The BASES Expert Statement on Interventions for Improving Performance in the Heat

Produced on behalf of the British Association of Sport and Exercise Sciences by Dr Jo Corbett, Dr Oliver Gibson, Dr Neil Maxwell, Dr Caroline Sunderland and Prof Neil Walsh.

Introduction

This expert statement presents practical, evidence-based strategies for individuals performing continuous or intermittent exercise (>30 minutes) in hot environments, defined as environments where exercise is negatively impacted by high thermal stress.

Background and evidence

Many individuals must exercise in the heat and numerous sporting events take place in hot environments, e.g. the 2020 Olympic Games (Tokyo) and the 2022 World Cup (Qatar). The detrimental influence of heat on optimal performance is well established, although the extent of the effect is continuous and depends on the balance between heat-gain and heat-loss, in some circumstances (e.g. high work-rates, humidity, thermal radiation, low air-flow) performance is impaired within modest ambient temperatures (≤15°C). Effective interventions can be administered in the days before (chronic), on the days of and during (acute) heat exposure and will achieve one or, more of, the following: 1) increased or maintained heat dissipation; 2) reduced initial body-heat content; and 3) altered thermal perception.

Chronic interventions

Heat acclimation/acclimatisation

Acclimation (labatory) or acclimatisation (natural environment) to heat (HA) reduces initial deep-body temperature and increases heat dissipation rates. The reduces the thermal-strain for a given external work-rate during exercise in a natural-stressful environment. HA is a powerful tool for mitigating the effects of heat, although efforts are required in limiting sweat evaporation, such as the microclimates within some protective clothing. Most studies have examined ‘slow’ adaptation (10-12 days exposure) (chronic), or on the day of and during (acute) heat exposure thereafter.

Pre-cooling strategies aim to reduce deep-body temperature to a high level that elicits pronounced sweating. This is often achieved through exercise (active effort), in a hot and humid environment, or small-scale cooling. Pre-cooling can lead to hydromiosis (a reduction in sweating caused by blocking of the sweat glands). Passive approaches to HA, e.g. hot-baths (≥40°C) of 15 to 40 minutes following training, can be effective (Zurawlew et al., 2016), but as yet unconfirmed as equal to the traditional active HA programmes. The duration and frequency of HA exposures that maximises efficacy is unknown, although 60-90 minute daily exposures are common when using the active approach. Longer (>10 daily exposures) rather than shorter (>5 daily exposures) programmes are more effective. Nevertheless, shorter programmes result in some significant adaptations and are time efficient (Neal et al., 2016). However, adaptation may be slower in females, who may require longer to achieve the same benefits (Mee et al., 2015).

Maintaining thermal-strain (isothermal-strain) as the individual adapts, through progressively increasing work-rate or environmental stress should be superior to exercising at a fixed work-rate and environmental stress, where the stimulus for HA diminishes as the individual adapts, although empirical support for this is lacking. Pre-cooling is typically used higher initial work-rates than fixed-work-rate protocols. In thermally-stressful environments this facilitates rapid elevation of deep-body temperature, but thereafter requires little exercise for maintenance, potentially reducing total work; this may be preferable for athletes competing against each other. Most HA approaches highlight deep-body temperature (rectal/axillary thermography) should be monitored for efficacy and safety and individuals should be monitored for signs and symptoms of heat illness. A target deep-body temperature of ~38·5°C is common (Gibson et al., 2015), higher temperatures are unnecessary and increase heat-risk is limited. There is little evidence supporting dehydration as a way of enhancing HA, or that HA improves performance in cool environments (Neal et al., 2016). It appears that HA is retained for at least 7 days (Neal et al., 2016) and any benefits that are lost within a month of HA are re-acquired with 2-4 further exposures (Weller et al., 2007).

Acute interventions

Hydration

Hyponatremia impairs heat-loss, exacerbating negative effects of heat on performance. Therefore, individuals exercising in thermally-stressful environments should aim to commence exercise in a euhydric state and prevent excessive dehydration (>2% body weight loss from water deficit). However, excessive drinking can cause hyponatraemia, which is life-threatening and individuals should drink until they have a prescribed fluid strategy.

