Sweat Mineral Losses

Minerals are lost in sweat. Prolonged exercise, especially in the heat, has the potential to create mineral deficiencies.

Is during-exercise replacement necessary? To answer this question we need to know:

- Is the amount of mineral lost in sweat significant?
- Are daily intakes typically greater than possible sweat losses?
- Are there body reserves or mechanisms to cope with occasional acute deficiencies?
- Will deficiencies result in performance or other problems?

Many minerals have several regulatory mechanisms. For example:

- The kidneys help regulate electrolyte balance. When electrolyte intake is high, excretion through the kidneys allows the body to normalize levels. When electrolyte intake is low, the kidneys conserve. When the kidneys are maximally conserving a mineral, and intake is inadequate, deficiency may result.

  The kidneys have the ability to vary the rate of sodium excretion by a factor of more than 100. A normal balance of sodium is maintained through a very wide range of intakes.
- Similar to kidney-regulation, sweat glands may regulate mineral concentration. Concentration may decrease as blood levels fall.
- Storage sites may release minerals when blood levels fall.

  Low blood levels of calcium may be corrected by the release of calcium from bone.

Of the 21 minerals possibly important in human nutrition, we will eliminate from discussion the trace minerals arsenic, boron, chromium, cobalt, copper, molybdenum, nickel, selenium, silicon, and vanadium. Too little is known about these minerals. Reliable data is not available about their concentration in sweat. Functions and toxicities are uncertain.

Details about all 21 minerals and their biochemistries are discussed in detail beginning on page 275.

We will eliminate fluorine/fluoride because water is generally fluoridated, and sweat levels are uncertain.

Finally, we will eliminate iodine and chlorine/chloride. These minerals are consumed along with sodium.

This leaves calcium, iron, magnesium, manganese, phosphorus, potassium, and sodium as possible candidates for concern and replacement.

Let us discuss these remaining minerals. Mineral intakes, absorption efficiency, body content, and sweat levels are listed in Table 2.

Intakes are based on US averages. Soil content can considerably change the mineral content of some foods and therefore intake.

Sweat concentrations vary considerably, and reliable data is often not available. Fitter athletes may have different concentrations than those less fit. Concentrations may change as a workout progresses.

Let us look at sodium to see how the table works. (We will discuss details about sodium below.) The typical daily intake is 4,000 milligrams (4 grams). Absorption efficiency is greater than 90%. Therefore, more than 3,600 milligrams are absorbed daily.

The sodium body content of a 70-kilogram (154 pound) person is about 90,000 milligrams (90 grams).

Sweat contains between 230 and 1,700 milligrams of sodium per liter (quart). Assuming an intermediate sweat concentration of 1,000 milligrams, a gallon (4 quarts, 4 liters) of sweat could contain 4,000 milligrams.

Sodium losses in a gallon of sweat can exceed daily intakes and lead to deficiencies.

The Intake X AE / Sweat multiplies typical intakes by absorption efficiency and divides by typical concentrations in one liter (quart) of sweat. This gives an estimate how many liters (quarts) it takes to use up a typical day's intake of the mineral.

Manganese concentrations in sweat are so relatively low that it would take about 300 liters (about 75 gallons) of sweat to use up a typical daily intake.

As you can see from the table, sodium is critical. Just four liters (quarts) of sweat might result in a loss equivalent to a typical daily intake. Calcium and iron are also of concern; as you will read, acute symptoms are not generally a problem.

Mineral	Typical Intake, mg	Absorption Efficiency	Body Content mg/70kg	Sweat mg/L	Intake X AE / Sweat[1]	Sweat Loss Deficiency?
Calcium	500	30%	1,400,000	28	5	Maybe[3]
Iron	15	10-35%	4,000	0.1-0.4	15	Maybe[3]
Magnesium	300	10-70%	25,000	8.3-14.2	15	No
Manganese	2	5%	20	0.0025-0.0045[2]	33	No
Phosphorus	1,200	55-70%	700,000	40[4]	18	No
Potassium	2,700	>90%	250,000	150	16	No
Sodium	4,000	>90%	90,000	230-1,700	4	Yes
Zinc	11	<40-90%	2,000	0.36-0.68[2]	13	No

Table 2. Mineral intakes, body content, and sweat concentrations. Amounts are given in milligrams for easy comparison. [1]Intake X AE / Sweat = typical daily intake, multiplied by typical absorption efficiency, divided by amount in 1 liter (quart) of sweat. [2]Biolab Medical Unit (UK) reference ranges. Maybe[3] means that deficiencies are common in the general population, and that sweat losses could worsen such deficiencies. [4]Estimate.

Calcium

With an intake of 500 milligrams and an absorption efficiency of about 30%, about 150 milligrams of calcium are absorbed daily.

With a loss of about 28 milligrams per liter of sweat, it is easy to sweat out about 112 milligrams of calcium with a gallon (4 quarts, 4 liters) of sweat. This could impact your daily intake.

Acute exercise symptoms are generally not a problem. Calcium deficiency symptoms occur over time, generally resulting in osteoporosis and its symptoms.

Calcium deficiency is relatively common in the general population and aerobic endurance athletes can increase their losses with sweating. In addition to targeting calcium intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily supplement.

Read more about calcium nutrition on page 280.

Iron

With an intake of 15 milligrams and an absorption efficiency of about 25%, about 4 milligrams of iron are absorbed daily.

With a loss of about 0.3 milligrams per liter of sweat, it is easy to sweat out about 1.2 milligrams with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

As one becomes iron-deficient, absorption increases, so theoretically a new iron balance might be achieved.

