpensive. They are easy to transport to competition sites and can be worn during warm-up and precompetition preparation. Large groups of athletes can be cooled simultaneously as long as a freezer is available to freeze towels.

ICE SLURRY MIXTURES

Although cooling garments and water immersion seem to be effective at decreasing core temperature, the application of cold directly to the upper- or lower-body musculature may also cool the muscles, decreasing any benefits derived from warming up those muscles. Instead, more aggressive internal precooling techniques involving the ingestion of cold water, ice, or an ice slurry (14) may be an effective alternative for decreasing core temperature without affecting active musculature.

An ice slurry is a mixture of both ice and liquid water, such as a slush drink that can be purchased at a convenience store. Ice slurry mixtures are more effective at reducing heat load than either cold water or ice. The slurry combines the heat absorbing abilities of ice water and the extra heat required to melt the ice particles. This results in a greater heat sink than liquid alone, increasing the potential to reduce the rate of heat retention in the body. Evidence for this has been provided by Siegel et al. (34), who found run times to exhaustion at the first ventilatory threshold were almost 10 minutes greater for a slurry ingestion group compared with a cold water group (50.2 ± 8.5 minutes versus 40.7 ± 72 minutes) accompanied by a 0.41°C greater decrease in core temperature at the start of the run.

Ice slurries can be an effective means of cooling large squads of athletes in sports such as football, rugby, or soccer, provided electricity is available and a staff member is around to make the slurries and refill the machine. Ice slurries can be mixed ahead of time and kept in a cooler for several hours. Commercial “slushie” machines are available that are relatively portable, weighing in at 35 kg (77 lbs) or less and operate on standard electricity, making them a practical tool that teams can use on road trips as well as for home games. Typical machines of this size can produce up to 7.5 L of ice slurry every 30–40 minutes, depending on ambient temperature. Athletes in individual sports can use commercially available “slush cups” to make single serving-sized slurries provided they have access to a freezer to keep the cup cold before use.

From experience, approximately 500 mL of slurry 20–30 minutes before the start of competition seems to be tolerable for most athletes and can fit into a warm-up routine. A potentially negative outcome of rapid consumption of ice slurry drinks is a cold stimulus headache, which can occur when cold drinks are rapidly consumed. A cold stimulus headache is usually short duration but can create an unnecessary distraction right before competition. Rather than trying to drink the slurry as quickly as possible, recommending gradual consumption over a 10- to 15-minute period seems to help prevent cold-induced headaches as does consuming ice slurries for several consecutive days before the competition. Although no research has reported gastric emptying problems with ice slurry mixtures, athletes who have difficulty tolerating carbohydrate or salts pre-event should try ice slurries in some less important events or during practice before using them at a major event.

CONCLUSION AND RECOMMENDATIONS

Precooling can help improve performance in hot and humid environments. The choice of a precooling strategy needs to consider the size of team to be cooled, the availability of water or electricity, the nature of the competition to follow and the logistics of transport, setup, and administration of the various protocols as well as any rules governing the use of these techniques on the sideline, bench, or in a warm-up area immediately preceding competition. The Table provides a summary of some of the key factors to consider when choosing a precooling method.

Conflicts of Interest and Source of Funding: The author reports no conflicts of interest and no source of funding.

REFERENCES


