1. Calcium and Vitamin D Nutrition in the Elderly

Calcium & Vitamin D Nutrition in the Elderly

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2. Functions of Calcium

Functions of Calcium

- Mineralization of bones and teeth
  hydroxyapatite = Ca_{10}(PO_{4})_{6}(OH)_{2}
  ~98% of total calcium in body in bones and teeth
- Blood coagulation, muscle contraction, transmission of nerve impulses
- Catalyst for enzymes, e.g., lipase
- Tooth development in utero and infancy

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3. Regulation of calcium: Hypocalcemia

Regulation of calcium: Hypocalcemia

**Major hormones**
- 1,25-dihydroxyvitamin D
- Parathyroid hormone (PTH)

![Diagram showing the regulation of calcium in hypocalcemia](image)

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4. Regulation of calcium: Hypercalcemia

Regulation of calcium: Hypercalcemia

**Major hormones**
- 1,25-dihydroxyvitamin D
- Parathyroid hormone (PTH)

![Diagram showing the regulation of calcium in hypercalcemia](image)

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5. Calcium Homeostasis

Calcium Homeostasis

- Daily obligatory loss should be replaced by diet
- If not, reservoir of calcium in bones is depleted

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6. Calcium absorption

Calcium absorption

- On average, net calcium absorption = 0 if dietary calcium intake < 200 mg /day
- Estimated minimum calcium intake = 400 mg (200 to get net absorption > 0 + 200 to cover obligatory losses)
- 1,25-dihydroxyvitamin D (calcitriol) enhances calcium absorption

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7. Some factors influencing calcium absorption

Some factors influencing calcium absorption

- Increased absorption
  - Increased renal or extrarenal 1,25-hydroxyvitamin D production
    - Growth
    - Pregnancy and lactation
    - Diseases such as primary hyperparathyroidism

8. Some factors influencing calcium absorption

Some factors influencing calcium absorption

- Decreased absorption
  - Decreased renal or extrarenal 1,25-hydroxyvitamin D production
    - Vitamin D deficiency, rickets
    - Chronic renal insufficiency
    - Hypoparathyroidism
    - Aging
  - Glucocorticoids
  - Malabsorption diseases
  - Other components of diet - fiber, phytic acid (cereal husks), oxalic acid (rhubarb, spinach, chard)

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9. Consequences of calcium insufficiency

Consequences of calcium insufficiency

- Children –
  - Delayed tooth eruption
  - Hypomineralization of developing tooth
- Adults –
  - Long-term insufficiency - osteoporosis

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10. Calcium intake and periodontal disease

Calcium intake and periodontal disease

- Nishida et al (J Periodontol, 2000) - Low dietary calcium intake associated with higher prevalence of clinical attachment loss (mean AL ≥ 1.5 mm) in NHANES III.
- Compared to ≥800 mg calcium /day:
  - 500-799 mg calcium /day: 1.3 times higher risk
  - <500 mg calcium /day: 1.3 to 1.6 times higher risk

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11. Vitamin D

Vitamin D

- Fat soluble vitamin – stored in body tissues
- FUNCTIONS
  - Acts as hormone to regulate calcium balance
  - May have role in inflammatory response

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12. Vitamin D

Vitamin D

- Sources:
  - Diet
    - Ergocalciferol (plant sources)
    - Cholecalciferol (animal sources)
  - Endogenous production from 7-dehydrocholesterol when exposed to ultraviolet radiation

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13. Endogenous vitamin D production

Endogenous vitamin D production

Skin

7-dehydrocholesterol

Pre-Vitamin D₃

Vitamin D₃

25(OH) vitamin D - D binding protein

Blood

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14. Forms of vitamin D in serum

Forms of Vitamin D in serum

- 25-hydroxy vitamin D [25(OH)D]
  - Major form in blood
  - Used to determine vitamin D status. Usual range is > 10 ng/ml
- 1,25-dihydroxy vitamin D [1,25(OH)₂D]
  - Biologically active form
  - Conversion occurs mainly in kidney

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15. Factors affecting Vitamin D status

