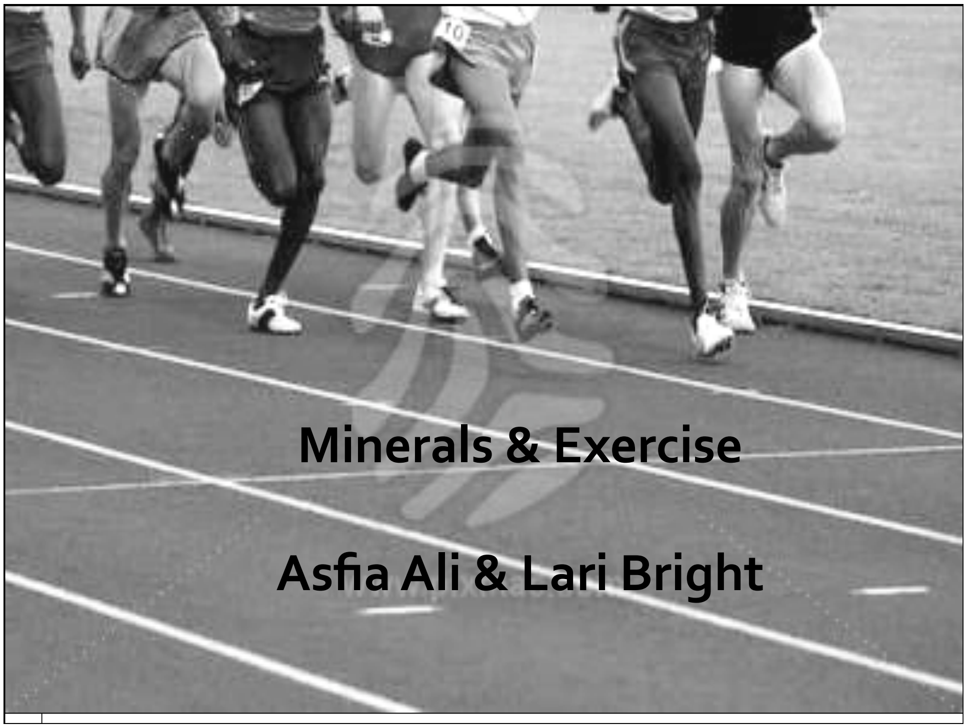

Minerals & Exercise

Asfia Ali & Lari Bright

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**
- Scott J. Montain, Samuel N. Cheuvront, Henry C. Lukaski (2007). International Journal of Sport Nutrition and Exercise Metabolism: 17,574-582.
- 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

k1131263 www.fotosearch.com

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 2 Effect of Exercise Duration on Sweat Mineral Concentrations During 35 °C Trials

Variable	10–70 min	170–390 min
Na, µg/mL[a]	986 (294)	1106 (395)
	720–1431	686–1738
K, µg/mL[a]	232 (27)	238 (44)
	201–262	200–313
Ca, µg/mL[a]	15 (7)	14 (5)
	8–25	6–21
Zn, ng/mL[b]	811 (953)	286 (189)*
	227–2501	89–584
Cu, ng/mL[b]	108 (136)	30 (13)
	27–349	13–46
Mg, ng/mL[b]	1196 (526)	1059 (178)
	623–1723	801–1262

Data are mean (standard deviation) and range for $n = 5$ subjects. The 170- to 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**
- Chinevere, T.D., Kenefick, R.W., Cheuvront, S.N., Lukaski, H.C., & Sawka, M.N. (2008). Medicine & Science in Sports & Exercise.
- 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 45ºC environment until
    - 100 continuous minutes
    - Core temperature 39.5º
    - Voluntary termination
  - 10 consecutive days
  - Polyethylene arm glove to collect sweat samples

Analysis & Results

<u>Analysis</u>

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

<u>Results</u>

- 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 hexokynase
- 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 sedanter
- V. Cinar, M. Nizamliogle, R. Mogulkoc (2006) *Acta Physiologica Hungarica.* Vol 93 (2-3), pp. 137-144

Purpose & Hypothesis

- The assessment of how magnesium supplementation affects plasma lactate levels at rest and exhaustion
- Lactate increases with exhaustion
  - Magnesium supplementation my 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**

Jonathan P. Folland, Rick Stern, Gary Brickley (2008). *Journal of Science and Medicine in Sport*: 11(8)464-468.

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_{2max}
  - 3 X 16.1 km time-trials
  - Randomly assigned supplement or placebo for 6 days
  - 16.1 km time-trial final VO_{2max} and power output

Analysis & Results

<u>Analysis</u>
  - Anova and Tukey HSD tests

<u>Results</u>
  - Time-trial performance was significantly improved after sodium phosphate loading
  - 5 out of 6 cyclists improved their power output
  - No significant increases in VO_{2max}

Sodium Phosphate Loading

- Found significant ergogenic effect on…?
  - Power

    Why not VO_{2max}?

- 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**
- Woolf, K., St. Thomas, M.M., Hahn, N., Vaughan, L.A., Carlson, A.G., & Hinton, P. (2009). *International Journal of Sport Nutrition and Exercise Metabolism*, 19, 519-535.

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

Biochemical parameter	Diagnostic range[a]	Activity Level, $M \pm SD$: Active (n = 28)	Sedentary (n = 28)	p
Hemoglobin[b] (g/dl)	<12.0	13.5 ± 1.1	13.8 ± 0.8	.22
Hematocrit[b] (%)	<36.0	40.1 ± 2.8	40.3 ± 2.0	.83
Mean cell volume[b] (fl)	78–100	89 ± 6	89 ± 3	.86
Mean cell hemoglobin[b] (pg)	<27	30 ± 2	30 ± 1	.32
Mean cell hemoglobin concentration[b] (g/dl)	<31.0	33.6 ± 0.9	34.2 ± 0.7	<.01*
Red cell distribution width[b] (%)	>14.5	13 ± 2	13 ± 1	.20
Iron[b] (μg/dl)	<35	81 ± 35	100 ± 43	.07
Total iron-binding capacity[b] (μg/dl)	>400	359 ± 47	352 ± 71	.66
% Transferrin saturation[b]	<16	23 ± 11	30 ± 12	.05
Ferritin[c] (ng/ml)	<12	32 ± 28	97 ± 87	.01*
Transferrin receptor[b] (μg/ml)	>8.0	7.3 ± 2.6	5.8 ± 1.3	.01*
TfR-F index[d,e]	>4.5	28 ± 91	8 ± 25	<.01*
C-reactive protein[d] (mg/L)	>1.0	2.5 ± 4.3	1.1 ± 1.7	.65

[a]Diagnostic ranges determined using Gibson (2005), Sonora Quest Laboratories, Phoenix, AZ; Institute of Medicine. Food and Nutrition Board. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc (2001); and Department of Nutritional Sciences, University of Missouri, Columbia. [b]Determined using independent t tests. [c]Significance level determined using the log ferritin; M and SD are back-transformed data. [d]Determined using Mann–Whitney nonparametric test. [e]TfR-F index = transferrin-receptor index (transferrin receptor/log ferritin).
*Independent t tests indicated that the groups were significantly different ($p < .05$).

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

<u>Analysis</u>

- Independent sample t-tests to compare mean scores

<u>Results</u>

- 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

Human Ecological Model

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