Bones: Calcium & Beyond
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Bone Basics
• Bones are the foundation of our skeleton
• Bone is a dynamic tissue
  ▫ Formation - building up of bone by osteoblasts
  ▫ Resorption - broken down by osteoclasts
• Collagen – forms matrix for mineralization

Bone Basics
• During growth, formation exceeds resorption
• Although bone length stops after puberty, bone continues to accumulate
• Peak bone mass is achieved around age 35 and is influenced by exercise and nutrition

Exercise: weight bearing activity
What is the benefit?
• Improves peak bone mass during growth
• Plays a role in supporting bone mass gain from age 20-30
• Supports maintenance of bone mass later in life.

Some examples
• Jogging/running
• Soccer/tennis/basketball
• Weight lifting
• Gymnastics
• Climbing stairs
• Dancing

Dietary factors related to bone development
• Calcium
  ▫ 99% of the body's calcium is in bone
  ▫ Released from bone if blood levels are low
• Phosphorus
  ▫ With calcium, mineralizes bone
• Vitamin D
  ▫ Active form = 1,25 dihydroxyvitamin D
  ▫ Improves calcium absorption from intestine
  ▫ Role in osteoblast and osteoclast functioning

Dietary factors related to bone development
• Protein
  ▫ Forms the bone matrix = collagen
• Vitamin K
  ▫ Cofactor for an enzyme required for osteoblast activity
• Zinc
  ▫ Role with many enzymes and hormones
Concerns with bones and Galactosemia

- DXA scans show poor/delayed bone mineralization
- Low levels of growth factors/enzymes related to bone formation and resorption (Panis et al., Bone, 2004)
  - Formation = osteocalcin, bone alkaline phosphatase
  - Resorption = NTX and CTX from collagen breakdown

Why are bone differences noted?

- Hormonal differences (IGF-1, estrogen)
- Abnormal collagen formation
- Uridine diphosphate galactose?
- Nutrition Factors
  - Adequate phosphorus intake in galactosemia, but inadequate calcium intake in ~ 75%
    (Rutherford et al., Br Diet Assn J, 2002)
  - Low vitamin D levels

Calcium - Requirements

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Calcium (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 6 mo.</td>
<td>200</td>
</tr>
<tr>
<td>7 to 12 mo</td>
<td>260</td>
</tr>
<tr>
<td>1 to 3 yrs</td>
<td>700</td>
</tr>
<tr>
<td>4 to 8 yrs</td>
<td>1000</td>
</tr>
<tr>
<td>9 to 18 yrs</td>
<td>1300</td>
</tr>
<tr>
<td>Adults</td>
<td>1000 (10 yrs = 1200)</td>
</tr>
</tbody>
</table>

Calcium - Sources

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount</th>
<th>Calcium (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Products</td>
<td>1 cup</td>
<td>More than 250</td>
</tr>
<tr>
<td>Fortified dry cereal</td>
<td>1 oz</td>
<td>236 – 1043</td>
</tr>
<tr>
<td>Soy Formula</td>
<td>1 cup</td>
<td>170</td>
</tr>
<tr>
<td>Soy milk, fortified</td>
<td>1 cup</td>
<td>300</td>
</tr>
<tr>
<td>Sardines</td>
<td>3 oz</td>
<td>325</td>
</tr>
<tr>
<td>Tofu, firm</td>
<td>½ cup</td>
<td>250</td>
</tr>
<tr>
<td>Orange juice, fortified</td>
<td>½ cup</td>
<td>200 - 260</td>
</tr>
<tr>
<td>Salmon, canned with bone</td>
<td>3 oz</td>
<td>181</td>
</tr>
<tr>
<td>Leafy greens</td>
<td>½ cup</td>
<td>14 - 178</td>
</tr>
</tbody>
</table>

Vitamin D - Requirements

- Requirements for vitamin D were increased in 2010 by the National Research Council
- Vitamin D levels in Infant formulas, supplements and fortified foods are being adjusted to meet new standards

<table>
<thead>
<tr>
<th>Age</th>
<th>Vitamin D μg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>10 (400 IU)</td>
</tr>
<tr>
<td>1-3 years</td>
<td>15 (600 IU)</td>
</tr>
<tr>
<td>4-8 years</td>
<td>15 (600 IU)</td>
</tr>
<tr>
<td>9-18 years</td>
<td>15 (600 IU)</td>
</tr>
<tr>
<td>19-70 years</td>
<td>15 (600 IU)</td>
</tr>
<tr>
<td>&gt; 70 years</td>
<td>20 (800 IU)</td>
</tr>
</tbody>
</table>

Vitamin D - Sources

- The best source of Vitamin D is the sun but for those living in northern climates, too little exposure during winter.
- Sun blockers decrease vitamin D production.