Pre- and per-cooling

Pre- or per- (during exercise) cooling techniques include: 1) external, e.g. cool water immersion, cooling garments; 2) internal cooling, e.g. the ingestion of cold-liquids or ice-slurry; and 3) mixed-methods (multiple external and/or internal). Pre-cooling strategies aim to reduce deep-body temperature by ~0.5-1.0°C, enabling greater heat-storage before hyperthermia develops. So long as a notable heat-sink is generated pre-cooling can be effective (Tyler et al., 2015). External cooling requires application of a cold medium to the skin sufficient to disrupt thermal state. Vasoconstriction in the periphery is often used, with temperatures of 12-18°C, durations of 20-30 minutes, and deep-body temperature monitoring for safety. However, decreased muscle and skin temperature may be very uncomfortable (Zurawlew et al., 2016), the circulating blood diverts away from active tissues and slows nerve conduction and muscle contraction, which can cause initial feelings of ‘sluggishness’. Vasodilatation also causes diuresis, which is increased by hydrostatic pressure if water immersion is used. Applying cool liquids or ice-slurry, internal cooling may reduce this ‘sluggishness’ and contribute to hydration. Typically, 7.5 kg body mass of cold-liquids (carbohydrate/electrolytes) or ice-slurry are ingested in the 20-30 minutes before exercise. For a given volume, ice-slurry creates a larger heat loss compared to cold-liquids and may be more effective, caused by higher latent heat of fusion, but ingesting ice-slurry can be uncomfortable, reducing ad libitum drinking. Theoretically, mixed-methods should generate the greatest heat-sink, although this has yet to be investigated. Few studies have employed a realistic ‘warm-up’, practitioners should consider the purpose and integration of warm-up within any pre-cooling intervention.

Some interventions induce sensations of coolness with minimal influence on body temperature. L-menthol, applied cutaneously, or swilled/ingested in drinks in low concentrations, stimulates cooling although the evidence that this enhances performance is equivocal. Applying cold water to the skin significantly increases blood flow to the skin and may be more appropriate in situations where evaporative heat-loss is restricted; e.g. protective clothing. The effectiveness of ventilated vests is affected by the air ventilation the vest and is reduced with hotter and more humid air.

Perceptual manipulations

Perceptual manipulations are of two kinds: 1) reducing or interrupting sensations of hotness; and 2) altering perceptions of body temperature. Practitioners should remain vigilant to any phenomena that could affect ingestion, e.g. by altering palatability/tolerance of ingested cold-liquids or ice-slurry.

Pre-/per-cooling

Table 1. Strategies for improving performance in the heat

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Strategy</th>
<th>Strengths</th>
<th>Limitations</th>
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</thead>
<tbody>
<tr>
<td>Heat acclimation/ acclimatisation</td>
<td>Active approach: (&gt;5 × 60-90 minute daily exposures), or long-term programme. Passive approach: 5-15 minutes hot-baths following training.</td>
<td>Reduces initial body-heat content, increases thermoregulatory capacity.</td>
<td>Significant adaptations retained with chronic heat. Must be well tolerated to be effective. Re-induction possibly quicker than acquisition.</td>
</tr>
<tr>
<td>Pre-/per-cooling</td>
<td>External: e.g. cool water immersion, cooling garments; Internal: e.g. cool-liquid or ice-slurry ingestion; Mixed-methods: multiple external and/or internal;</td>
<td>Vasoconstriction reduces metabolic heat production.</td>
<td>Cold-liquids or ice-slurry may affect ingestion, or may be less palatable/tolerated in situations. Cooling garments effectively influenced by environmental conditions.</td>
</tr>
<tr>
<td>Hydration</td>
<td>Ensures euhydration before exercise and prevents excessive dehydration.</td>
<td>Maintains thermoregulatory capacity.</td>
<td>Cost-effective.</td>
</tr>
<tr>
<td>Hydration</td>
<td>Reduces initial body-heat content and/or misses heat sink.</td>
<td>Efficient when properly administered.</td>
<td>Cost-effective.</td>
</tr>
<tr>
<td>Pre-/per-cooling</td>
<td>L-menthol application; Local-cooling.</td>
<td>Reduced perception of hotness.</td>
<td>Little/no effect on peripheral temperature.</td>
</tr>
<tr>
<td>Pre-/per-cooling</td>
<td>Mixed-methods.</td>
<td>Local-cooling.</td>
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Table 1 presents an overview of typical pre-/per-cooling strategies that can be used to influence body temperature. It is not exhaustive but should provide practitioners with a starting point. The table is arranged in ascending order of efficacy. Perceptual manipulations are of two kinds: 1) reducing or interrupting sensations of hotness; and 2) altering perceptions of body temperature. Practitioners should remain vigilant to any phenomena that could affect ingestion, e.g. by altering palatability/tolerance of ingested cold-liquids or ice-slurry.

Conclusion and recommendations

Performance in the heat can be improved by increasing or maintaining heat dissipation, reducing initial body-heat content or altering thermal perception. The optimal intervention(s) for a particular individual must be determined on a case-by-case basis taking into account their personal characteristics, environment, capacity, safety issues (see Table 1). Any intervention should be practised before competition, under supervision of an experienced practitioner and with appropriate monitoring.

References