



HEAT - A BURNING ISSUE

IT'S TOO HOT TO RUN...

by Dr. JEAN-PIERRE DE MONDENARD

Heat is responsible for many breakdowns, each with its own particular mechanism. Debilitation through loss of water, or dehydration, is known as *heat exhaustion*. *Sunstroke* corresponds to an attack on the brain and meningitis due to intense sun radiation on the head and back of the neck. Finally, *heatstroke* is due to a breakdown in the elimination of heat by the body and occurs particularly in hot, heavy weather, when the body is submitted simultaneously to intense exertion.

TEMPERATURE REGULATION DURING EXERCISE

Unlike the majority of living beings whose body temperature differs little from that of the ambient air, some species, like birds and mammals, keep their internal temperature more or less constant, independently of sun or snow.

It is this "homothermal" mechanism, which is the thermo-regulation or automatic regulation

of body temperature, that brings into play a series of complex functions, some of which are still not fully understood.

"Man's thermo-regulatory system includes heat-sensitive receivers, which register the temperature of the skin and the deep parts of the body, and transform this information into nerve impulses which converge towards an integration centre known as the thermal centre (which main-

tains our internal temperature at 37° C) situated at the base of the brain in the hypothalamus, where they are compared with the standard human temperature of about 37° C. If the temperatures differ, orders are sent out to the different effective centres to correct them."

Heat produces two reactions:

- dilatation of the blood vessels;
- secretion of sweat through the sudoriferous glands.

Six elements modify the importance of cutaneous vasodilation and sudation:

- 1) the average air temperature around the jogger in action;
- 2) the temperature of the solar radiation upon contact with the uncovered cutaneous layer (head, arms, legs);
- 3) the speed of air displacement around the body: a draught, even of equal temperature to the ambient air, has a cooling effect, since it encourages evaporation;
- 4) air humidity: dry air increases evaporation;
- 5) the intensity of the exertion: this level influences the production of heat by the muscles;
- 6) the thermal resistance of clothing.

1. Overheating under exertion

Body temperature increases with exertion. This increase is due to the great quantities of energy needed to put the muscles into action. In effect, the energy is liberated through the breaking down of glucose (sugar) and lipids (fats).

This process produces heat while raising the body temperature; 50 kilocalories (Kcal) is enough to induce a rise of about 1 degree. For one hour of sustained exertion a jogger uses up about 900 Kcal (varying of course with the subject's weight, the wind speed, percentage of slope, etc.). In this example, the body temperature would pass from 37° to 55° C, if there were no way of cooling it.

If the sun is shining while you run, the body absorbs a certain amount of heat through infrared radiation which penetrates deeply through the skin. Sometimes dozens of Kcal are involved, which the body then has to eliminate. The runner's white singlet reflects more of the sun's rays than dark colours, and thus contributes to lowering the amount of heat absorbed by radiation. On the other hand, running with the chest uncovered is not the best way to combat heat.

In fact, the skin, whatever its pigmentation, behaves like a "black body", that is to say, it absorbs all the infrared radiations without reflecting them.

To avoid overheating the body (heat from exercise + the heat of the sun's rays) the body must be cooled, partly by conduction, convection and the radiation of heat in the best surrounding environments, but above all through the evaporation of sweat on the skin. Sudation is consequently very important during intense, prolonged physical exercise such as that involved in running a race.

2. The release of heat

During exercise, 80 % of the energy released is transformed into heat. The human body can only accommodate a small amount (less than 10 % of the 80 %). It is therefore essential that the heat produced by the body during exercise be constantly discharged during training or competition.

Different mechanisms exist:

- irradiation of surrounding cold surfaces: the body produces heat and thus radiation, which heats "objects" close at hand;
- conduction by direct contact with cold surfaces;
- heating of ambient air (convection);
- heat and water vapour discharged through the lungs;
- evaporation of perspiration.

