Minerals & Exercise
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Minerals have an effect on Athletic Performance

Performance has an effect on Mineral Status
Olympic Athletes Running and Sweating Minerals

- Beijing - Aug 18: Athletes competing in Men's 3000m Steeplechase race inside the Bird's Nest stadium during the Beijing Olympics. August 18 2008 Beijing China

Essential Minerals

Major Minerals
- Calcium
- Phosphorus
- Magnesium
- Sulfur, Potassium, Sodium, Chloride

Trace Minerals
- Iron
- Zinc
- Copper, Chromium, Selenium, Fluoride, Iodine, Manganese, Molybdenum, Boron, Vanadium
Sweat Mineral Loss

- Calcium, Magnesium, Zinc, Copper, Iron
- Sodium, Potassium => electrolyte discussion
- Begin with Calcium...

Calcium Functions

- 99% exists in bone and teeth
- Blood coagulation
- Neuromuscular excitability*
- Cellular adhesiveness
- Transmission of nerve impulses*
- Maintenance/Functionality of cell membranes
- Enzymatic activation and hormonal secretions
Food Sources of Calcium

Research on Sweat Mineral Loss

- **Sweat Mineral-Element Responses During 7 h of Exercise-Heat Stress**

- Magnesium, Calcium, Sodium, Potassium, Zinc, Copper
Purpose & Hypothesis

- Effect of Exercise Duration on Sweat Mineral Composition
- Sweat mineral conservation would produce reductions in content over time

Subjects and Design

- Subjects
  - Six Men and One Woman (Military)
- Design
  - 5 X 60 minute treadmill test in both 27 °C
  - 40% relative humidity and 35 °C
  - 30% relative humidity
- Sweat samples obtained with closed-pouch sweat-collection
Analysis & Results

Analysis

1-way ANOVA exercise duration and sweat composition

Results

- 27°C had minimal effect on calcium, sodium and potassium
- Zinc concentrations fell 42% with no further conservation
- Considered Magnesium a trace element...?

Mineral Composition

<table>
<thead>
<tr>
<th>Variable</th>
<th>10–70 min</th>
<th>170–390 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na µg/mL</td>
<td>986 (294)</td>
<td>1106 (395)</td>
</tr>
<tr>
<td>K µg/mL</td>
<td>232 (27)</td>
<td>238 (44)</td>
</tr>
<tr>
<td>Ca µg/mL</td>
<td>15 (5)</td>
<td>14 (5)</td>
</tr>
<tr>
<td>Zn ng/mL</td>
<td>811 (953)</td>
<td>286 (189)*</td>
</tr>
<tr>
<td>Cu ng/mL</td>
<td>227–2501</td>
<td>89–584</td>
</tr>
<tr>
<td>Mg ng/mL</td>
<td>1196 (526)</td>
<td>1059 (178)</td>
</tr>
</tbody>
</table>

Data are mean (standard deviation) and range for n = 5 subjects. The 170–390 min values are single sweat samples collected after either 170–230 or 330–390 min of heat exposure. *P < 0.05 vs. baseline.
Zinc

DRI:
• 11 mg/day for males 19-70
• 8 mg/day for females 19-70

*vegetarians may require more

Zinc Functions

- 60% in muscle
- 30% in bone
- Involved in > 300 enzymatic reactions
- Growth, muscle, & tissue synthesis/repair
- Energy production
- Immune Function
- Copper-Zinc Superoxide Dismutase
Research on Sweat Mineral Loss

- Effect of Heat Acclimation on Sweat Minerals
  - Calcium, Copper, Iron, Magnesium, & Zinc

Purpose & Hypothesis

- Effect of exercise-heat acclimation on mineral concentrations found in sweat
- Exercise-heat acclimation will decrease sweat mineral concentrations of calcium, copper, iron, magnesium & zinc
Subjects and Design

