



COMPETITION IN HOT AND HUMID ENVIRONMENTS

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1 Introduction

The Men's Hockey World Cup had been awarded to the city of Kuala Lumpur, Malaysia, due to be held in February 2002. The hot and humid environment prevalent in Kuala Lumpur brings into focus the need by all concerned to make adequate preparations to meet the expected requirements of athletes competing in such bright, hot and humid climates.

Obviously when the combination of heat, humidity and bright sunshine is present, extra caution must be exercised. This is vital not only for competition but also for the planning of practice sessions.

Dr Kathleen Watson, the Chairman of Medical Committee of the FIH, had entrusted me with the task of preparing a paper to advise the FIH as to the essential points of consideration for competition in a hot and humid environments and to make the appropriate recommendations to oversee the health-care of players competing in a tropical climate. This will allow them to compete safely to their optimum performance level, within the parameters dictated by the environment competition itself, which is unavoidable.

2 Physiological considerations

The body's physiological processes will continue to function normally as long as body temperature is maintained within a normal range.

Maintenance of body temperature depends on the body's ability to dissipate heat.

Body temperature can be affected by five factors explained in the following sections.

2.1 Metabolic Heat Production

Normal metabolic function results in the production and radiation of heat. Metabolism will always cause an elevation of body heat, depending on the intensity of the physical activity. Therefore, the higher the metabolic rate, the more heat is produced.

2.2 Conductive Heat Exchange

Heat loss or heat gain can result from contact with other objects. A hockey player competing on artificial turf on a sunny and hot day will experience an increase in body temperature by just standing on the turf.

2.3 Convective Heat Exchange

The temperature of the surrounding circulating medium can influence the gain or loss of body heat. A cool breeze will cool the body by removing heat from the surface of the body. However, if the surrounding ambient temperature is higher than the skin's temperature, body heat increases. Therefore, effective convection requires a cool environment.

2.4 Radiant Heat Exchange

Radiation may result in heat loss or heat gain. Body temperature is increased by radiant heat from sunshine. The effects of radiant heat are, obviously, much greater in the sunshine than in the shade. On a cloudy day, body heat may also be lost from the body by radiation. During exercise, the body works to dissipate heat away from the body produced in metabolism by dilating the superficial arteries and veins, therefore channeling the heat way via blood to the superficial capillaries.

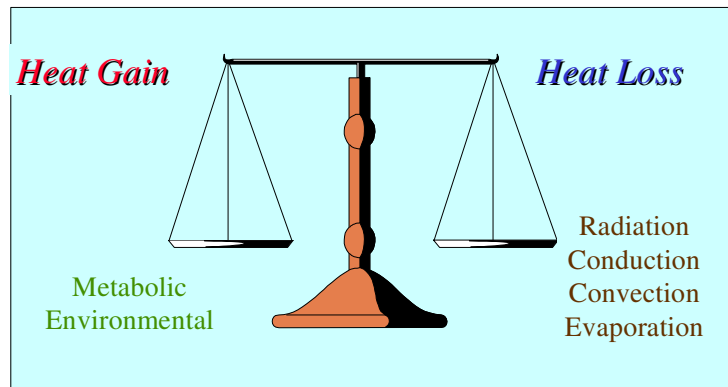
2.5 Evaporative Heat Loss

The body's sweat glands in the skin transport water allows water to be transported to the skin, taking with it large amounts of heat. When the radiant heat and temperature of the environment

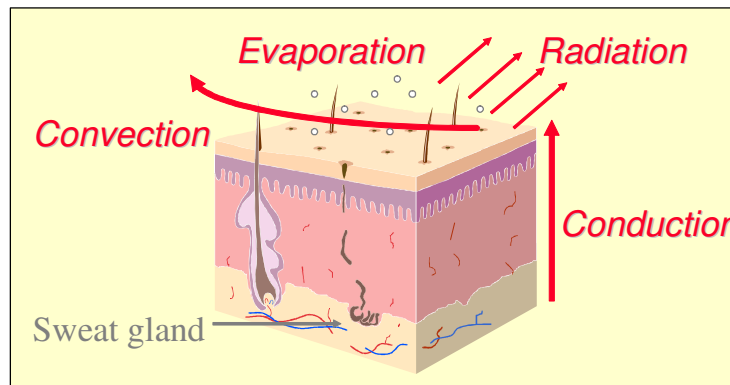
are higher than the body temperature, the loss of body heat then becomes very dependent on sweat evaporation. A normal person is able to sweat off about one quart (approx 1.14 litres) of water per hour for approximately two hours.

