**Introduction:** Electrolytes, the mineral salts that conduct the electrical energy of the body, perform a cellular balancing act by allowing nutrients into the cell, while excreting waste products. Certain elements, sodium, chloride, magnesium, calcium and potassium, play a primary role in cellular respiration -- that of muscle contraction and nerve impulse transmission. It is at the cell membrane where these electrolytes conduct electrical currents similar to nerve impulses.

**Sweat:** Endurance performance in heat is normally lower in warmer temperatures than cooler temperatures. Here’s why: in order to control an excessive rise in body temperature, the blood flow to the skin increases in order to dissipate heat to the environment. This shift of blood to the skin will result in a lesser proportion of blood, and hence oxygen, being delivered to the working muscle. So, in warmer temperatures the body has to slough off more heat through sending more blood to the skin, which results in less blood and oxygen in muscles. In some individuals the circulatory adjustments may not be adequate and the body temperature will rise rapidly, leading to hyperthermia (excessive body heat). About 99% of sweat is water, with a number of major electrolytes found in varying amounts. Since sweat is derived from the extracellular fluid (fluid outside the cell) the major electrolytes found are sodium and chloride. The concentration of salt in sweat is variable, but averages about 2.6 grams per liter of sweat loss. Potassium, magnesium, calcium, iron, copper, zinc, amino acids and some of the water-soluble vitamins can also be found in sweat.

**Too much water?:** Hyponatremia is defined as a decrease in sodium concentration in the blood, which can have adverse effects on muscle contraction and performance. If hyponatremia becomes excessive death can occur. One study following a three-day cycling stage race competition concluded that 27% of participants were hyponatremic. Symptoms of hyponatremia include headache, nausea, muscle cramping and fatigue. Although there may be many causes of
hyponatremia, the most common one is overhydration, many times resulting from athletes superhydrating in the days leading up to a race without an appropriate increase in electrolytes. In some cases, superhydrating can produce hyponatremia prior to the race ever starting. However, racing with water only also causes hyponatremic conditions because the body requires electrolytes to effectively perform cellular respiration. Hyponatremia, rare in events lasting less than 4 hours, has been shown in recent medical studies of slower marathon runners and ultra-distance triathletes to be at least as problematic and dangerous...if not more so...than dehydration.

Sodium and Chloride: Sodium is one of the principle positive ions in the body’s fluid and is found primarily outside the cell (extracellular). Chloride, another extracellular electrolyte, has a negative ion and works closely with sodium in the regulation of body-water balance and electrical impulses across the cell membrane. Consuming adequate amounts of sodium and chloride, more commonly known as table salt, is crucial to maintaining the volume and balance of fluids outside your body’s cells, including in your blood. Sodium is especially important because it plays a key role in transporting nutrients into cells to be used for energy production, tissue growth, and repair. Sodium also assists in muscle contraction and nerve impulse transmissions. During exercise, your body loses fluids and sodium through sweating. This causes a decrease in your blood volume, thereby increasing sodium and chloride concentrations in the blood. The increased concentration of electrolytes in the blood through decreased blood volume is what triggers the thirst mechanism. By the time you have become thirsty, your electrolytes are already out of balance, so restoration of blood volume is critical for the prevention of dehydration. Water consumption is effective in increasing your blood volume, however there is a consequential dilution of sodium in your blood due to the increased blood volume and excessive sodium losses in sweat, so electrolyte replenishment is key. Drinking fluids with added sodium instead of just plain water is the best option, particularly when your exercise bouts last longer than one hour.

Potassium: Potassium, the main electrolyte found inside the body’s cells (intracellular) and stored in muscle fibers along with glycogen, plays a key role by helping transport glucose into the muscle cell. Potassium also interacts with both sodium and chloride to control fluid and electrolyte balance and assists in the conduction of nerve impulses. When glycogen breaks down to supply energy for your workouts, muscle cells are depleted of potassium. As a result, there is a greater concentration of potassium in your blood and greater quantities are lost in the urine. Symptoms of potassium depletion include nausea, slower reflexes, irregular heartbeat, drowsiness, and muscle fatigue and weakness. Although potassium deficiencies are rare, they may occur under certain conditions -- during fasting, diarrhea and when using diuretics. Replenishing potassium after loss during exercise is important, but hyperkalemia (high serum potassium levels) can cause electrical impulse disturbance and possible death. Individuals should never take potassium supplements in large doses without the advice of a physician.
Magnesium: Magnesium is an element found in every cell in your body, with the largest concentrations found in the bones, muscles, and soft tissues. Magnesium forms part of 300+ enzymes involved in nerve impulse transmission, muscle contraction, and ATP (or energy) production. Increased levels of exercise deplete your body’s stores of magnesium so it is crucial to replenish what you have lost. Magnesium helps regulate the synthesis of protein and other compounds such as 2,3-DPG, which is essential for optimal oxygen metabolism. Investigators suggest that prolonged exercise increases magnesium losses from the body via urine and sweat. Signs of magnesium depletion include dizziness, muscle weakness, fatigue, irritability, and depression.

Electrolyte Concentrations intra/extra cellular and in sweat

<table>
<thead>
<tr>
<th></th>
<th>extracellular (mmol/L)</th>
<th>Sweat (mmol/L)</th>
<th>Intracellular (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>137-144</td>
<td>20-80</td>
<td>10</td>
</tr>
<tr>
<td>Potassium</td>
<td>3.5-4.9</td>
<td>4.0-8.0</td>
<td>148</td>
</tr>
<tr>
<td>Calcium</td>
<td>4.4-5.2</td>
<td>3.0-4.0</td>
<td>0-2.0</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.5-2.1</td>
<td>1.0-4.0</td>
<td>30-40</td>
</tr>
<tr>
<td>Chloride</td>
<td>100-108</td>
<td>30-70</td>
<td>2</td>
</tr>
</tbody>
</table>


By Sally Warner MA, Ph.D.
Six practical recommendations:

1) Use electrolytes with your water when hydrating. Hydrating solely with water leads to water intoxication and an electrolyte imbalance.

2) Acclimate to heat by exercising in heat

3) Test different levels of electrolytes during training in heat

4) Weigh yourself prior to a long exercise bout in heat and again afterwards. Subtract the total fluids you took in and the difference will be your hydration deficit.

5) Make sure your recovery drink has adequate amounts of electrolytes. (See chart below)

6) Do not make any drastic changes to your diet for the days leading up to the race and on race day. Drastic changes can adversely affect your electrolyte balance.

Acceptable ranges for electrolytes in a recovery drink

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>150-750mg</td>
</tr>
<tr>
<td>Potassium</td>
<td>200-1000g*</td>
</tr>
<tr>
<td>Calcium</td>
<td>400-1200mg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>200-800 mg</td>
</tr>
<tr>
<td>Chloride</td>
<td>90-750mg</td>
</tr>
</tbody>
</table>

*Excess potassium can become problematic (see potassium)

Resources:

www.nationaldairycouncil.org


Brouns, F., et al. 1992 Rationale for upper limits of electrolyte replacement


