SECTION 3

MEDICAL PROBLEMS OF ENVIRONMENTAL EXTREMES

23 DESERT EXPEDITIONS

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Humans are well equipped to live in hot areas provided they are acclimatised to the environment. Yet many people fall victim to the effects of heat, not only in the tropics, but also while exercising in temperate latitudes. This chapter aims to provide a greater understanding of the mechanism, diagnosis, treatment and prevention of heat-related illnesses and other problems associated with deserts.

Figure 23.1 *Working with the Bedu in the Wahiba Sands, Sultanate of Oman (RGS/R. Turpin)*

Climate

Most people have a romantic view of deserts with huge undulating sand dunes as far as the eye can see, punctuated with lush oases. The reality is rather different. It is convenient to divide deserts into three types as identified by Maria Harding in *Weather to Travel*:

- Hot desert
  - High day-time temperatures dropping sharply at night
  - Little precipitation
  - No cool season
  - Sahara, Middle East, Australia
- Steppe
  - Semi-arid edges of hot deserts
  - Tropical grasslands
  - Rainy season
  - Sahel, central India
- Cold desert
  - Higher latitudes
  - Extremes of temperatures with severe winter season
  - Gobi desert in Mongolia, Antarctica.

Most deserts do, however, share some common features:

- High day-time temperatures
- Low night-time temperatures
- Minimal surface water
- Poor vegetation
- Cloudless sky
- Variable wind speed with dust/sand (and snow) storms
- Sparsely populated.

Preparation

Most desert expeditions are vehicle based. The most comprehensive resource for these expeditions is the *Vehicle-dependent Expedition Guide* by Tom Sheppard, available from the Expedition Advisory Centre at the RGS. It covers all aspects of planning, communications and equipment for vehicle expeditions. *Sahara Overland* by Scott is also excellent. It contains detailed information including GPS waypoints for a range of expeditions and has a linked website (www.sahara-overland.com) with up-to-date reports from travellers.

Medical planning for desert expeditions starts with a thorough pre-expedition questionnaire and health assessment including a dental check. Deserts are among

the most remote and isolated regions in the world, and medical assistance may be non-existent. A simple delay of a re-supply vehicle or a navigation error may be potentially disastrous when water supplies are running low. The psychological effects of this challenging environment should not be underestimated, and planning must be meticulous and allow a large safety margin of time, water, fuel and food. As much advice as possible should be sought from previous expeditions. Local knowledge is invaluable and every opportunity should be taken to check details of proposed route and conditions prior to each leg of the journey. Maps are often scarce or unreliable, as most "roads" may simply be nomadic tracks, which vary from season to season. It is easy to overestimate the distance that can be covered either on foot or by vehicle.

Clothing, footwear and shelter

In deserts, *light*, *loose-fitting clothes* made of natural materials covering the body and a *hat*, scarf or *khaffieh* covering the head provide protection from the sun and allow air to circulate and so evaporate sweat. Shorts and T-shirts are also convenient and generally perfectly adequate, but it is important to use sun block on exposed skin. The colour of clothes is not of great importance. In direct sunlight white will reflect heat, black will absorb it. Logically, lighter-coloured clothes should be cooler; in practice loose clothing, whatever its colour, will be most comfortable. Sunglasses and goggles are essential eye protection for desert travel.

Footwear needs to be light, comfortable and tough. Shoes, trainers and boots all have disadvantages. Feet enclosed in footwear in hot climates become sweaty, smelly, soft, wrinkled and often infected with fungi. The disadvantage of bare feet or flip-flops is the lack of protection from the heat of the ground, from rocks or thorns or occasionally snakes and parasitic infections. The choice must depend on the conditions. For sand and gravel deserts go for walking sandals, trainers or desert boots; rock and volcanic larva may require heavier footwear. Whatever you choose, make sure you care for your feet. Treat blisters early and take every opportunity to allow your feet to air and dry.

