



Exercising in the Heat . . . Part I

Or the art of staying alive during summer races

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I can already hear laughter. That is quite acceptable, I deserve it. But admit it: who could possibly be in a better position to describe heat effects on your running performance than me? Okay, I should have maybe done some more research before APOC 2002, but if I had, maybe I would have never really experienced the *real* effects of overheating! (Yes, I was found unconscious near the finish line at APOC 2002. The temperature that day was of 36 C/97 F in the forest, 39C/102F in the sun. Crazy!) So you can avoid my mistake, here is a compilation of the latest research development on exercising in the heat, its effects on athletic performance, and how to prepare our bodies for exercising and competing in the heat.

Effects of heat during exercise

Exercising in the heat can cause some serious threat because your body is faced with two competing demands: (1) muscles

requiring oxygen to continue firing (that is usually achieved by having more blood going to the muscles) and (2) extra heat produced needing to be transported to surface tissues (now meaning that the blood has to move away from the muscles to dissipate heat at the surface). So you can easily understand why it is so hard to perform well in the heat! Let's begin by looking at what happens deep inside...

▲ Circulatory adjustments: for some still unknown reason, the volume of blood your heart can pump (called *stroke volume*) is usually lower during exercise in the heat. But this is compensated by a proportionate increase in number of beats per minute (called *heart rate*), meaning that your total *cardiac output* (product of stroke volume by heart rate) remains similar in hot and cool environments. However, in maximal exercise



(interval training, race situation...) this compensatory increase in heart rate is not sufficient to offset the stroke volume decrease and therefore maximal cardiac output and aerobic power are reduced. Also, when exercising in heat, a lot of your blood gets redirected towards the surface so that you can evaporate most of the heat.

This is done to the expense of some organs (since your muscles continue to demand high levels of blood and oxygen) like your liver and kidneys, which can lead to some further complication (see below in *Accumulation of lactic acid* and *Water loss in heat*).

▲ Maintenance of blood pressure: heavy exercise in the heat is almost always accompanied by dehydration (which reduces the plasma volume). This means that relatively less blood is pumped throughout

the body so the blood pressure would tend to drop. In order to maintain adequate pressure, shutting down of blood vessels (called *vasoconstriction*) in your viscera (liver, kidneys, stomach...) occurs, which puts even more stress on them.

▲ Accumulation of lactic acid: sub-maximal exercise is usually well tolerated in the heat because of the adaptations stated above. Nevertheless, it is generally accomplished with a greater dependence on anaerobic metabolism than in cooler conditions. This results in the early accumulation of lactic acid because normally your liver processes most of the lactic acid. Now that the circulation to the liver has been almost shut down, the lactic acid cannot be metabolized as effectively. The circulation to muscles has also been decreased by the increase of circulation to surface blood vessels, meaning that you cannot

Jeff Watson's Depiction of Marie-Cat's APOC 2002 Adventure





transport the lactic acid out of your muscles as adequately as normal. Both of these factors may be responsible for early fatigue during even moderate exercise in the heat (imagine now racing...).

▲ Higher core temperature: the heat generated by exercising muscles can raise the body temperature to much higher degrees than external heat stresses alone (in other words, running brings your core temperature to a much higher level than scorching heat ever could). Within limits, the increase in core temperature during exercise does not reflect a failure of the heat dissipating mechanism. To the contrary, it is a well regulated response that even occurs during exercise in the cold. Conclusion: outside temperature alone does not affect core temperature significantly.

▲ Water loss in the heat: now here is one thing that can affect core temperature. In a few hours of hard exercise in the heat, water loss or dehydration can reach proportions that impede heat dissipation and severely compromise cardiovascular function and work capacity. For an elite athlete water loss by sweating may reach a peak of about 3 liters per hour during severe work. As dehydration progresses and plasma volume drops, sweating is reduced and keeping your core temperature within normal limits (called *thermoregulation*) becomes progressively more difficult. Dehydration increases core temperature, increases heart rate and decreases sweat rate, leading to very poor performance and potential risks from heat stress (called *heat illnesses*).

Complications from excessive heat stress

▲ Heat cramps/ muscle spasms: heat cramps and muscle spasms are common and occur during or after intense physical activity. They are usually observed in the specific muscles that are exercised. This form of heat illness is probably due to an imbalance in the body's fluid and electrolyte concentrations. During heat exposure, salts can be lost as a result of profuse sweating. Muscle spasm (cramps) may occur if these electrolytes are not replenished. Prevention of that phenomenon can usually be assured by increasing the daily intake of salt several days preceding the period of heat stress.