We will deal with the last three in detail:

a) *heat released by convection*

Generally, the body temperature is higher than the air temperature, and this is for three reasons:

- it is rare, in our latitudes, to run in an air temperature above 37° C;
- the long-distance runner, especially if bare-chested, receives solar radiation which raises the heat of the skin ;
- during exercise, the body "heats up" and this heat is conveyed towards the skin by the circulation of the blood.

To combat heat, our bodies have the power to induce the dilatation of small cutaneous blood vessels which facilitate the flowing out of the heat produced in the deeper parts of the body, especially the muscles, towards the surface zones such as the skin.

Acceleration of the subcutaneous circulation can reach a level 20 times higher than normal during violent exertion; at the same time, the irrigation of muscles and internal organs is diminished.

Thus the air in contact with this "burning skin" is reheated and absorbs heat. During a race, if the subject moves rapidly, and especially if there is a wind, the layers of air in contact with the skin are continually renewed. The cooler the ambient environment (altitude), the more wind there is, the more rapid the athlete's descent, and the greater the part of the skin uncovered by clothing, the higher are the heat losses through convection.

For a jogger running flat out in the sun, this mechanism is not enough to ensure cooling of the body; the heat arriving on the skin through the blood must be eliminated in the surrounding environment. The processes of calorie transfer by radiation and convection are sometimes insufficient here.

When the radiating temperature or that of the air is higher than the skin temperature it can even happen that the body stores up the heat. The only calorific means of elimination then lies in sudation.

In practice, during outdoor exercise the cooling induced by the air increases the elimination of heat through *Convection* and *Radiation*, on condition that the temperature of the ambient air is lower than 33-34° C. Above that, the surrounding environment contributes heat to the body through convection. For these reasons, the organization of competitions or exercises of long duration must be avoided as much as possible when temperatures reach this level.

b) Heat released through evaporation

The loss of heat through evaporation is due to the elimination on the skin of the sweat produced by specialized glands (sudoriferous) which number about three million. This mechanism takes over from the others (convection, radiation, conduction) when the heat becomes more intense (exertion + sun). The main consequence of sudation, apart from the elimination of heat, is to induce a loss of fluid. Thus, during intense exercise the body may lose more than 2 litres of water in an hour through perspiration. During a marathon, the loss may reach up to 6 litres. Resting, the maximum amount of sweat pro-

duced varies on average between 600 and 800 millilitres an hour, according to the subject and his state of acclimatization, which may vary according to the heat.

Each litre of perspiration eliminates 600 kilocalories (Kcal). By multiplying the weight in grams of perspiration lost by the body during the exercise by 0.6, the amount, in Kcal of heat, eliminated by evaporation is obtained.

But in order to be efficient, this sudation must be able to evaporate. The drier the ambient air, the higher the percentage of perspiration which evaporates. If the heat is damp, that is to say saturated with water vapour, the rate of sudation dries up. Thus the hygrometry, when raised, may prevent the evaporation of the sudation; as a result, damp heat is more dangerous than dry heat. Even the ability to sweat profusely is not an advantage. If you are climbing a hill with a steep slope, and therefore at reduced speed, the loss through convection is considerably eased, and drops of sweat appear in number on the skin, without time to evaporate properly. Heat loss is therefore insufficient and perspiration ineffective. For this reason, anyone fond of summer outings must be careful not to go barechested. The same phenomenon follows the end of an intense and prolonged physical effort. As the runner is immobile, the air speed is nil, and drops of sweat cannot evaporate easily and inundate the face, especially the forehead and arms.

Finally, we know that sudation can only be evaporated instantly if the output of the sudoriferous gland is low. If it is too high, part of the sweat secreted spreads out over the skin and thus loses a great part of its capacity to disperse energy.

During exertion, most of the heat is eliminated by evaporation. Between 25° and 30° C, two-thirds of the heat produced is eliminated through sweating.

c) Heat released through respiration

When the air exhaled through the mouth is hotter than the air absorbed and, in addition, it is saturated with water vapour, heat is also expelled through the lungs. When we go jogging in winter, we seem to blow out "smoke". The quantity of water vapour eliminated rises when the air temperature falls. In summer, this loss is insignificant.