It is possible to travel for months in desert, scrub and bush land without the need for shelter. A camp bed off the ground as protection against snakes, scorpions and spiders makes a perfect bed, but remember to shake out your shoes in the morning. A tent will protect you from flies and the unwanted attention of domestic dogs near human habitation. A tent and a decent campfire will provide a reasonable sense of security against hyena and lion for those dubious about the protection of fire alone. Where large animals and domestic dogs are present, keep food in a secure position away from you, preferably in a locked vehicle. If there is wind or a sandstorm, bivouac against a natural shelter such as rocks or stay in your vehicle. Beware of making camp in wadis or dry river courses; flash flooding from rain many miles away can be very rapid and, if not lethal, it will be inconvenient.

HEAT-RELATED ILLNESSES

Heat-related illnesses are preventable, yet are a potential life-threatening hazard for all expeditions. It is essential that all expedition members are aware of the risk factors, recognition and treatment of heat illness.

Heat-related illnesses cover a range of symptoms from lethargy and headache to death. They result from combinations of high environmental temperature/humidity, ineffective heat loss and increased bodily heat production, especially from exercise. They can occur at any temperature, but are most common in hot, humid environments. They are serious but preventable conditions which are underdiagnosed. Heat stroke carries a case fatality of between 17 and 70%.

Definitions

Traditionally, heat-related illness has been described using a variety of terms including heat syncope, heat cramps, heat stress, heat exhaustion and heatstroke. These terms are misleading as they are not necessarily caused by an increase in core temperature. In this chapter the term "heat-related illness" refers to any debilitating condition resulting from an increase in core temperature.

Incidence

Heat stroke is responsible for around 240 deaths per year in the United States. In the UK there are over 200 cases of heat stroke every year. Both of these figures are probably underestimates. Among military populations in a hot, humid climate (Singapore), the incidence may be as high as 3.5 cases per 1,000 soldiers.

Prevention

- Identify individuals at risk
- Monitor environmental heat stress
- Adjust the daily aims of the expedition accordingly
- Educate expedition members about heat illness, its early recognition and treatment
- Provide adequate clean drinking water, shade and latrines
- Prepare a robust medical evacuation plan.

Acclimatisation

Effective acclimatisation takes about 2 weeks. To acclimatise expeditioners should exercise for a *minimum* of 60 minutes a day in the heat. Light clothing (e.g. T-shirt and shorts) should be worn to encourage evaporative heat loss. Ideally individuals should undertake light-to-moderate exercise for 2–3 hours daily. Those who are less fit should adopt work/rest cycles to make up the required acclimatisation time (e.g. 45 minutes of exercise followed by 15 minutes of rest in the shade and fluid replacement). They should be supervised at all times. The body increases the amount of

TABLE 23.1 **RISK FACTORS FOR HEAT-RELATED ILLNESS**

Environmental
- High temperature
- High humidity
- Poor shade

Constitutional
- Extremes of age
- Reduced physical fitness
- Women are less heat tolerant than men
- Obesity
- Previous heat intolerance

Behavioural
- Lack of acclimatisation
- High physical workload
- Excessive/inappropriate clothing
- Inadequate water intake
- Dehydration (e.g. from flying, diarrhoea, alcohol)
- Recreational drug use (e.g. "ecstasy")

Medical
- Any intercurrent illness (e.g. chest infection, diarrhoea)
- Any chronic disease (e.g. diabetes, heart disease)
- Heat rash (prickly heat) and other skin diseases
- Inappropriate diuresis or other renal diseases
- Medication (e.g. beta-blockers, diuretics, antidepressants, antihistamines)

sweat produced (but it is more dilute), which increases evaporative cooling and keeps the core temperature down. As a result, an acclimatised person has a higher fluid requirement than a non-acclimatised person and may require up to 1.5 litres of water an hour.

The intensity of exercise should be gradually increased each day, working up to an appropriate physical training schedule adapted for the environment. Physical training should be conducted in the morning or evening, when it is cooler. Air-conditioned vehicles and hotel rooms should be avoided.

Some degree of acclimatisation can be obtained in temperate climates prior to departure. Hot baths twice a day, and wearing more clothing than normal when

exercising, are both effective. Physical fitness is also crucial. Any strenuous physical activity raises the core temperature, but this needs to be done regularly in order to have a protective effect. Any change of environment with significant additional heat stress will require an additional period of acclimatisation.