But it must be remembered that sweating itself does not cause heat loss. It is the evaporation of sweat that results in the heat dissipation. Therefore the surrounding air must be relatively free of water for evaporation to occur.

Heat loss to the environment is severely impaired when the relative humidity rises to 65% and there is virtually no heat loss when the relative humidity reaches 75%. Therefore effective evaporation requires a dry environment. When the ambient humidity is high, the capacity of the environment to accept water is reduced. Thus little sweat can evaporate and sweat drips off with very little heat removed.



Removal of Body Heat from Skin



It follows then that heat-related health problems such as heat cramps, heat exhaustion and heat-stroke have the highest probability of occurring in **bright sunshine, high temperature** and **high humidity** conditions.

However, it must be emphasized that these medical problems may also occur **if the body's ability to dissipate heat is impaired.**

| Heat Loss in Rest & Exercise | | |
|--|--------------|------------------|
| Mechanism of heat loss | % total/rest | % total/exercise |
| Conduction & convection | 20 | 15 |
| Radiation | 60 | 5 |
| Evaporation | 20 | 80 |
| <i>Estimated during prolonged exercise at 70% $VO_{2\ max}$</i> | | |

3 Physical Performance

Regardless of the level of physical conditioning, athletes in general just take extreme caution when exercising in hot, humid weather.

Essential points of consideration for exercise in the heat:

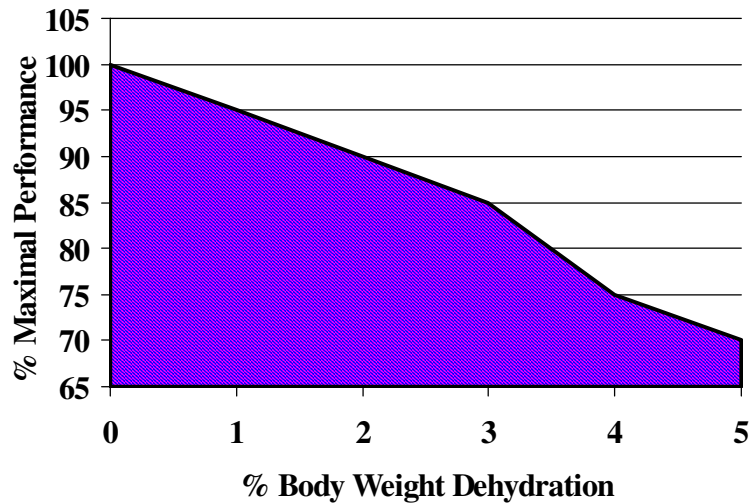
- exercise increases the demand of blood-flow to muscles
- exercising muscles generate heat
- heat is dissipated by increasing blood-flow to the skin
- competition between blood flow to muscle and to skin may result in impairment of performance and increased risk of heat illnesses
- exercise increases oxygen uptake
- exercise in the heat results in a higher heart rate for the same intensity of exercise
- increased sweat production and respiration demands more energy
- muscles use more glycogen and generate more lactate, which hastens the onset of fatigue
- during exercise evaporation is the major method of heat dissipation
- endurance, strength and skill performance are adversely affected
- athletes can lose more than 1 litre of fluid per hour which can seriously impair performance.

Also note that:

- 2.5% loss of body weight by sweating in a sauna resulted in a 30% reduction in power
- 2.0% loss of body weight by sweating caused a 3.7% slow down in 1500 m running time = 6 seconds for elite runners

(Maughn & Shirreffs. Sport Science Exchange #65, 1977)

Physical Performance & Dehydration



Factors which reduce tolerance to heat:

- lack of acclimatization
- dehydration
- glycogen depletion
- sleep loss
- alcohol
- infectious disease – especially traveler's diarrhea

4 Medical considerations

Prolonged exposure to extreme heat may result in heat illness.

Heat stress is preventable but statistics show that each year many athletes suffer from illness and even death from heat-related causes.

4.1 Heat Rash

Heat rash or prickly heat is a benign skin condition with a red, raised rash accompanied by tingling and prickly sensations during sweating. It usually occurs when the skin is continuously wet with unevaporated sweat. The rash is generally localized to areas of the body that are covered by clothing. The rash may be prevented by continuous toweling.