Factors affecting Vitamin D status

- Season
- Age
  - Endogenous production decreases
  - Exposure to sunlight decreases in some segments of population (homebound, institutionalized)
- Use of sunscreen blocks endogenous production
- Diseases that affect stomach, intestinal tract, kidney (site of conversion to active form), liver
- Medications

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16. Vitamin D production in skin by season

Vitamin D production in skin by season

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17. Calcium and Vitamin D in the Elderly: Slide 17

**Sunscreen and Vitamin D production in skin**

![Bar graph showing serum 25(OH)D levels for control and sunscreen users. Normal range is 20 to 150 nmol/L.](image)

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18. Calcium and Vitamin D in the Elderly: Slide 18

- Most healthy individuals can make enough vitamin D from casual exposure to sunlight
  - E.g., 10 to 60 minutes of exposure to hands, face and forearms per week, *without sunscreen*

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19. Diseases related to vitamin D deficiency

Diseases related to vitamin D deficiency

- Children –
  - Rickets
- Adults
  - Osteomalacia
- Many cases of vitamin D deficiency are result of
  - diseases that cause fat malabsorption
  - medications that interfere with vitamin D/fat absorption
  - or limiting exposure to sunlight (without adequate diet intake)

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20. Calcium and Vitamin D in the Elderly: Slide 20

Awareness about vitamin D Nutrition And fortification of milk has largely eliminated rickets

However, in a recent article (Bishop, 2003 Lancet, 362:1389) it has been shown that rickets is on the rise

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Cancer and exposure to sunlight

- There is an inverse relationship between prostate cancer mortality and exposure to sunlight
- Similar trend exists for breast, colon, colo-rectal cancer

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Osteoporosis

- Reduction in bone density such that bones fracture easily even with low trauma
- More than 1.5 million fractures each year
- Among the elderly, 80-90% of all fractures are due to osteoporosis
- 80% of patients with osteoporosis are female, 20% male

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23. Normal bone

Normal bone

- Pores are small, regular in shape & distribution
- Trabeculae separating pores are thick and continuous
- Good support, resistant to breaking

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24. Bone Remodeling

Bone Remodeling

Bone remodeling unit
- Activation of osteoclasts
- Resorption of minerals and matrix
- Reversal
- Migration and differentiation of preosteoblast
- Matrix formation
- Mineralization

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25. Uncoupling

Uncoupling

Resorption > Formation
- Increases with age
- Other factors, e.g., hypogonadism, calcium insufficiency
- Can result in osteoporosis

26. Osteoporotic bone

Osteoporotic bone

- Pores are large, irregular in shape
- Trabeculae are thin, fractured in some areas
- Poor support, easy to fracture

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27. Vertebral fractures

Vertebral fractures

- More than 700,000 vertebral fractures each year in US
- Loss of height and curvature of the spine are consequences of osteoporosis
- Often unrecognized or misdiagnosed

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28. Hip fractures

Hip fractures

- 300,000 hip fractures each year in US
- About one-quarter of hip fracture patients who were ambulatory before the fracture require long-term care afterward
- About one-quarter of hip fracture patients over age 50 die within 1 year

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29. Costs of osteoporosis

Costs of osteoporosis

- Hospital and nursing home costs are more than $15 billion per year (and rising)
- Loss of mobility and independence

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30. Causes of low bone density

Causes of low bone density

- Failure to build up peak bone mass in young adulthood
- Excessive rate of bone loss in older adulthood

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31. Bone mineral content changes with age

Bone mineral content changes with age

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32. Risk factors for osteoporosis

Risk factors for osteoporosis

- Being female
- In women, being postmenopausal
- In men, low testosterone levels
- Advanced age
- Caucasian or Asian ethnicity
- Family history of osteoporosis
- Thinness and/or small frame

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Risk factors for osteoporosis

- Cigarette smoking
- Low level of physical exercise
- Excessive use of alcohol
- Use of certain medications such as corticosteroids or anticonvulsants

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Dietary risk factors for osteoporosis

- Low calcium intake, especially long term
- Low vitamin D intake, especially if limited exposure to sun
- Low protein
- Excessive alcohol
- Excess sodium
- Excess caffeine, if calcium intake is low
- Excess vitamin A?
- Low folate, vitamin $B_{12}$, vitamin K?