The benefits of acclimatisation are lost over 20–40 days after returning to a temperate climate.

Assessment of heat risk

There are four environmental characteristics that influence heat stress:

- Air temperature
- Solar (or radiant heat) load
- Absolute humidity
- Wind speed.

Measuring these factors is difficult. A wet bulb globe thermometer (WBGT) measures the first three, but is expensive. Further details are available on the RGS website. The following method is designed for use in the field with no equipment.

- Each individual should work out their maximum heart rate (220 minus age) (e.g. a 40-year-old will have a maximum heart rate of 220 minus 40 = 180 beats/minute).
- The group should all work to the lowest figure obtained.
- The group should undertake the proposed activity for one work period (e.g. 30 minutes) under close supervision.
- Immediately after this initial work period all should recheck their heart rates. If anyone's heart rate exceeds 75% of the age-adjusted maximum (e.g. 180 × 0.75 = 135 beats/minute) the next working period should be reduced by one third (e.g. to 20 minutes with 40 minutes' rest).
- The group should rest in the shade and rehydrate for the remainder of the hour.
- Repeat the process until the 75% age-adjusted maximum has not been exceeded.

Fluids

Maintain an adequate fluid intake. Fluid must be drunk before, during and after exercise. Thirst is a poor guide to fluid requirement, as 2–3% dehydration significantly impairs exercise tolerance but does not initiate thirst. If individuals drink only enough to satisfy their thirst they will be dehydrated. To avoid dehydration it is essential that all expeditioners are encouraged to drink water despite not feeling thirsty. Individuals may not drink enough in certain situations, e.g. before going to sleep (to avoid having to wake up and dress to urinate) or before long journeys. Expedition

leaders should therefore be aware of these factors and allow plenty of breaks during any activity along with an adequate number of suitable latrines. An inability to be able to spit is another indicator of dehydration.

Acclimatisation results in larger quantities of more dilute sweat being produced, so fluid requirements increase during the first 2 weeks of exposure.

The colour, volume and frequency of urine give the best guide to the adequacy of hydration. Dark yellow urine is a sure indicator that the individual is dehydrated, as is the desire to urinate less than twice a day. Changes in body weight offer a less useful guide, as weight loss is common, and caused not only by dehydration, but also by increased workload, gastrointestinal upset and decreased appetite due to heat and unfamiliar food.

Thirsty = dehydrated, dehydrated ***does not*** *= thirsty*

In hot environments, water losses can reach 15 litres per day per person. Complete replacement requires realistic estimates of potable water requirements, an adequate water logistic system, and individuals who understand and act on their water requirement.

Electrolytes

Sports drink manufacturers have heavily promoted their products as the ideal way to replace the water and salt lost in sweat. The principle that both water and salt should be replaced is correct, but for this to be effective the drink must contain a sodium concentration of at least 50mmol/l. Most sports drinks have a sodium concentration of 10–25mmol/l. The oral rehydration solution (ORS) recommended by the World Health Organization has a sodium content of 60–90mmol/l, but this is unpalatable in the quantities required. Whilst lifesaving for diarrhoeal illnesses, its use cannot be advocated for healthy people in the heat.

Some people have advocated salt tablets, but these irritate the stomach and provide an unknown amount and concentration of sodium as they are consumed with a variable amount of water. They are best avoided. In a study comparing the effectiveness of solid food and water with a commercial sports drink in fluid replacement, the former was more effective in restoring whole body water balance as the food contained more solutes than the sports drink.

Over-drinking

Whilst it is impossible to rely on thirst to drink enough water to avoid dehydration, it is equally important not to drink too much water as this can dilute the sodium content of the blood to such a level that fits, unconsciousness and death may occur. As a general guide if drinking causes distension of the stomach and feelings of nausea, then there is a possibility of over-drinking. The urine should be checked for colour and, if it is clear, the amount of water drunk should be reduced. It is not usual for young, healthy adults to get up more than once a night to urinate.

