VITAMINS & MINERALS: RECOMMENDATIONS FOR ATHLETES
OVERVIEW

• Essential compounds for biological functions
• Important co-factors in chemical reactions and for maintenance of homeostasis
• Vitamins and minerals
• Key vitamins to assess in athletes: Vitamin D and B Vitamins
• Key minerals to assess in athletes: sodium, potassium, magnesium, calcium and iron
• Organic compounds/ catalysts involved in metabolic reactions
• Must be obtained in diet, except:
  • Vitamin D: synthesized from sunlight
  • Vitamin K: synthesized by bacteria in the intestine
• Deficiency may develop in 3-4 weeks
• Excess can lead to toxicity
• Several vitamins are in a precursor or provitamin form in foods and converted to the active form in the body
  • e.g. Beta Carotene
<table>
<thead>
<tr>
<th>Fat Soluble</th>
<th>Water Soluble</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dissolve in organic solvents</td>
<td>• Dissolve in water</td>
</tr>
<tr>
<td>• Usually ingested with fats</td>
<td>• Most are involved in energy metabolism</td>
</tr>
<tr>
<td>• Can be stored in large quantities</td>
<td></td>
</tr>
<tr>
<td>• Longer to develop a deficiency</td>
<td></td>
</tr>
<tr>
<td>• Toxicity can occur</td>
<td></td>
</tr>
<tr>
<td>• Tolerable Upper Intake Level</td>
<td></td>
</tr>
<tr>
<td>Fat-Soluble Vitamins</td>
<td>Water-Soluble Vitamins</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Biotin</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Folic Acid</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Pantothenic Acid</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Vitamin B1 (thiamin)</td>
</tr>
<tr>
<td></td>
<td>Vitamin B2 (riboflavin)</td>
</tr>
<tr>
<td></td>
<td>Vitamin B3 (niacin)</td>
</tr>
<tr>
<td></td>
<td>Vitamin B6 (pyridoxine)</td>
</tr>
<tr>
<td></td>
<td>Vitamin B12</td>
</tr>
<tr>
<td></td>
<td>Vitamin C (ascorbic acid)</td>
</tr>
</tbody>
</table>
# VITAMINS: BENEFITS FOR ATHLETES

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>RDI</th>
<th>Primary Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamin</td>
<td>1.2 mg</td>
<td>Energy</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>1.3 mg</td>
<td>Energy, Antioxidant</td>
</tr>
<tr>
<td>Niacin</td>
<td>16.0 mg</td>
<td>Energy</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>1.3 mg</td>
<td>Energy</td>
</tr>
<tr>
<td>Folate</td>
<td>400 mg</td>
<td>DNA Structure</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>2.4 mg</td>
<td>Works with folic acid</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>900 mg</td>
<td>Vision, Immune Function</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>90 mg</td>
<td>Structure (collagen formation), Antioxidant</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>600 IU</td>
<td>Calcium balance, other health benefits</td>
</tr>
</tbody>
</table>
7-dehydrocholesterol → Vitamin D₃ → 25-hydroxylase → 25OHD

Marker of Vitamin D Status

Sufficient
Insufficient
Deficient

Diet → Skin

ng/mL

Jeukendrup & Gleeson. Champaign, IL. Human Kinetics. 2018
The best way to know if Vitamin D supplementation is needed is to measure blood status.

<table>
<thead>
<tr>
<th>Total Serum 25(OH)D</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12 nmol/L</td>
<td>Severely deficient</td>
</tr>
<tr>
<td>12 – &lt;30 nmol/L</td>
<td>Deficient</td>
</tr>
<tr>
<td>30 – 50 nmol/L</td>
<td>Inadequate</td>
</tr>
<tr>
<td>&gt;50 nmol/L</td>
<td>Adequate</td>
</tr>
<tr>
<td>&gt;100 – 250 nmol/L</td>
<td>Suggested optimal (Zittermann, 2003)</td>
</tr>
<tr>
<td>&gt;120 – 225 nmol/L</td>
<td>Suggested optimal (Heaney, 2011)</td>
</tr>
</tbody>
</table>
Vitamin D Status
Proposed decision tree if status is unknown.
Vitamin D & Athletes

Many athletes are vitamin D deficient, even those who play outside and would expect a higher status!