HEAT EXHAUSTION

Hypoglycaemia (drop in blood sugar due to a lack of glucosidic nourishment during exertion) is a common cause of exhaustion but should not be confused with the debilitation induced by heat and dehydration.

Water to cool the motor

It is known that more than 45 minutes of physical activity leads not only to the consumption of fuel (sugars + fats) but also water loss. The sudation flow rises proportionally with the intensity of the effort. Losses of up to 12 litres in 24 hours have been noted among soldiers in training, and 4 litres per match for professional footballers and during some particularly hot marathons, “floods” of 6 litres. Now, serious scientific work has shown that the greater the water loss, the lower the physical capacity. A loss in liquid of 2 % in relation to body weight (about 1 to 1½ litres for a subject weighing 70 kg) reduces physical capacity by about 20 %.

For a 4 % dehydration of the body, working capacity is reduced by 40 % at 18° C exterior temperature and 60 % at 41° C.

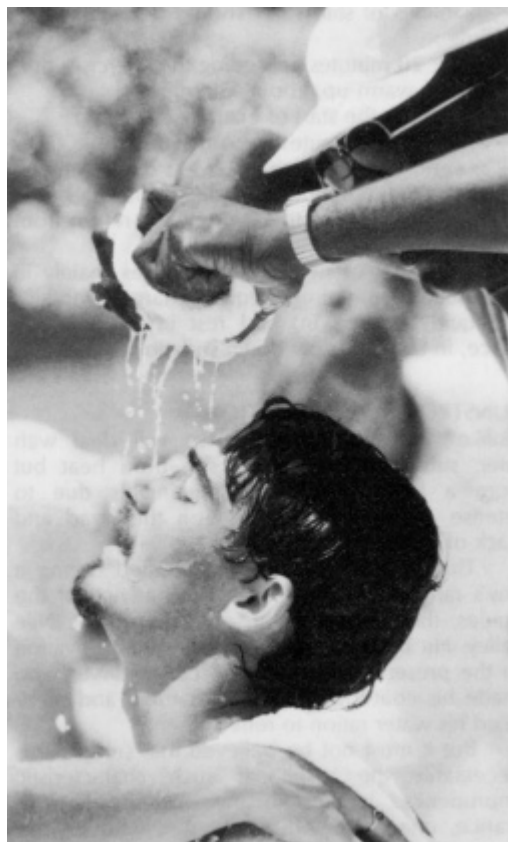
The persistent reduction of liquid space outside the cells and principally in the “tubes” leads to a reduction in blood volume which can reach 10 to 12 % when the “compensation” (drinks) is insufficient. This drop in blood volume, due to sudoral losses, results in a lowering of irrigation of the non-essential vascular territories (kidney, digestive tract, etc.). The cardiac rate is lowered and orthostatic or permanent arterial hypotension is frequently noted.

Exhaustion due to heat often occurs in someone who leads a sedentary life six days out of seven and suddenly decides to run 10 kilometres or more without any regard to the temperature. Liquid loss is demonstrated by:

- body temperature round about normal for a certain effort;
- cold, sweaty skin;
- sleepiness, a sensation of weakness or inability to complete the exercise followed by vomiting, tachycardia (acceleration of the pulse) and hypotension.

Heat exhaustion may also occur in a trained runner who finds himself in summer suddenly exposed to an unaccustomed temperature.

Not accustomed to drinking during exercise, and taking account of the importance of the



water loss, a more or less severe level of dehydration can occur all of a sudden and lead to heat exhaustion. The prevention of heat exhaustion involves hydration from the beginning of exercise (a circuit with a water spout available on each round).

Prevention and treatment

During more than 45 minutes of sufficiently intense activity, water and glucose absorption (25 to 30 g. per litre of water for an ambient temperature above 25 degrees) occurs according to each type of exercise (length and intensity).

