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Pre-cooling for Performance in the Tropics

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Pre-cooling improves power output by up to 7% in continuous exercise lasting less than an hour in tropical conditions. Although there are various cooling methods, practical and effective modes with suitable durations are yet to be determined for intermittent or more prolonged exercise. Research factoring in solar radiation and any placebo effect is necessary to determine the optimal strategies of pre-cooling for tropical conditions. KEYWORDS: ice-jackets, team sports, performance. Reprint pdf · Reprint doc · Reviewer's Comment

A Sportscience article by physiologists from the Australian Institute of Sport (AIS) highlighted empirical pre-cooling observations, the potential performance benefits, and rapid development of the AIS ice jacket prior to the 1996 Atlanta Olympics (Martin et al., 1998). Rapid development meant the issue of how best to use the ice jacket for various applications was not addressed. Researchers have since attempted to identify protocols for the ice jacket and to develop additional pre-cooling modalities for individual and team athletes competing in tropical conditions. The aim of this paper is to provide a brief overview of available pre-cooling methods and their potential impact on physiology and performance in tropical conditions.

Strategies to Improve Endurance Performance in Tropical Conditions

Maximum daily temperature in the tropics generally averages more than 30^{o}C year-round. In the wet season, humidity is also high. Hot and/or humid conditions limit cooling, because the temperature and vapor gradients between the skin and air are not conducive to loss of heat. In such conditions, body temperature becomes a factor limiting performance of high-intensity endurance exercise (Gonzalez-Alonso et al., 1999; Morris et al., 1998). Strategies that reduce resting body temperature or enhance dissipation of heat can therefore enhance performance.

Heat acclimatization and fluid ingestion are well-established methods for improving physical performance in the tropics. Acclimatization lowers resting body temperature and provides cardiovascular adaptations that aid heat loss (Buono et al., 1998). Fluid ingestion can attenuate the loss of plasma volume that would otherwise reduce blood flow to the skin and thereby compromise dissipation of heat (Armstrong et al., 1997). Athletes should continue to use these methods for competitions in the tropics, but in addition they should consider use of pre-cooling.

Application of ice via an ice jacket has become the usual approach to pre-cooling before an event. Ice jackets are conveniently portable and produce large reductions in skin temperature, so they have gained wide acceptance. However they usually cool only a small area, so they have only a small effect on core temperature. Immersion in cool water has a greater effect on core temperature by clamping a large surface area of skin at water temperature (Booth et al., 1997). Unfortunately, the provision of a bath adjacent to the playing area and the recommended immersion times are currently impractical.

Exposure to cooled air is an alternative means to cool a large surface area, but it also lacks effective practical delivery.

Pre-cooling and Performance

Table 1 is a summary of studies of the effect of pre-cooling on physiology and performance, sorted by duration of the exercise. All studies of exercise lasting up to 30 minutes have shown substantial effects on physiology (mainly heart rate and body temperatures), and most have shown beneficial effects on performance equivalent to 1-4% in mean power. With aggressive pre-cooling, the improvements are greater (up to 7%).

Table 1: Effects of pre-cooling on physical performance and performance-related physiology (at the end of the performance test) in simulated tropical environments. Studies are sorted by duration of exercise.

Exercise Duration (min)	Cooling Duration (min)	Cooling Modes	Environment temperature and humidity		Effect		Reference
			°C	%	Physiology	Performance (%)[a]	
0.8	45	RA+IJ	33	60	+	~ -6.0	Sleivert et al., 2001
1.2	30	W	29	80	+	+3.3	Marsh & Sleivert, 1999
4	30	IJ	33	60	+	+1.8[b]	Yates et al., 1996
6	5	IM	30	30	+	+3.0[c]	Myler et al., 1989
6.4	20	F+W	38	40	+	- 0.6[d]	Mitchell et al., 2003
15	45	IJ+RA	33	60	+	+7.0[e]	Cotter et al., 2001
27	9	IJ	32	60	+	+2.8	Smith et al., 1997
30	30	W	30	32	+	?	Wilson et al., 2002
30	30	W	30	32	+	?	White et al., 2003
30	60	W	31	60	+	+6.0[f]	Kay et al., 1999
30	60	W	32	62	+	+4.2	Booth et al., 1997
28-63	30	W	40	19	+	+3.0[g]	Gonzalez et al., 1999
60	31	W	27	60	0	?	Bolster et al., 1999
80	20	IJ	30	60	+	2.4[h]	Duffield et al., 2003
90	60	W	26	62	0	?	Drust et al., 2000

F = Fan, IJ = Ice Jacket, IM = Ice Massage, RA = Refrigerated Air, W = Water.
Observed effects: + = benefit, – = harm, 0 = trivial, ? = not assayed.