TABLE 23.2 **A COMPARISON OF RECTAL, TYMPANIC AND ORAL METHODS OF MEASURING CORE TEMPERATURE**

	Rectal	*Tympanic*	*Oral*
Pros	Most accepted and validated method for measuring core temperature	• Easy to measure • Increasingly used by GPs and hospitals • Fast and accurate in experienced users • Easy to monitor changes in temperature	• Easy to measure • Known by most people
Cons	• Expedition personnel, especially teenagers, may be reluctant to use • Rectal lag	• Operator dependent • Correct placement required in order to get an accurate temperature	• Unreliable – requires a conscious co-operative patient who has not recently drunk any cold or hot fluids • Thermometer must be placed under the tongue • Casualty should not breathe through mouth

In conclusion plenty of water should be made freely available to expedition members. Water drinking discipline should be imposed during and after work periods, and food should be provided during rest periods. Table salt should be available, but salt tablets are not necessary. Soups are an excellent source of both fluid and electrolytes. Sports drinks should be used only by athletes competing in the heat who are familiar with the products, and ORS reserved for those with diarrhoea.

Note: the above guidelines apply to hot, dry environments such as deserts. The potential for evaporative heat loss is much reduced by hot, wet environments (e.g. jungles), resulting in a larger increase in body temperature for a given intensity of work. In jungles acclimatisation sessions should be conducted at a lower intensity than for hot, dry environments with mandatory rest/work cycles. The importance of maintaining and restoring fluid balance applies equally for hot, wet environments.

Measurement of core temperature

Traditionally the gold standard for measuring core temperature has been measurement of rectal temperature. However, there is poor correlation between the rectal temperature and the severity of symptoms, and the critical core temperature remains unknown (fatalities have been reported with rectal temperatures of 39.5°C and survivors with temperatures of 47°C). There is a well-documented lag between the measurement of core temperature and the rectal temperature. It is important that medical personnel are aware of the limitations of the measurement of core temperature. Two other methods are available. Their pros and cons are summarised below. Rectal temperatures remain the accepted gold standard, but tympanic (ear drum) temperatures may be acceptable in experienced hands.

RECOGNITION OF HEAT ILLNESSES

Anyone suffering the following symptoms in a hot (and/or humid) environment, or during increased physical activity in a temperate environment, should be treated as a victim of heat illness until proven otherwise:

- Weakness
- Lethargy
- Headache
- Dizziness
- Confusion
- Nausea
- Vomiting
- Muscle cramps
- Fatigue
- Hysteria
- Anxiety
- Impaired judgement
- Hyperventilation/tachypnoea
- Diarrhoea
- Staggering
- Collapse
- Convulsions
- Loss of consciousness

MANAGEMENT OF HEAT ILLNESSES

The *7* Rs:

1. Recognise signs and symptoms – if in doubt treat as heat injury.
2. Rest casualty in shade – get rest of group under cover and drinking water.
3. Remove all clothing – strip to underwear.
4. Resuscitate – maintain airway.
5. Reduce temperature ASAP – evaporative cooling and intravenous fluids.
6. Rehydrate – oral or intravenous fluids.
7. Rush to hospital – consider evacuation.

The most important thing to remember is to remove the casualty from the source of heat and place him or her in the shade. Remember that the ground can be a continued

source of heat and the ideal position is on a stretcher or bed, which allows circulation of air. A hammock is ideal for encouraging heat loss. It is not necessary, or indeed desirable, to use ice-cold water. This causes constriction of the surface blood vessels and a reduction in blood flow to the skin. The skin therefore appears cool, while the warm blood circulates beneath, rising in temperature from metabolic processes.

The patient should be sprayed or splashed with water and fanned to encourage evaporative cooling. A wet sheet may be used instead. The administration of a cold intravenous solution of less than 1 litre of saline within an hour has been shown to result in significant reduction in core temperature and an improvement in the clinical condition of the patient.

Heat-injured casualties who have not been cooled and are shivering are seriously ill. Their temperature has risen so quickly that they have lost the ability to control their temperature and will complain of feeling cold. They will not feel hot or thirsty. They will be pale with cold skin. They will want to be wrapped in warm clothing, which only increases their core temperature, as does shivering. This is not normal and they must have their core temperature measured to exclude heat illness or a febrile illness such as malaria.