In hot weather, the following broad guidelines should be observed:

- between a meal taken at least three hours beforehand, and the start of an event, small

quantities of still water should be taken regularly;

- in the 20 minutes preceding the exercise, during the warm-up, about 150 ml;
- just before the start of exercise: 150 ml;
- every 20-25 minutes: about 150 ml;
- as soon as the exercise is over: drink as much as desired, without limit (plan to have a bottle ready in advance to be drunk on return from jogging or an event).

The treatment of heat exhaustion lies mainly in rehydration (sometimes requiring large quantities of liquids poured in) and rest in a cool, airy place, in order to slow down sudation.

SUNSTROKE, OR INSOLATION

Unlike "heatstroke", which we will deal with later, sunstroke does not result from heat but from a brain lesion and meningitis due to intense radiation of the sun on the head and back of the neck.

Three French tourists almost died during a day's ramble on foot. Against the advice of the guides, they set off on an excursion in the Nile valley. Hit by insolation, they owe their salvation to the presence of mind of a camel driver who made his coat into a shelter for them and sacrificed his water ration to refresh them.

But it must not be believed that sunstroke is necessarily the result of such characteristic imprudence. loggers in the northern half of France, unaccustomed to the sun, who expose themselves to it for hours on the roadsides or the beach can also be victims.

The symptoms

Running full tilt, during the hottest part of the day and especially if bare-headed, the following signs appear: red, swollen face, buzzing in the ears, dizziness, headache, nausea, sleepiness, raised pulse, weak, rapid respiration, then suddenly the subject is unable to carry on and collapses on the ground. If, despite this warning, he tries to continue, heatstroke is possible.

Action to be taken

- Stop all exercise;
- undress the runner;
- take him to a cool, ventilated place;
- place ice-bags or cold compresses on the forehead and back of neck.

Prevention

Sunstroke can have long-term repercussions. A few weeks after he had won a silver medal at the Games of the XVIIIth Olympiad at Tokyo, Basil Heatley fell victim to serious insolation and disappeared from athletic circles. This example should prompt us to protect ourselves properly.

The head must be protected in the case of prolonged exposure using a light, white, airy cap or visor. It is possible to improve protection with two caps, "Sherlock Holmes" style, one with a visor on the front protecting the forehead, and another at the back protecting the nape of the neck. For many years now, a road race organizer (semi and marathon) has had to provide sponging posts every five kilometres, in between refreshment posts, where the runners can sprinkle themselves with water and sponge down afterwards. In the same way, wearing a cap that has been wrung out in cold water brings long-lasting coolness. In the case of tropical temperatures — when it is better not to run at all — a soft rubber sponge filled with cold water can be worn under the singlet, suspended by a cord, to hang over the nape of the neck. This humidity is all the more effective since the water vaporises on the same principle as the Spanish "alcarazas", (a porous clay jug in which water cools by evaporation).

HEATSTROKE

Heatstroke or malignant hyperthermia is a rare but extremely worrying occurrence and the final stage in the overheating of the body.

At Stockholm in 1912, during the Olympic marathon, the Portuguese runner Lazaro died following an accident of this kind.

It involves a sudden breakdown in thermoregulation, cessation of sudation and hyperthermia. Failure to recognize it immediately can have serious consequences since any delay in treatment increases the prognosis. Diagnosis is, however, simple and lies above all in the level of rectal temperature, which is always above 39° C. The accumulation of heat is favoured by different elements:

- excessive production of heat through physical exercise;
- additional heat coming from high ambient temperatures;
- thick, hot, dark garments;

— absence of wind to facilitate evaporation by replacing the hot gassy molecules by cooler ones;

— raised level of hygrometry.