- **Subjects**
  - 8 healthy men

- **Design**
  - Treadmill walking in 45°C environment until
    - 100 continuous minutes
    - Core temperature 39.5°
    - Voluntary termination
  - 10 consecutive days
  - Polyethylene arm glove to collect sweat samples

Analysis & Results

**Analysis**

- Paired t-tests to analyze day 1 & day 10 sweat mineral concentrations

**Results**

- Loss of calcium, copper, & magnesium significantly decreased on day 10
- Zinc & iron also decreased; not statistically significant
Magnesium

- DRI:
  - 400mg per day for males 19-30
  - 420mg per day for males 30-70
  - 310mg per day for females 19-30
  - 320mg per day females 30-70

Ubiquitous in foods
Ubiquitous in the body

Functions of Mg++

- Over 300 enzymatic functions in which food is metabolized and new products are formed
- Mg-ATP providing “Free-Energy Currency”
- Integral to glycolysis as a hexokinase
- Required for lipid metabolism
- Amino acid activation in RNA and DNA polymerases
- Enzymatic steps in Citric Acid Cycle
- Three of Four key enzymes in gluconeogenesis
Research on Magnesium & Lactate

- The effect of magnesium supplementation on lactate levels of sportsmen and sedentary


Purpose & Hypothesis

- The assessment of how magnesium supplementation affects plasma lactate levels at rest and exhaustion

- Lactate increases with exhaustion
  - Magnesium supplementation may positively affect performance of sportsmen by decreasing lactate levels
Subjects & Design

- **Subjects**
  - 30 healthy subjects
    - Sedentary with magnesium supplementation
    - Magnesium and training group
    - Training group
- **Design**
  - 20 mile shuttle run to exhaustion
  - Blood sample

Analysis & Results

**Analysis**
- Variance Analysis and Duncan multiple range test

**Results**
- Decrease of lactate levels at rest and exhaustion in magnesium supplemented groups
Phosphorus in Exercise

- RDA: 700mg per day for people 19-70
- Energy Metabolism ATP
- 2,3-diphosphoglycerate...
  - What?

Food Sources:
- Protein rich foods
- Cereal grains

Phosphorus & Phosphate

- Phosphate loading
- Increase in ATP (Mg-ATP)
- 2,3-diphosphoglycerate
  - Essential for oxygen release from hemoglobin
Research on Phosphate Loading

- Sodium Phosphate Loading Improves Laboratory Cycling Time-Trial Performance in Trained Cyclists


Purpose & Hypothesis

- Examine the influence of phosphate sodium phosphate on endurance performance.

- Sodium phosphate loading would increase maximal oxygen uptake
Subjects & Design

- **Subjects**
  - 7 trained male cyclists with similar age and ability

- **Design**
  - Preliminary VO$_{2\text{max}}$
  - 3 X 16.1 km time-trials
  - Randomly assigned supplement or placebo for 6 days
  - 16.1 km time-trial final VO$_{2\text{max}}$ and power output

Analysis & Results

**Analysis**
- Anova and Tukey HSD tests

**Results**
- Time-trial performance was significantly improved after sodium phosphate loading
- 5 out of 6 cyclists improved their power output
- No significant increases in VO$_{2\text{max}}$
Sodium Phosphate Loading

- Found significant ergogenic effect on...?
  - Power
    - Why not VO$_{2\text{max}}$?
  - Let's Hypothesize

Iron

- DRI:
  - 8 mg/day for males 19-70
  - 18 mg/day for females 19-50
  - 8 mg/day for females 50-70

*DRI assumes 75% heme iron
*Vegetarians may require more
Iron Function

- Component of numerous enzymes
- Oxygen delivery to various tissues
- 74% present in hemoglobin & myoglobin
- 1% enzymes of energy metabolism

Iron Deficiency

- Improper dietary consumption of iron
- Loss of iron in sweat
- Gastrointestinal bleeding
- Myofibrillar stress
- Intravascular hemolysis
- Menstruation in women
Research on Iron