[a] Expressed as change in mean power or equivalent mean power averaged over any constant pre-load, using procedures of Hopkins et al. (2001).
[b] -1.2% in 1000-m time on a Concept II rowing ergometer, after a 1000-m preload.
[c] 1.0% in distance in a 6-min test on a Concept II.
[d] 7.0% in time to exhaustion.
[e] 16-17% in mean power over 15 min, following a 20-min pre-load.
[f] Gain in distance on a cycle ergometer with unknown relationship between speed and power. The gain seems too large relative to the physiological effects.
[g] 37% in time to exhaustion.
[h] Mean power in repeated sprints.

So how does a cooler body improve endurance performance in tropical conditions? Constant power tests of trained athletes consistently elicit core temperatures of ~40°C at exhaustion in hot conditions (Nielsen et al., 1993; Nybo and Nielsen, 2001; Gonzalez-Alonso et al., 1999). This so-called set-point temperature for fatigue occurs irrespective of acclimation (Nielsen et al., 1997) and hydration status (Febbraio et al., 1996), implicating high core temperatures as a cause of fatigue in hot conditions. By lowering their initial core temperature, athletes have a greater heat storage reserve prior to attaining high core temperatures. Theoretically, the improved heat storage reserve would permit selection of a greater pace (and therefore, heat production) during a time trial (Cotter et al., 2001) or extend the time to exhaustion at a set pace (Gonzalez et al., 1999). Vigorous activity in hot conditions rapidly utilizes the heat storage reserve, resulting in negligible physiological effects after more than ~30 minutes of exercise. Researchers have therefore questioned the use of pre-cooling for prolonged endurance events (Bolster et al., 1999). Regardless of the diminished physiological benefits towards the end of a bout, a higher power output during the early stages of performance results in a greater mean power output or speed overall for continuous events and presumably an overall enhancement in endurance for team sports.

Unfortunately, there has been less research on the effects of pre-cooling for intermittent high-intensity activity that characterizes most team sports, and the findings are inconclusive. Drust et al. (2000) found little effect of a reduction in body temperature prior to a 90-min bout of soccer-specific treadmill exercise in warm vs temperate conditions, but their warm condition may not have represented a sufficient challenge to core temperature. Duffield et al. (2003) evaluated the effect of wearing an ice jacket for 5 min before and 10 min during intermittent cycling that simulated the demands of field hockey in warm humid conditions. The mean effect was not statistically significant but it was substantialeven though effective pre-cooling durations in other studies have been 15-60 min. Athletes continue to use ice-jackets for pre-cooling before prolonged exercise in tropical conditions (Brearley et al., 2002), but clearly more research is needed to determine whether the perception of improved comfort translates into worthwhile effects on performance.

The Placebo Effect of Pre-cooling

There is a possibility of a placebo effect from pre-cooling, attributable to the expectation that pre-cooling will improve performance. Indeed, the placebo effect may be partly responsible for enhancements in performance lasting a few minutes, because core temperature cannot reach the critical limiting value within this period. Researchers have addressed the placebo problem in only one study, by using colored thermoneutral water and suggesting to athletes that it might confer a benefit similar to that of pre-cooling (Yates et al., 1996). Use of other bogus treatments or suggestion of the possibility of decreased performance due to lower muscle temperature are other options in experimental design to guard against placebo effects.

In failing to account for a placebo effect, researchers probably overestimate the physiological contribution of pre-cooling to the small performance improvement. The danger in any placebo-induced performance is that it increases the risk of heat illness. Athletes who ignore physiological cues that would otherwise cause them to reduce exercise intensity risk fainting or hyperthermia.

Future Research

Pre-cooling for exercise in the heat merits further investigation. Such research should account for the high solar radiation observed in the tropics (Marsden et al., 2001) that adds to the thermal load (Nielsen et al., 1988) and may diminish the small benefit for pre-cooling observed in laboratory studies. Inclusion of a placebo would further assist the scientific rigor of the investigation of pre-cooling strategies.

Future research should also focus on alternatives to the ice jacket that are more practical than cool-water immersion. External pre-cooling of the head, neck or hands and internal pre-cooling via ingestion of crushed ice or intravenous administration of cool fluids are possibilities.

A combination of pre-cooling strategies would also be worth investigating for team sports, because intermittent activity produces higher core temperatures than continuous exercise of the same average intensity (Cable and Bullock, 1996; Kraning and Gonzalez, 1991). This more aggressive approach to pre-cooling is unlikely to compromise sprint performance when athletes first go onto the field, as muscle temperature rapidly reheats during a short warm-up (Sleivert et al., 2001).

The National Heat Training and Acclimatisation Centre (NHTAC), located in Darwin, Australia, is examining the risk to health and the impairments in performance that occur during intermittent high-intensity exercise in a tropical environment. Research that is also in progress on strategies to reduce these problems should be valuable for local and non-heat acclimatized athletes competing in tropical conditions and may be useful for national teams competing in the 2004 Athens Olympics.

Link to Reviewer's Comment.

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