With cooling, the return to a normal temperature is often associated with shivering. It is important to continue to monitor the core temperature, as an individual's thermoregulatory capacity has been damaged. These individuals are at continued risk of both hyperthermia and hypothermia.

Stop the activity for all participants

Measure core temperature, pulse rate, blood pressure and conscious level (see Chapter 12). While a fall in systolic blood pressure is a poor indicator of early volume depletion, its presence reliably indicates that the patient is seriously ill and is a sign of impending cardiorespiratory collapse. Aspirin and/or paracetamol is of no value in heat illness and treatment should not be given. Glucose should be given orally or intravenously as casualties are often hypoglycaemic.

If conscious

- Lay the casualty down in the shade.
- Raise their feet.
- Strip them to their underwear.
- Spray their whole body with water.
- Fan their skin vigorously to aid evaporation.
- Give them water to drink.

If unconscious

- Place them in the recovery position (risk of vomiting).
- Protect their airway.
- Give them intravenous fluids (isotonic saline).
- Cool them by spraying the body with water and fanning the skin.
- Evacuate as an emergency.

MINOR HEAT ILLNESSES

Sunburn

Sunburn reduces the thermoregulatory capacity of skin and also affects central thermoregulation. Sunburn should be prevented by the use of adequate sun protection. When it does occur, affected individuals should be kept from significant heat strain until the burn has healed.

Heat syncope

Fainting on standing in the heat is thought to occur due to blood pooling in the legs and increased blood flow to the skin. Upon standing the blood supply to the brain is temporarily interrupted, causing loss of consciousness. Although most cases of heat syncope are harmless, the potential for heat illness should be considered, especially following physical work in the heat, or after the acclimatisation period.

Heat oedema

Mild swelling of the limbs may be experienced during the first few days of exposure to heat, during which time the plasma volume increases to allow for the increased blood flow to the skin.

Heat cramps

The precise mechanism behind heat cramps is unknown. Heat cramps may occur in salt-depleted individuals recovering after a period of work in the heat, but also with any unaccustomed exercise, even in cool conditions, e.g. swimming. Salt supplementation has been found to reduce the incidence of heat cramps. Cramp is painful and can recur but does not have any long-term effects. If the individual is otherwise well, there is no association with heat illness. Treatment is supportive with salt supplementation to food for a few days. Intravenous fluids are rarely required.

Miliaria rubra

Miliaria rubra is an inflammatory skin eruption, which appears in actively sweating skin in humid conditions. In dry climates, miliaria may be seen on skin covered by

clothing. Each lesion represents a blocked sweat gland, which cannot function efficiently, and therefore the risk of heat illness is increased in proportion to the amount of skin surface involved. Sleeplessness due to itching and secondary infection of occluded glands may further affect thermoregulation. Miliaria is treated by cooling and drying affected skin, avoidance of sweating, controlling infection and relieving itching. Sweat gland function recovers with replacement of the damaged skin, which takes 7–10 days.

Eyes

Eyes are prone to damage from sand and direct sunlight. A sand-filled eye can be cleared by bathing the open eye in clean water. The eye may have an abrasion or retained foreign body, which should be dealt with as described in Chapter 13. Several pairs of sunglasses and goggles are needed to prevent sand getting in during storms. Sunglasses should be worn at all times during the day, even when overcast.

Throat

Dry air, sand and insects make breathing difficult, and the development of a dry persistent cough likely. A loose cloth (muslin) over the nose and mouth can prevent foreign bodies entering and prevent some loss of moisture.

SUMMARY

Heat-related illnesses can present a real threat to any expedition, but with proper preparation and management all are preventable. It is essential that all expedition members are aware of the risk factors, recognition and treatment of heat illness. Expedition organisers need to take account of the lengthy time required to acclimatise properly, and construct a suitable, flexible itinerary and programme of physical work. Unusually energetic individuals may need to be restrained from excessive physical effort. The medical plan should include a medical briefing to all personnel, adequate work/rest cycles with suitable hydration, provision for taking the core temperature and administering intravenous fluids, and a pre-arranged casualty evacuation plan which can be relied upon 24 hours a day.