Guideline Five

SPORTS MEDICINE AUSTRALIA

HEAT STRESS AND EXERCISE

FACTORS AFFECTING BODY TEMPERATURE

Humans can tolerate relatively small variations in deep body (core) temperature. To maintain an internal temperature of 36-38^{o}C there needs to be a balance between heat gain and heat loss. Heat gain can result from muscular activity, metabolism of food, shivering and hot environmental conditions. Factors contributing to the body's heat loss can be by:

- convection (movement of air or water adjacent to the skin)
- conduction (direct contact with a colder object)
- evaporation [where body heat is lost from the skin when sweat is vaporised]; and
- radiation [where body heat is transferred by electromagnetic waves to the surrounding environment].

When heat gain exceed heat loss, core body temperature increases.

Additionally, heat stress creates cardiovascular strain and can lead to thermal injuries such as heat cramps, heat exhaustion or potentially fatal heat stroke.

Core temperature increases during activity in the heat. The magnitude of this elevation is proportional to the exercise intensity. Evaporation of sweat is the most important method of temperature regulation in hot environmental conditions. As cooling occurs by the alteration of liquid sweat to vapor the part of the sweat that is dripping is not effective in eliminating heat. But, in warm, humid conditions with no cooling breeze, the effectiveness of evaporative heat loss is dramatically reduced. This makes the athlete more susceptible to dehydration and high core temperature.

EFFECTS OF HEAT STRESS ON THE BODY

While the evaporation of sweat serves to transfer heat from skin to air, skin blood flow is the vital mechanism for transferring heat from core to skin during heat stress and exercise. Under these conditions the circulatory system must supply the increased metabolic requirement of the exercising muscles while providing at the same time a regulation to body temperature by increased skin blood flow. During maximal exercise this necessary compromise of blood flow, combined with the reduction of blood volume caused by loss of fluid by sweat has been suggested to be responsible for decreasing an individual's maximal aerobic capacity ($V0_2max$) in a hot environment relative to a moderate environment.

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THE IMPORTANCE OF ADEQUATE HYDRATION

Excessive sweating places demands on the body's fluid reserves. Sweat is over 99% water, with most of the water derived from blood plasma, which is 91% water. Hence, sweating reduces blood volume and creates dehydration. If fluids are not replaced, core temperature may rise to dangerous levels.

Fluid replacement maintain plasma volume so that circulation and sweating can proceed at optimal levels. 400-600ml (2-3 standard classes) of fluid should be consumed at least 30 minutes before and 200-300 (1-2 glasses) every 15 minutes during physical activity in hot humid conditions. In events up to 90 minutes plain cold, water is the best fluid to consume. Heavily concentrated salt/sugar solutions should be avoided since they retard water absorption.

In prolonged (over 90 minutes) intense exercise in the heat commercially availably carbohydrate/electrolyte replacement fluids may improve endurance performance by increasing glucose availability. The optimal concentration for these drinks is considered to be 5-10% as higher concentrations will slow gastric emptying.

The thirst mechanism is generally an imprecise guide to water needs at the feeling of thirst is delayed and suppressed during exercise. Fluid intake prior to and following the event combined with regular intake throughout should ensure that fluid losses are completely replaced. Complete rehydration should occur before participation in another event or training session.

ACCLIMATISATION AND HEAT STRESS

Repeated exposure to hot environments results in the progressive adaptation of several physiological systems to thermal stress. There is a faster onset of and improved capacity for sweating leading to cooler skin and core temperature during exercise in the acclimatised versus unacclimatized individual. This therefore decreased the level of skin blood flow needed to regulation of body temperature. This leads to an improved exercise capacity and less discomfort on subsequent exposures to the heat. Full acclimatisation generally occurs in about 10 days of moderate training and exposure to hot environmental conditions. Ability to acclimatise is also dependant on age, sex, humidity and physical fitness.

Holiday seekers in warm climates and people exercising on unseasonably hot days should realise that they are more prone to thermal injuries due to lack of acclimatisation. The duration and intensity of the activity should be reduced, fluid intake increased and exercise times adjusted to avoid exercising during the hottest times.

GENDER AND HEAT STRESS

There are few differences in men's and women's responses to heat stress when they are matched by aerobic fitness level. In hot humid conditions women may have an advantage in losing heat because of their larger surface area to body mass ratio. Additionally, in humid climates males lose the advantage of greater sweat production as the sweat drips and does not vaporise.

CHILDREN AND HEAT STRESS

Children are at a greater risk of suffering heat stress compared to adults because of a number of physiological differences.

- Children have a larger surface area to body mass ratio than adults and
- can gain heat faster from the hot environment by radiation, convention and conduction.
- They also produce more metabolic heat per unit mass than adults at a given running speed probably because of lower economy of movement.

Additionally, childrens' sweating capacity is lower than adults as is their capacity to convey heat by blood from the body core to the skin.

RECOMMENDATIONS FOR THE PREVENTION OF THERMAL INJURIES

1. Event organisers are advised to obtain measurements of dry, wet and black globe thermometer readings over a number of days at the event location and during the expected time period in which the event is to be conducted.
2. The Heat Stress index or WEGT (wet-bulb globe temperature) needs to be calculated immediately before the start of the event to ensure that conditions are within acceptable safety limits. Additional readings may need to be taken if the temperature humidity or air velocity were to change markedly.
3. The American College of Sports Medicine regards the Heat Stress Index (WBGT) as a reliable measure of the environmental heat stress. The consensus is that an index value calculated at 28^{o}C or greater would indicate that the competitors risk their health if they were to exercise (all but the most moderate exercise) under those conditions. Index values less than 28^{o}C suggest that exercise may be acceptable provided discretion is used.
4. The event should be staged during the cooler months, but if this is not possible then the event should be conducted with an expected completion before 8.00am (morning events) and starting time after 6.00pm (afternoon events).
5. Even organisers should provide information about heat stress prevention i.e. acclimatisation, fluid replacement, appropriate clothing, cooling the body, correct pacing and signs and symptoms of heat stress, prior to the date of the event and preferably on the entry form.

6. Specialist sports medical staff and paramedics briefed in the treatment of dehydration, hyperthermia and other related conditions should either be in attendance or close at hand. The number of medical staff required would depend on the number of competitors, the nature of the event and the expected weather conditions.

7. The nearest hospital should be informed of the event in advance. Details of the event such as date, time, location, number of participants and possible injuries should be provided.

8. Adequate equipment must be provided for the treatment of heat stressed and injured individuals. Necessary equipment for the cooling of hyperthermic individuals such shade, ice, cold packs, cold intravenous fluids and fans should be included. Other necessary equipment would be oxygen and resuscitation apparatus for life support and the more basic equipment like beds, blankets and other first aid supplies for the less severe cases.

9. Adequate water supplies must be available for both ingestion and external body cooling. In addition to this water other cool to cold fluids should be provided for fluid replacement. A general rule is that each competitor consume approximately 500ml of cool water 30 minutes before competition and about 200-300ml every 10-20 minutes during competition. Further cool to cold fluid should be ingested after the event, possibly with some electrolytes added to replace those lost in sweat.

10. Individuals should allow for an acclimatisation period before performing maximal efforts in hot conditions.

11. When exercising in the heat individuals should wear light weight, loose and porous clothing of absorbent material to facilitate evaporation of sweat. In sunlight conditions light coloured clothes should be worn since dark colours absorb light more and add to the radiant heat gain.

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