Figure 1: Vitamin D status in athletes from a variety of sports in the sunny months (upper graph, dark bars) and winter (lower graph, lighter bars). NCAA, National Collegiate Athletic Association. Data represent male and female athletes unless specified. Error bars (if present) represent reported standard deviation. Developed using references of Bergen-Cico & Short, 1992; Bescoa Garcia & Rodriguez Guisado, 2011; Close et al., 2013; Halliday et al., 2011; Hamilton et al., 2010; Helle & Björkan, 2011; Lehtonen-Veromaa et al., 1999; Maimoun et al., 2006; Peeling et al., 2013; Pollock et al., 2012; Storlie et al., 2011; Willis et al., 2012; Wyon et al., 2014.
**Figure 2:** Vitamin D intake in athletes from a variety of sports. NCAA, National Collegiate Athletic Association; HS, high school. Data represent male and female athletes unless specified. Error bars (if present) represent reported standard deviation. Developed using references of Bergen-Cico & Short, 1992; Bescos Garcia & Rodriguez Guisado, 2011; Clark et al., 2003; Halliday et al., 2011; Helle & Bjerkan, 2011; Lehtonen-Veromaa et al., 1999; Rankinen et al., 1998; Storlie et al., 2011; Ziegler et al., 2001.
“Suboptimal” vitamin D status is linked to increased risk for acute illness, inflammatory injury, stress fracture, muscle pain/weakness and suboptimal muscle performance. Athletes with a history of these issues may benefit from assessment of vitamin D status.
Since B vitamins are associated with energy production, they are found in many sports nutrition products, and athletes seek those products that have high doses.

**MYTH – B vitamins themselves do NOT provide energy.** Rather they aid in the production of converting macronutrients to energy.

There is no need to consume above the recommended amount.
B VITAMINS & ATHLETES VIDEO

Link to video on B Vitamins and their role in producing energy
<table>
<thead>
<tr>
<th>Macrominerals/Major</th>
<th>Microminerals/Trace Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily required intake</td>
<td>Daily required intake</td>
</tr>
<tr>
<td>&gt; 100mg or</td>
<td>&lt;100mg or</td>
</tr>
<tr>
<td>&gt; 0.01% body weight</td>
<td>&lt;0.01% body weight</td>
</tr>
<tr>
<td>Calcium</td>
<td>Cobalt</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Chromium</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Manganese</td>
</tr>
<tr>
<td>Sodium</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Arsenic</td>
</tr>
<tr>
<td>Sodium</td>
<td>Nickel</td>
</tr>
<tr>
<td>Potassium</td>
<td>Vanadium</td>
</tr>
</tbody>
</table>

Iron
Iodine
Fluoride
Zinc
Selenium
Copper
• Inorganic Compounds
• Elements (other than C, H, O, N)
  ✓ Associated with structure & function of the body
• Electrolytes: Sodium, Potassium, Chloride, Magnesium, Calcium, Phosphate
• Calcium:
  ✓ Bone structure
  ✓ Muscle contraction
• Iron
  ✓ Oxygen transport
• Phosphorous
  ✓ ATP
### MINERALS: BENEFITS FOR ATHLETES

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>RDI</th>
<th>Primary Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>15000 mg</td>
<td>Fluid Balance</td>
</tr>
<tr>
<td>Potassium</td>
<td>4700 mg</td>
<td>Fluid Balance</td>
</tr>
<tr>
<td>Calcium</td>
<td>1000 mg</td>
<td>Structure</td>
</tr>
<tr>
<td>Iron</td>
<td>8 mg (M)</td>
<td>Energy</td>
</tr>
<tr>
<td></td>
<td>18 mg (F)</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>400 mg</td>
<td>Energy, Structure, Muscle &amp; Immune Function</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>700 mg</td>
<td>Structure, Energy</td>
</tr>
<tr>
<td>Zinc</td>
<td>11 mg</td>
<td>Structure, Immune Function</td>
</tr>
</tbody>
</table>
• Usually ingested as NaCl
  ✓ Maintenance of resting membrane potential
  ✓ Generation of action potential in nerves
  ✓ Drives cotransport of other substances (e.g. glucose)

• Primary electrolyte determining the extracellular fluid volume

• If sodium stores fall the extracellular volume decreases
  ✓ Potential problems maintaining MAP and body temperature
  ✓ Special attention to athletes & workers in hot environments
    ▪ Generally, consume higher calories = usually not a concern

• American intake is ≈3,400 mg/d & UL for adults is 2,300 mg/d!
• The major ion of intracellular fluid
• Aids in electrical impulse transmission in the nerves, skeletal muscle and heart
• Potassium balance is tightly regulated in the body
• Hyperkalemia – higher than normal blood level of potassium, could lead to cardiac arrhythmia
• Good food sources = bananas, citrus fruits, vegetables, milk
Electrolytes are minerals that have an electric charge.

Sodium is the electrolyte lost in the greatest quantity in sweat.

