

Energy metabolism in the human body is only 20-40% efficient, the remaining 60-80% of all energy produced in the muscle cell is lost as heat (similar to an automotive engine). Heavy exercise generates up to 20 times more heat than at rest. Excess heat is not only a major limiting factor in performance but can ultimately lead to heat exhaustion therefore heat must be dissipated continuously.

The primary mechanism for dissipating heat is sweat production. Sweat evaporates off the skin together with the associated heat. Sweat contains water and salts (mostly sodium and chloride) therefore excessive sweating can lead to a major loss of both. A single litre of sweat contains nearly 3 gram of sodium chloride and athletes working intensively in the heat can lose up to 2.5 litres of sweat per hour. Assuming a marathon paddle takes for an average paddler approx 2 hours that translates to 15 gram of salt (2.5 teaspoons) and 5 litre of fluid loss which exceeds by far the normal daily intake.

Secondary to the sweat production the body will dissipate heat by moving more blood to the skin allowing the dissipation of heat away from the body's inner core to the body surface where sweat can do its work. Both mechanisms, the increased blood flow to the skin and sweating, rely heavily on adequate blood volume. In other words a reduced blood volume results in compromised blood flow to the skin and reduced sweat production.

Additionally working muscles require good perfusion to receive nutrients, oxygen and to remove metabolic by-products. We now realise that there is a simultaneous and competing need for blood volume within our organ systems during heavy exercise. With a low blood volume heat regulation and muscle activity can be severely compromised. Therefore maintenance of blood volume should be considered as the primary indicator whether performance can be sustained during a marathon.

You probably know the answer to this question: Is it ok to drink water for hydration during exercise? No! During exercise we lose water, electrolytes and blood sugar! Sports beverages should contain all 3 things! If we drink large amounts of plain water oedema can occur that we experience as bloating.

It is recommended for any exercise longer than 30 minutes that a good quality sports beverage should be consumed even before thirst occurs. "Thirst" is a sensation of dry a mouth and throat and occurs linear with blood plasma concentration. Unfortunately thirst is only occurring when already 2 litres of body water are lost and is a poor indicator for fluid requirements. If you get thirsty during a race or training, it's already too late and most likely you are already experiencing a lowered performance due to low blood volume! Generally during exercise fluid loss exceeds fluid intake making it impossible to re-hydrate completely during the activity. To avoid dehydration we must train ourselves to drink on a fixed schedule and you are more likely to drink what tastes good, so make an effort and treat yourself whether you feel thirsty or not.

Fluid input is also depended on how quickly the consumed fluid can now enter the blood stream. The main influencing factor for the speed at which water can be absorbed by the intestine during the exercise lies in the amount of carbohydrates in the solution. A 6-7 % carbohydrate solution appears the best balance for speedy absorption. Highly concentrated exercise gels can cause a temporary shift of fluid from the blood to the intestine to dilute the gel. This can have a negative impact on the fluid household as described earlier, therefore gels should be consumed with plenty of fluid for dilution.

Even a minor level of under-hydration (2% of body weight) will lead to measurable reduction in aerobic performance because:

- Temperature regulation is adversely affected (body overheats)
- Muscle perfusion is disturbed (oxygen, electrolyte and sugar delivery impacted)

It is critical to already enter the exercise in a state of optimal hydration and maintain blood volume as best as possible.

How to best re-hydrate: Staying hydrated at all times will assist recovery and should be part of your exercise regime to start the next exercise in optimal hydration. After exercise:

- Start a single larger dose of fluid intake (500ml)
- Consume approx. 250ml every 15 min (3l within first 3 hours)

Heat Exhaustion: Symptoms of heat exhaustion are weakness, cold and clammy skin, fatigue, nausea and a weak pulse. A dehydrated person also has stopped sweating and the skin feels dry. Those symptoms are the cause of either cardiovascular insufficiency, hypotension or poor energy availability. Hypotension can lead to inadequate blood supply to the brain potentially leading to a semi-conscious state. The person should be cooled down immediately (wet towels or cold water shower) and provided with cool drinks if at full consciousness. Do not continue any exercise on the same day.

Heat stroke: A heat stroke is an extremely dangerous situation where the body temperature exceeds 40°C. The skin is hot and dry and the pulse rate very fast. This is a stage of decompensation. The athlete potentially loses full consciousness or at least experiences signs of central nervous system dysfunction such as confusion. This person needs to be hospitalized asap.