4.2 Heat Cramp

Heat cramps are extremely painful muscle spasms that occur most commonly in the calf and abdomen, although any muscle may be involved. The occurrence is related to the excessive loss of water and electrolytes (sodium, chloride, potassium, calcium, magnesium) which are essential elements in muscle contraction. The balance of the concentrations of these elements within the body is upset when there is profuse sweating resulting in losses of large amounts of water and small quantities of these electrolytes, i.e. dehydration. This imbalance will ultimately cause painful muscle contractions and cramps.

The person most likely to suffer from heat cramps is the one who is in fairly good condition but simply over-exerts himself in the heat.

Heat cramps may be prevented by replacement of sodium, chloride, potassium, magnesium and calcium, and most importantly, water to teat dehydration. This is best achieved by the ingestion of isotonic drinks. Ingestion of salt tablets is not recommended.

The electrolytes are best replaced and its heavy loss off-set by judicious nutrition :

- by simply putting in a bit more salt in food
- foods such as banana are rich in potassium
- calcium is present in milk, cheese and dairy products.

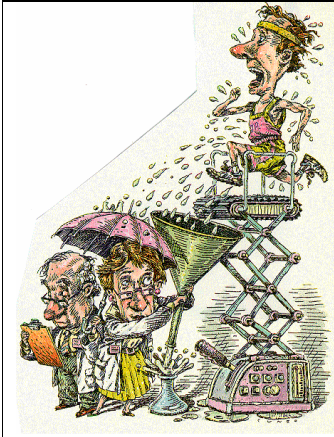
The immediate treatment for heat cramps is consumption of large quantities of water and mild stretching with ice massage of the muscle in spasm. Rest the player in a cool place. The use of muscle relaxants may be considered if symptoms are not alleviated with the first-aid measures.

A player who is suffering heat cramps should not return to practice or the field of play or resume playing as cramping is most likely to reoccur.

4.3 Heat Syncope

Heat Syncope or heat collapse, is associated with rapid physical fatigue during over-exposure to heat. It is usually caused by standing in heat for long periods or by not being accustomed to exercising in heat. It is caused by peripheral vasodilatation of the superficial blood vessels, hypotension or a venous pooling of blood in the extremities, which results in symptoms of dizziness, fainting, and nausea.

Heat syncope is quickly relieved by lying down the player, while elevating the legs, in a cool environment and replacing fluids orally.

| | |
|---|---|
|  | <p><i>Sweat Loss</i></p> <p>Some athletes lose up to 5 kg of fluid in 2.5 hours of exercise through sweating.</p> <p>Sodium and potassium are lost in that sweat.</p> <p>Fluid replacement without these electrolytes will cause gastrointestinal problems after several hours.</p> |
|---|---|

| Physiological Effects of Dehydration | |
|--|--|
| <ul style="list-style-type: none"> • increased plasma osmolality • decreased plasma volume • increased blood viscosity • decreased urine production • decreased central venous pressure | <ul style="list-style-type: none"> • decreased cardiac filling pressure • decreased stroke volume • decreased cardiac output • decreased skin blood flow • decreased sweat rate • increased body temperature |

4.4 Heat Exhaustion

Heat Exhaustion results from inadequate replacement of body fluids lost through sweating.

Clinically, the player may suffer from

- low blood pressure (collapse)
- profuse sweating
- pale skin, feeling cold and clammy with or hot and dry
- mildly elevated temperature (102degreesF)
- dizziness, confusion
- hyperventilation and breathlessness
- a rapid weak pulse.

It may be possible sometimes to spot a player who is experiencing problems with heat exhaustion.

He/she may :

- develop heat cramps
- become disoriented and light-headed.

A player who has not adequately replaced lost fluids may experience a drop of physical performance from the usual standards. The heat regulating systems are functioning but there is inadequate blood volume to dissipate heat through the skin.

Generally, people with poor conditioning who attempt to exercise in heat will experience heat exhaustion.

It is essential to measure the player's body temperature with a rectal thermometer to differentiate the condition from that of heatstroke. In heat exhaustion the rectal temperature will be around **102 degrees F** (approx. **39 degrees Celsius**).

The player with heat exhaustion may be treated as in heat cramps plus intravenous fluids if unable to take adequate oral fluids. Replacement of fluids is critical and the player should be placed in a cool environment.



4.5 Heatstroke

Heatstroke is a **serious life-threatening emergency**. The specific cause of heatstroke is unknown. It is clinically characterized by:

- a sudden collapse (low blood pressure) with loss of consciousness
- skin which is hot, flushed and dry
- may feel a chill with 'goose-bumps'
- throbbing headache
- confusion, ataxia
- shallow breathing,
- a rapid strong pulse
- and most importantly a core temperature of **106 degrees F (41.1 degrees Celsius)** or higher.