- Iron Status in Highly Active and Sedentary Young Women


Purpose of Study

- Iron status in both active and sedentary women

- Differentiate between novel markers and traditional markers of iron status
Biochemical Markers

Table 3: Biochemical Data for Active and Sedentary Women

<table>
<thead>
<tr>
<th>Biochemical parameter</th>
<th>Diagnostic range</th>
<th>Active (n=28)</th>
<th>Sedentary (n=28)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>&lt;12.0</td>
<td>13.5±1.1</td>
<td>13.8±0.8</td>
<td>.22</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>&lt;36.0</td>
<td>40.1±2.8</td>
<td>40.3±2.0</td>
<td>.83</td>
</tr>
<tr>
<td>Mean cell volume (fL)</td>
<td>78-100</td>
<td>89±4.6</td>
<td>89±3.3</td>
<td>.86</td>
</tr>
<tr>
<td>Mean cell hemoglobin (pg)</td>
<td>&lt;27</td>
<td>30±2</td>
<td>30±1</td>
<td>.32</td>
</tr>
<tr>
<td>Mean cell hemoglobin concentration (pg/dL)</td>
<td>&lt;31.0</td>
<td>33.6±6.9</td>
<td>34.2±0.7</td>
<td>&lt;.01*</td>
</tr>
<tr>
<td>Red cell distribution width (%)</td>
<td>&gt;14.5</td>
<td>13±2</td>
<td>13±2</td>
<td>.20</td>
</tr>
<tr>
<td>Torstar (ug/dL)</td>
<td>&lt;35</td>
<td>81±35</td>
<td>100±43</td>
<td>.07</td>
</tr>
<tr>
<td>Total iron-binding capacity (ug/dL)</td>
<td>&gt;400</td>
<td>350±47</td>
<td>352±71</td>
<td>.66</td>
</tr>
<tr>
<td>% Transferrin saturation*</td>
<td>&lt;16</td>
<td>23±11</td>
<td>30±12</td>
<td>.05</td>
</tr>
<tr>
<td>Ferritin (ng/mL)</td>
<td>&lt;12</td>
<td>32±28</td>
<td>97±87</td>
<td>.01*</td>
</tr>
<tr>
<td>Transferrin receptor (ug/ml)</td>
<td>&gt;8.0</td>
<td>7.3±2.6</td>
<td>8.0±1.3</td>
<td>.01*</td>
</tr>
<tr>
<td>TTR-Fe Index</td>
<td>&gt;4.5</td>
<td>28±91</td>
<td>8±25</td>
<td>&lt;.01*</td>
</tr>
<tr>
<td>Transferrin receptor index (transferrin receptor/log ferritin)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Diagnostic ranges determined using Gibson (2007), Sorensen Queen Laboratories, Phoenix, AZ, Institute of Medicine, Food and Nutrition Board. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, fluoride, iron, iodoside, nickel, vanadium, and zinc (2001) and Department of Nutritional Sciences, University of Missouri, Columbia. Determined using independent t-tests. Significance level determined using the t-test. M and SD are back-transformed data. Presented using Mann-Whitney nonparametric test. TTR-Fe Index = transferrin receptor index (transferrin receptor/log ferritin).

Subjects and Design

- **Subjects**
  - 28 highly active women
  - 28 sedentary women
- **Design**
  - 7-day weighed-food record
  - 7-day pedometer/activity log
  - Fasting blood sample retrieved
Analysis & Results

Analysis
- Independent sample t-tests to compare mean scores

Results
- Active women had lower iron stores than sedentary women
  - 50% active subjects iron depleted
  - 18% sedentary subjects iron depleted
- Measures other than those conventionally used may be needed to assess iron status
  - Serum transferrin receptor
  - Transferrin-receptor index

Recommendations

Adequate intake on all minerals based on DRI’s

Whole Food consumption

Supplementation

Human Ecological Model
References


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References