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Calcium & D nutrition and bone

- Children and adolescents
  - If calcium intake is low, increasing it can increase bone mass during growth
- Elderly
  - If calcium and vitamin D intakes are low, increasing them can slow down (but probably not stop) bone loss
  - Calcium and vitamin D supplementation to intakes near or above recommended amounts can reduce risk of osteoporotic fracture

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Dietary Recommendations

- Calcium – aim to (1) increase peak bone mass, and (2) reduce the rates of bone loss and fracture
- Vitamin D – aim to eliminate seasonal variation in blood levels of vitamin D and other hormones involved in calcium regulation

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37. Adequate Intakes

### Adequate Intakes

<table>
<thead>
<tr>
<th>Age</th>
<th>Calcium (mg/day)</th>
<th>Vitamin D (IU/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-6 months</td>
<td>210</td>
<td>200</td>
</tr>
<tr>
<td>6 months-1 year</td>
<td>270</td>
<td>200</td>
</tr>
<tr>
<td>1-3 years</td>
<td>500</td>
<td>200</td>
</tr>
<tr>
<td>4-8 years</td>
<td>800</td>
<td>200</td>
</tr>
<tr>
<td>9-18 years</td>
<td>1300</td>
<td>200</td>
</tr>
<tr>
<td>19-50 years</td>
<td>1000</td>
<td>200</td>
</tr>
<tr>
<td>51-70 years</td>
<td>1200</td>
<td>400</td>
</tr>
<tr>
<td>71+ years</td>
<td>1200</td>
<td>600</td>
</tr>
</tbody>
</table>

From Food and Nutrition Board, National Academy of Sciences, Washington DC, 1997

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38. Dietary sources of Calcium

### Dietary sources of Calcium

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39. Nutrient content of foods

Nutrient content of foods

<table>
<thead>
<tr>
<th>Food item</th>
<th>Serving</th>
<th>Calcium (mg)</th>
<th>Vitamin D (IU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk or yogurt</td>
<td>1 cup</td>
<td>280</td>
<td>100</td>
</tr>
<tr>
<td>Pizza</td>
<td>2 slices</td>
<td>300</td>
<td>Minimal</td>
</tr>
<tr>
<td>Cheese</td>
<td>1 ounce</td>
<td>200-300</td>
<td>Minimal</td>
</tr>
<tr>
<td>Greens (e.g. collard, kale)</td>
<td>¾ cup</td>
<td>230</td>
<td>0</td>
</tr>
<tr>
<td>Canned salmon</td>
<td>3 oz</td>
<td>150-300</td>
<td>500</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>1</td>
<td>Minimal</td>
<td>30</td>
</tr>
<tr>
<td>Chocolate</td>
<td>1 ounce</td>
<td>Minimal</td>
<td>30</td>
</tr>
<tr>
<td>Calcium-fortified fruit juices</td>
<td>1 cup</td>
<td>~300</td>
<td>0</td>
</tr>
<tr>
<td>Fortified breakfast cereal</td>
<td>¾ - 1 cup</td>
<td>Varies</td>
<td>varies</td>
</tr>
</tbody>
</table>

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40. Calcium and Vitamin D in the Elderly: Slide 40

- Age 21-50, to meet calcium recommendations with food, need to eat:
  - 3.5 cups of milk, (300 calories skim; 525 calories whole)
  - or 7 slices pizza, (1000 calories)
  - or 3.5 cups of cooked greens (100 calories)

- Age 51+, calcium recommendation increases by 20%, vitamin D by 100%
  - Many elderly need fewer calories, less fat, cut down on food intake

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41. Supplemental sources

Supplemental sources

- Calcium
  - Vitamin and mineral supplements
  - Fortified juices
  - Upper limit of intake is 2500 mg/day
- Vitamin D
  - Vitamin and mineral supplements
  - Upper limit is 2000 IU/day. Excess can be harmful

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42. Recommendations to Decrease Osteoporosis Risk

Recommendations to Decrease Osteoporosis Risk

- Don’t smoke
- Maintain healthy weight
- If drink alcohol, do so in moderation
- Get some sun

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43. Calcium and Vitamin D in the Elderly: Slide 43

Keep physically active

- Modest improvements in BMD
- Improve muscle strength and coordination

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44. Eat a balanced diet

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