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount</th>
<th>IU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod liver oil</td>
<td>1 T</td>
<td>1,360</td>
</tr>
<tr>
<td>Sockeye Salmon</td>
<td>3 oz</td>
<td>794</td>
</tr>
<tr>
<td>Mackerel</td>
<td>3 oz</td>
<td>385</td>
</tr>
<tr>
<td>Tuna fish, canned</td>
<td>3 oz</td>
<td>154</td>
</tr>
<tr>
<td>Fortified rice milk</td>
<td>1 cup</td>
<td>120</td>
</tr>
<tr>
<td>Fortified Orange Juice</td>
<td>1 cup</td>
<td>100</td>
</tr>
<tr>
<td>Fortified Soy Milk</td>
<td>1 cup</td>
<td>120</td>
</tr>
<tr>
<td>Soy Formula</td>
<td>1 cup</td>
<td>100</td>
</tr>
</tbody>
</table>
Calcium and Vitamin D intake for Galactosemia
• Without dairy products, consuming enough calcium and vitamin D is challenging
• Use fortified formulas, soy milk, rice milk
• Supplements are often required to ensure adequate intake.

Supplement Study:
40 children with galactosemia
• Ages 3-17  (Pani et al, Bone, 2006)
• Blind, placebo controlled trial
  • 750 mg calcium + 10 µg vit D + 1 mg vit K OR Placebo
  • Testing completed at baseline, 1 yr and 2yr
• Results: Significant improvement in various growth factors, enzymes in treated group
• Bone Mineral Density improved with supplements, but only in pre-pubertal children

Choosing a calcium supplement
• There are several forms of calcium available:
  ▫ Calcium carbonate is the most concentrated form of calcium
  ▫ Calcium citrate is more easily absorbed
• Avoid calcium sources made from bone meal, dolomite, or oyster shell. These preparations may not be absorbed as efficiently or may contain contaminants.

Choosing a Calcium Supplement
• Taking calcium with meals will increase absorption.
• Calcium is most efficiently absorbed if taken in doses of 500-600 mg or less several times a day.
• Supplements may contain lactose fillers.
  ▫ Check the ingredient list.
  ▫ Look for supplements with calcium + vitamin D

Importance of a general multivitamin and mineral supplement
• Picky eaters, those not taking formula or fortified beverages
• Look at vitamin D, zinc, vitamin K
• Calcium will be low in general supplements
• Check for lactose fillers

Can you get too much calcium or vitamin D?

<table>
<thead>
<tr>
<th>Age</th>
<th>Vitamin D</th>
<th>Calcium</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 6 mo</td>
<td>1000 IU</td>
<td>25 mcg</td>
</tr>
<tr>
<td>7 to 12 mo</td>
<td>1500 IU</td>
<td>38 mcg</td>
</tr>
<tr>
<td>1 to 3 years</td>
<td>2500 IU</td>
<td>63 mcg</td>
</tr>
<tr>
<td>4 to 8 years</td>
<td>3000 IU</td>
<td>75 mcg</td>
</tr>
<tr>
<td>9 to 18 years</td>
<td>4000 IU</td>
<td>100 mcg</td>
</tr>
<tr>
<td>Adults</td>
<td>4000 IU</td>
<td>2000 mg</td>
</tr>
</tbody>
</table>
Monitoring Bone Health

- Labs:
  - Total 25-OH Vitamin D
  - Check levels even if intake is adequate
  - Goal: Levels: 35 – 50 ng/ml
  - Calcium, phosphorus
  - Electrolytes, BUN, creatinine
  - TSH
  - 24 hour urinary calcium
- DXA scan: Begin age 8 to 10 years

Good Resources

- Visit Office of Dietary Supplements, National Institutes of Health website
  - ods.od.nih.gov/Factsheets/vitaminD
  - ods.od.nih.gov/Factsheets/calcium