Potassium is also lost in sweat, but these are relatively small compared to sodium.

In the body, sodium is found in the extracellular space, potassium intracellular to help maintain fluid balance.

Requirements for athletes may be above recommended intakes due to sweat losses, although the amount is highly variable among individuals.

Deficiency, particularly of sodium, may lead to muscle cramping.
• Helps maintain nerve and muscle function, heart rhythm, blood pressure, immune system, bone, blood glucose levels; promotes calcium absorption

• Has been studied as an ergogenic aid for athletes due to the role in energy, muscle function, and maintenance of blood glucose

• Most athletes do not consume adequate magnesium in their diets

• Some evidence suggests meeting the RDA may enhance athletic performance
• Combines with phosphorus to form teeth and bones
• Bone is constantly turning over calcium and phosphorous
  ✓ Must be replaced in the diet
• If diet is deficient in calcium for a long period of time osteoporosis can develop
  ✓ More common in women
  ✓ Accelerated at menopause
  ✓ Related to fracture
    ✓ Dietary calcium intake
    ✓ Inadequate estrogen
    ✓ Lack of physical activity
• Calcium intake is difficult to assess
• Tightly regulated in the body
• Lost in sweat
• Calcium citrate and calcium carbonate
  ✓ Well absorbed as supplement
  ✓ Plateaus ≈500 mg
    ✓ Optimal dosage spread throughout the day
• Athletes at risk:
  ✓ Amenorrhea or Oligomenorrhea
    ✓ Decreased estrogen secretion
  ✓ Low calorie intake and body fat, high physical activity
• High risk of early osteoporosis
Weight bearing activities promote deposition of calcium in bone.

Influenced by:
- Sex (Female)
- Calcium intake
- Estrogen levels
- Alcohol intake
- Caffeine intake
- Family history

**Bone formation and demineralization in calcium homeostasis**

High blood calcium:
- Bone Formation
- Blood Ca$^{2+}$
- Calcitonin, Vitamin D
- Osteoblasts Ca$^{2+}$ uptake
- Kidney
  - Increased Ca$^{2+}$ excretion in urine

Low blood calcium:
- Bone Demineralization
- Blood Ca$^{2+}$
- PTH, Osteoclasts
- Ca$^{2+}$ mobilization
- Gut
  - Decreased Ca$^{2+}$ reabsorption in kidney tubules
  - PTH, Vitamin D
IRON

- RDA:
  - 8 mg/day M
  - 18 mg/day W
- Location:
  - Hemoglobin in RBCs for oxygen transport
  - Myoglobin in muscle
  - Cytochromes in the mitochondria
- Large portion of the remaining iron is bound to ferritin in the liver
  - Serum ferritin sensitive measure of iron status
- Diet provides iron in two forms:
  - Heme (ferrous)
    - Fish, meats
    - Better absorption
  - Nonheme (ferric)
    - Vegetables

"Iron drain" = gradual depletion of iron form the body when dietary intake is inadequate.
Condition in which the hemoglobin concentration is low

• \(<13 \text{ g/dL M}\)
• \(<12 \text{ g/dL F}\)

• Due to:
  - Loss of blood
  - Lack of vitamins and minerals
  - Most commonly lack of Iron

• Iron deficiency Anemia
  - Not only hemoglobin affected
  - Iron bound to transferrin in plasma reduced
  - Serum ferritin is low
  - Often low in competitive female athletes
## Do Athletes Need More Iron?

<table>
<thead>
<tr>
<th>Conditions and causes</th>
<th>Sports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low body weight: chronically low energy intake to achieve low body weight</td>
<td>Gymnastics, horse racing, ballet, ice dancing, dancing</td>
</tr>
<tr>
<td>Making competition weight: drastic weight-loss regimens to achieve desired body weight</td>
<td>Weight-class sports (rowing, wrestling, boxing, judo)</td>
</tr>
<tr>
<td>Low fat: drastic weight-loss regimens to achieve low body fat</td>
<td>Body building</td>
</tr>
<tr>
<td>Vegetarian diets</td>
<td>Endurance events</td>
</tr>
<tr>
<td>Training in hot, humid conditions</td>
<td>Endurance events</td>
</tr>
</tbody>
</table>
KEY TAKEAWAYS

✓ Overall, consuming the recommended amounts of vitamins and minerals can help improve performance, as compared to a deficient state.

✓ Going above recommended amounts does not lead to a greater performance benefit.

✓ Key vitamins to assess in athletes are Vitamin D and the B Vitamins.

✓ Key minerals to assess in athletes are sodium, potassium, magnesium, calcium and iron.