Acute exercise symptoms are not a problem. Iron deficiency occurs over time, generally resulting in anemia and its symptoms.

Iron deficiency is relatively common in the general population, particularly in women, and aerobic endurance athletes can increase their losses with sweating. In addition to targeting iron intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily multivitamin/multimineral supplement.

Keep in mind that iron excess can be a serious problem.

Read more about iron nutrition on page 304.

Magnesium

With an intake of 300 milligrams and an absorption efficiency of about 50%, about 150 milligrams of magnesium are absorbed daily.

With a loss of about 10 milligrams per liter of sweat, it is easy to sweat out about 40 milligrams of magnesium with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

Although magnesium deficiency could theoretically result from exercise, no studies have shown improved performance with supplements and diarrhea is a frequent side effect.

In addition to targeting magnesium intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily multivitamin/multimineral supplement.

Read more about magnesium nutrition on page 314.

Manganese

With an intake of 2 milligrams and an absorption efficiency of about 5%, about 100 micrograms of manganese are absorbed daily.

With a loss of about 3 micrograms per liter of sweat, it is easy to sweat out about 12 micrograms of manganese with a gallon (4 quarts, 4 liters) of sweat. This will not impact your daily intake.

Read more about manganese nutrition on page 319.

Phosphorus

With an intake of 1,200 milligrams and an absorption efficiency of about 60%, about 720 milligrams of phosphorus are absorbed daily.

With a loss of about 40 milligrams per liter of sweat, it is easy to sweat out about 160 milligrams of phosphorus with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

Occasional phosphate supplements may improve athletic performance.

Read more about phosphorus nutrition on page 325.

Potassium

With an intake of 2,700 milligrams and an absorption efficiency greater than 90%, about 2,500 milligrams of potassium are absorbed daily.

With a loss of about 150 milligrams per liter of sweat, it is easy to sweat out about 600 milligrams of potassium with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

Although potassium can occasionally be a problem to replace for athletes in ultra-distance events who rely solely on potassium-poor fluids for nutrition, those who eat solid food are usually protected against deficiency.

Read more about potassium nutrition on page 330.

Sodium

Sodium is the electrolyte priority for the aerobic endurance athlete. A low concentration of sodium in the blood is associated with weakness, fatigue, seizures, and occasionally death.

For the non-athlete, the daily requirement is about 500 milligrams.

The average American ingests two to five grams (2,000 to 5,000 milligrams) of sodium a day. Typical intakes may vary considerably. Many individuals consume half this amount and many consume more than twice this amount.

With an intake of 4,000 milligrams and an absorption efficiency over 90%, about 3,600 milligrams of sodium are absorbed daily.

With a loss of about 1,000 milligrams per liter of sweat, it is easy to sweat out about 4,000 milligrams of sodium with a gallon (4 quarts, 4 liters) of sweat. This could overwhelm your daily intake.

Blood sodium levels may drop.

In temperate weather conditions, this may take 4 or 5 hours. In high-heat conditions, sodium depletion can occur in just a couple of hours.

In many athletes, low sodium problems first occur in target long-distance events—because these events may last 50% longer than the longest previous training session.

Many athletes who are sodium-depleted are also dehydrated. However, those with low blood sodium are often relatively less dehydrated than their competitors who have blood levels closer to normal.

The reason is that athletes tend to rehydrate with fluids that have a lower sodium concentration than blood. Those who drink the most tend to dilute sodium the most and have lower blood concentrations.

For aerobic-endurance athletes, it is reasonable to plan on an intake of up to a maximum of one gram (1,000 milligrams) of sodium per liter of fluid loss. This is about one-half teaspoon of salt.

Cyclists may have a relatively easy time ingesting sodium snacks. Triathletes can ingest salt snacks while cycling. Runners tend to have finished their event before trouble with sodium sets in. Walkers, in the heat for many hours, are the most at risk, especially if they rely only on gels and water for their event nutrition.

Here is another reason for consuming salt: It helps the body rehydrate.

Read more about sodium before events on page 15.

Read more about sodium after events on page 21.

Read more about sodium, including the sodium content of selected foods and hyponatremia starting on page 342.

Zinc

With an intake of 11 milligrams and an absorption efficiency of about 60%, about 7 milligrams of zinc are absorbed daily.

With a loss of about 0.5 milligrams per liter of sweat, it is easy to sweat out about 2 milligrams of zinc with a gallon (4 quarts, 4 liters) of sweat. This could modestly impact your daily intake.

In addition to targeting zinc intake through diet, it is reasonable for some athletes to assure intake of the RDA with a daily multivitamin/multimineral supplement.

Read more about zinc nutrition on page 350.

Muscle Cramps

Many of the reasons for muscle cramps are still unknown.

Fluid and mineral imbalance may be one of many causes. This imbalance is probably more of a problem in the local muscle cell area than a reflection of overall body electrolyte imbalance or dehydration. Some of the electrolytes implicated are sodium, magnesium, potassium and calcium.

Target this cause of muscle cramps by eating a diet rich in carbohydrate, magnesium, potassium, and calcium—a diet good for overall general health as well.

If riding long, hard, or day-after-day in the heat, add sodium to your diet.

Read more about other causes of muscle cramps in the ABC handout referenced on page 401.

Summary

During exercise, it is all about sodium.

Most mineral losses in sweat are unimportant or compensated for by the increased caloric consumption of athletes.

Calcium and iron may be exceptions. Some athletes may need calcium or iron supplements for general health.

A daily multivitamin/multimineral supplement will help provide the RDA of most minerals. Calcium requires a separate supplement.