A series of experiments have been carried out to study the resistance to heat of passengers in outer space. Soviet experts, like their American colleagues, have noted that in the case of a breakdown in the thermal protective system cosmonauts can endure a temperature above 100 degrees for several minutes. But one condition for human endurance is essential: it must be dry heat. Our bodies are really steam engines and burn about 3,000 to 3,500 Kcal a day including a 10 km jog, which is enough to boil 27 litres of water. Part of these calories are dissipated through evaporation when the air is dry. In a

humid atmosphere, on the other hand, this safety-valve plays its role with more difficulty.

Medication

It appears that certain drugs which act on the nervous system could in certain cases encourage the occurrence of this type of accident, even in our climate.

Amphetamines have induced more heat stroke than a burning sun.

The death of the Englishman Tom Simpson, while it does not concern the world of running, is a good example.

During the stage at Ventoux, in the 1967 Tour de France, the British cyclist fell victim to malignant hyperthermia through dehydration and



amphetamine doping in addition to the exertion. All this led to mortal "overheating".

Symptoms

Heatstroke involves:

- high central temperature, often above 39.5°, sometimes beyond 42° C, the prognosis then being very poor;
- hot, dry, reddened skin;
- signs of a cerebral attack: stumbling gait, headache, vertigo, robot-like gestures, mild state of confusion (the victim does not react to calls from his team-mates).

At an advanced stage, the victim is seen to collapse and lose consciousness.

Action to be taken (see box: Heat stroke, the most efficient treatments)

The main aim of the treatment is to lower the body temperature rapidly:

- place the subject in a cool, airy place: undress him and wrap his body in sheets which have been dampened in cold water (change them frequently);
- take care to ensure that there is good ventilation, move any curious hangers-on away from the scene;
- if the means are available, immerse him in a freezing cold bath. This is the most efficient and rapid means of lowering body temperature;
- give him plenty to drink, but only if the subject is still conscious. If not, refrain from giving him liquids, as doing so may suffocate him, and send for resuscitation equipment.

Prevention

The best protection consists in limiting to a maximum those factors which increase the risk of heatstroke:

- do not run outside during the hottest part of the day. Some organizers have understood this problem and arrange the start of the race either early in the morning or late in the afternoon;
- without progressive adaptation, the length and intensity of training must be reduced when it gets hot, especially if there is little wind and high humidity. It should be stressed that 4 to 6 weeks are needed to adapt oneself to a very hot climate;

— avoid too much clothing. The WHO points out that it is possible to reduce by half the thermal charge of the sun's rays by wearing white garments. They must be loose to encourage air circulation and evaporation. It is also possible, thanks to a new polypropylene fibre (LIFA material) to improve the dissipation of heat by evaporation. In fact, this material is "open" and non-absorbant, which enables perspiration to pass through and evaporate by limiting overheating of the body. Clothing which does not allow the air to pass through should not be worn. The summer styles in our lands, which reduce clothing to the absolute minimum, are not very suitable for heat protection. It has in fact been proved that the micro-climate created by the garment quite clearly limits the external thermal constraints and the perspiration losses.

- wear white headgear;
- take sufficient fluids according to the intensity and duration of the exercise;
- get used to sweating in hot weather in order to be able to withstand heat better. Training in hot weather or acclimatization is expressed in a more rapid triggering off of perspiration and a lowering in cutaneous circulation. This decrease enables the muscles and internal organs to avail of a greater quantity of blood. In addition, thanks to regulatory mechanisms, the volume of plasma contained in the blood rises temporarily. Heat acclimatization is all the more rapid when the subject practises regularly. In fact, whatever the air temperature, intense respiratory activity enables heat tolerance to be increased. This is why athletes suffer less from the heat than sedentary persons. Hydric restriction does not activate acclimatization to heat and the old saw that "drinking before exercise will make the legs weak" is a mistake which can be dangerous to health by increasing the risk of heat stroke;
- avoid running immediately after a meal. During digestion, the blood volume concentrates mainly at visceral level and the elimination of heat can then be interrupted.

In conclusion, it is clear that to be "in the running" in the summer, we must guard against the effects of heat. Thus heat exhaustion, sunstroke and heatstroke can be avoided all at one go.