If left untreated or treated inadequately, unconsciousness, coma and eventually death may result. The heatstroke victim suffers from a breakdown of the thermo-regulatory mechanism caused by excessively high body temperature and the body loses the ability to dissipate heat through sweating.

Heatstroke and occur suddenly and without warning, with the player usually not suffering from any symptoms or showing signs of heat cramps or heat exhaustion.

The risk of death due to heatstroke can be significantly reduced if the body temperature is **lowered to normal within 45 minutes**. The longer the body remains elevated at 106 degrees F (41.1 degrees C), the higher the mortality rate.

First aid efforts must be directed towards **lowering the body temperature**:

- **strip all clothing** from the player
- **sponge down with cool water**
- **fanning** with a towel or a fan
- **do not immerse in cold water** as this will cause vasoconstriction and exacerbate the problem by not allowing more heat to be transferred to the surface via the blood
- **ice** may only be applied in the **carotid (neck), axillary, femoral and popliteal areas** as these areas have relatively superficial large arteries, which may transfer heat from the blood to the coolant by conduction
- **intravenous fluids**
- **airway support** may be necessary, with monitoring of urine output

It is vital that the victim be **transported to hospital** as quickly as possible. **Do not wait** for an ambulance; send the player in whatever vehicle that is available.

| Complications of Heat Illness | |
|--------------------------------------|----------------------|
| Cardiovascular | - arrhythmia, MI, PE |
| Neurological | - CVA, convulsions |
| Hematological | - DIVC |
| Renal | - renal failure |

| | |
|-------------------|--|
| Gastro-intestinal | - liver damage, gastrointestinal bleed |
| Muscular | - rhabdomyolysis |

5 Preventing Heat Illness: Rehydration

It is essential that players **continually replace fluids** lost through sweating by drinking large quantities of water. Even low levels of dehydration, such as less than 2% of body weight, may adversely affect thermoregulatory and cardiovascular response and reduce capacity for exercise and impair performance.

A person running will lose between **1.5 to 2.5 litres of water per hour** through sweating, even more as the temperature and humidity rises. Goalkeepers in their protective gear and clothing may lose even more fluids, even with apparently less activity.

Sweating occurs whether or not a player drinks and so, dehydration will result if fluid loss is not replaced by **adequate fluid intake** over several hours. Fluids should be taken **ad libitum**.

Drinking fluids in **volumes that approximate the fluid loss** will maintain important physiological functions and improves physical performance significantly.

Although players should consume fluids *ad libitum*, they are **seldom able to drink to replace more than 50% of their fluid loss**. Furthermore, the feeling of fullness of their stomach makes it uncomfortable to perform exercise.

The essential point with fluid replacement is how rapid the fluid is absorbed, relayed from the stomach to the intestine and finally transferred to the bloodstream:

- cold drinks (7.2 – 12.8 degrees C / 45 – 55 degrees F) tend to empty faster from the stomach than do warmer drinks
- cold drinks are not more likely to produce cramps, as some people may believe
- they do not offer any particular risk to the normal heart.

Players must have **unlimited access to water**. Failure to allow *ad libitum* consumption will undermine the player's performance and predisposes to unnecessary risk of heat illness.

Hypo-hydration will result in reduced muscular strength and endurance, decreased blood and plasma volume, altered cardiac function, disturbed thermo-regulatory function, decreased renal function, reduced glycogen stores, and loss of electrolytes.

Consumption of hypertonic fluids such as simple sugar and electrolyte solutions will tend to slow down gastric emptying. A solution that contains a 5% solution of simple sugars and electrolytes may retard fluid replacement and is therefore **not recommended during activity**, though they may be used before and after exercise.

Commercially prepared **isotonic drinks** may be used for fluid replacement. Carbohydrate content is maximized by the use of glucose polymers, while keeping the solution optimally isotonic.

6 Recommendations and guidelines for the prevention of heat-related health and medical problems

Obtain players' **history** of previous heat illnesses.

Allow a period of **seven to ten days for acclimatization**.

Instruct players to wear **appropriate clothing** during the acclimatization period.

Take regular measurements of the **WBGT index**.

Encourage players to **adequately replace fluids**.

Record body weight of players before and after, for practice and matches.

Identify **susceptible** players.

Constantly be vigilant and monitor players for **signs of heat illness**.

Players must have unlimited **access to water**.