▲ Heat exhaustion: exercised-induced heat exhaustion is believed to be caused by ineffective circulatory adjustments (described above) compounded by a depletion of plasma due to excessive sweating. Blood usually accumulates in the dilated surface blood vessels reducing the central blood volume necessary to maintain the cardiac output. Heat exhaustion is characterized by a weak and rapid pulse, low blood pressure

(observed in standing), dizziness, headache and general weakness. Body temperature, however, is not elevated to dangerous levels (less than 40°C or 104°F).

▲ Heat stroke: this is the most serious and complex of the heat-stress illnesses and requires immediate medical assistance. Heat stroke is essentially a failure of the heat-regulating mechanisms brought on by excessive high body temperatures. When the thermoregulation fails (your central thermostat literally busts), sweating usually ceases and the skin becomes dry and hot. Body temperature can rise to dangerous levels (over 40°C).

Heat stroke is a medical emergency. The symptoms can often be subtle but if left untreated, the disability progresses and death follows due to circulatory collapse and eventually damage to the central nervous system (brain and spinal cord). If found facing a possible case of heat stroke, one must take aggressive steps to lower the core temperature as quickly as possible (whole body immersion in ice cold water remains the gold standard).

Decreasing the effects of heat

You cannot stop the heat from doing its damage (unless you have some serious connections with Weather Man!), but you can certainly help your cause. There are quite a few factors that can help you perform better in heat, let alone perform safely.

▲ Staying well hydrated: ingestion of extra water prior to exercise in the heat provides some protection because it delays the development of dehydration. In this regard, it would be wise to consume 400-600ml (13-20 oz.) of cold water before exercising in the heat. This procedure, however, does not replace the need for continual fluid replacement and is not as effective in maintaining thermal balance as consuming an equal volume of water during the exercise – a volume of about 250ml (1 cup) ingested at 10-15 minute intervals is probably a realistic goal because larger volumes tend to produce feelings of a full stomach.

Another important factor is the rate of gastric emptying, meaning the speed at which your stomach is emptying fluids to feed the rest of your body. The faster, the better. Cold fluids (5°C or 41°F) are emptied from the stomach at a faster rate than fluids at body temperature. The volume of fluid in the stomach is also of importance because gastric emptying speeds up for each 100ml increase in gastric volume (up to 600ml). So to obtain the best fluid absorption, the stomach should remain partially filled and the fluid ingested should be relatively cold.

▲ Avoid using sugary drinks: it has been observed

that gastric emptying is slowed down when the ingested fluid contains concentrated simple sugars, whether in the form of glucose (honey, ripe fruits...), fructose (fruits) or sucrose (granulated sugar, dates...). A 10% glucose solution, for example, cuts the rate of gastric emptying by one-half that of plain water (and it drops exponentially)! So during exercise in the heat, when the need for water greatly exceeds the need for carbohydrate supplementation, concentrated sugar drinks may hinder water replacement.

▲ A small amount of salt might be beneficial: it appears that pure water absorbed from the gut rapidly dilutes the plasma concentration of sodium, which stimulates urine production and blunts the sodium-dependant stimulation of thirst. Maintaining plasma concentration of sodium by adding a small amount of this electrolyte to the ingested fluid may sustain the thirst drive and more rapidly restore lost plasma volume. So the use of electrolyte replacement drinks might be wise to stay well hydrated.

▲ Staying lean: obesity is a liability when working in the heat. Because the specific heat of fat is greater than for muscle tissue, excess fat increases the insulatory quality of the body shell and slows down the conduction of heat to the surface. In other words, the heat gets trapped below the layer of fat. Lovely!

▲ Choose clothing carefully: warm weather clothing should be loose fitting to permit the free circulation of air between the skin and environment to promote water movement away from the skin. Avoid thick and heavy materials like sweat shirts and clothing made of rubber fibers or with rubber prints on them – they produce high relative humidity close to the skin and retard the vaporization of moisture from the skin surface. This significantly inhibits or even prevents evaporative cooling (try exercising in a rain jacket one day, and you will for sure understand the principle!). Color is also important because dark colors absorb light and add to the radiant heat gain whereas light colors reflect heat rays.

▲ Follow your menstrual cycle: a female's menstrual cycle can affect how females perform in the heat because it affects their core temperature. Females may find that some days the heat doesn't affect them, while other days they feel mysteriously hotter. Women, try to make note of those days and figure out what part of your menstrual cycle makes you more susceptible to heat.

▲ Acclimatize to the heat: you can certainly create some acclimatization to the heat by training in the heat and simulating its effects. This will be the main subject of Part II of this article. Stay tuned!