HOT AND COLD

This type of ailment occurs when four factors are added:

- direct sunshine (absence of clouds which reflect some of the rays);
- low level of hygrometry;
- strong cross-wind (a race against the wind increases the sensation of cold);
- a fast race.

The explanation of this phenomenon is as follows: when the race comes to an end, the runner, like his clothes, is covered with sweat. Because of the wind, evaporation and the cooling down process continue with the same intensity as during the event, while the production of heat diminishes suddenly.

Thermal regulation is thus profoundly disturbed and in a very short time, the body temperature, which had risen during the exercise, can drop very low to reach the stage of hypothermia such as that presented by Alberto Salazar during the 1982 Boston marathon. Although he won the race, his body temperature dropped to 32°C upon finishing.

To avoid this annoying consequence it is essential to remain active after exercise in order to limit the cooling down, which is inevitable, since the heat thus produced is much less than that let off during the race.

Thus the body has time to regain its normal temperature.

J. P. M.



HEATSTROKE : THE MOST EFFICIENT MEANS OF TREATMENT

The high occurrence of heatstroke during the pilgrimage to Mecca in the hot season led the Saudi Arabian Minister for Health to ask for a study to be made of the ways in which it can be treated.

The central temperature was raised above 39,5° among six volunteers through physical exercise carried out in a room heated to 48°. Different cooling techniques were then compared. Methods using a cold water mattress or cold water spray were poorly tolerated by conscious subjects. It was spraying in an air temperature of between 35° and 45° C (which means that the water had a temperature of between 25° and 35° when it reached the body) which produced the most rapid cooling (loss of 25° in 6 minutes as against 15 to 18 minutes for the other methods).

TEN "HOT SPOTS"

1. When you start training under a blazing sky, the usual intensity and distance should be reduced. Seven to ten days are required in order to become acclimatized to heat. This period enables the body, by progressive training, to favour the perspiration mechanism rather than the redirection of blood to the skin to limit overheating.
2. Before a race, the warming-up period must be reduced to avoid any prejudicial source of heat.
3. The principle of "prehydration" should be adopted. As its name indicates, it consists of drinking still water before exercise, that is to say between eating a meal and taking exercise.
4. Drink more water regularly during training (dehydration limits effort and can lead to more or less severe problems). In competition, and especially where novices are concerned, it is imperative to drink at the different refreshment posts right from the start.

5. Encourage your body to lose heat by sprinkling yourself with water at every opportunity. During road races, there are sponging posts every 5 km.
6. Dress lightly, and wear light-coloured garments (cap, singlet, shorts, socks) which reflect the sun's rays. Some garments can thus reflect more than 65 % of the radiant charge.
7. Once the finish line has been reached, you are advised not to stop suddenly but to continue running for 5 to 10 minutes so as to avoid a blackout (especially for those who are unfit) which may be linked to and increased by the heat, and its corollary, dehydration. In fact, once the exercise is over, the heart begins to slow down its rhythm and the intensity of its propulsion while all the blood vessels (arteries and veins) remain open. The result of this is to lower blood pressure in the arteries and the quantity of blood which reaches the brain becomes insufficient. It may happen that the runner loses consciousness. This ailment should not be confused with a cardiac incident where the blackout is linked to the intensity of the effort and not to its cessation. This type of trouble can be avoided by continuing to jog for a few minutes after reaching the finish or by lowering the head between the knees. The brain is then lower than the heart and the blood reaches there more easily.
8. Once training is over, do not rush under the shower or into a sauna for you risk collapsing. In effect, the shower increases the movement of the blood towards the skin and penalizes the heart.
9. Once at the finishing post, drink as much as you want. This will encourage the reconstitution of your energy stock and restore liquid capital.
10. Up until you go to bed, drink as much as you can to rehydrate yourself, while at the same time encouraging the elimination of toxins ; at your next meal, eat fewer proteins, especially meat, so as to limit accumulation of wastes.