

Soy and Bone Health

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Outline:

- Epidemiologic Studies
- Absorption of calcium in cow's milk, fortified soymilk and calcium fortified fruit drinks
- Other factors in bone health: bone resorption and calcium excretion
- Summary of research on soy and bone health
- Remaining questions

Epidemiologic Studies

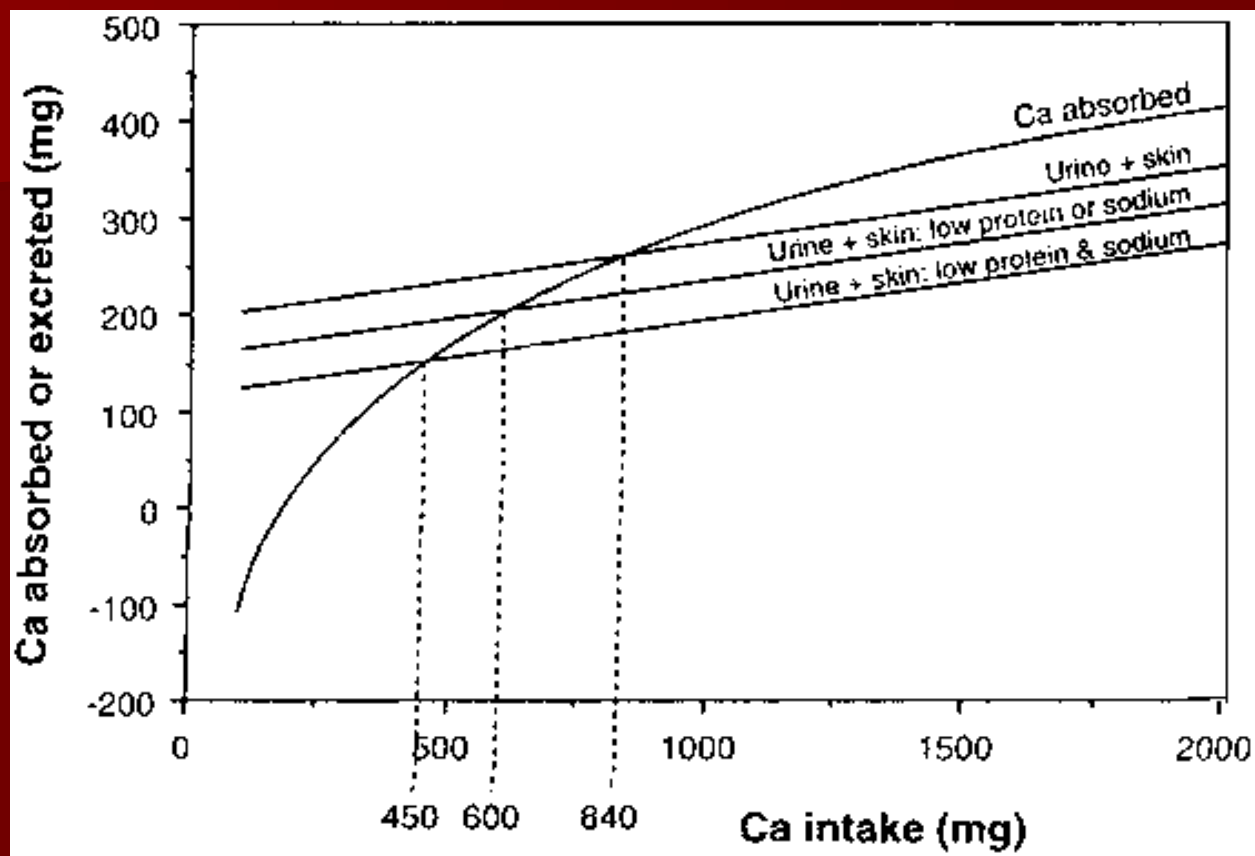
- WHO reports a lower incidence of osteoporosis in Asian women compared to their Western counterparts despite smaller bones and lower calcium intake of Asians¹
- Among Asian-American women, hip fracture likelihood is half of Caucasian women²
- Numerous observational studies show that higher soy intake is associated with higher bone mineral density³

1. WHO 1994

2. Lauderdale et al, 1997; Silverman & Madison, 1988

3. Horiuchi et al 2000; Somekawa et al 2001; Greendale 2002

WHO Position on Calcium Balance



“In a western-style diet, absorbed calcium matches urinary and skin calcium at an intake of 840 mg. Reducing animal protein intakes by 40 g reduces the intercept value and requirement to 600 mg. Reducing both sodium and protein reduces the intercept value to 450 mg”

Fortified Soymilk and Bone Health

- Dr. Heaney's Congressional testimony on Milk and Soymilk¹
 - All individuals can consume 2 to 3 servings of milk per day regardless of presence of lactose intolerance (after a few weeks of building up milk intake)
 - Fortified soymilk is NOT a substitute for cow's milk
 - Calcium not well absorbed and not evenly distributed in soy beverages
 - Milk is "nature's perfect food"
 - Lack of quality assurance standards for calcium added to fortified soymilk

¹ Statement of Robert P. Heaney, MD Before the US House of Representatives Committee on Education and the Workforce. October 7 2003 in regard to Reauthorization of the Child Nutrition Act and Richard B. Russell National School Lunch Act.

Fortified Soymilk and Bone Health

- **Research by Dr. Robert P. Heaney on Calcium Absorption**
 - **SUBJECTS:** Study of 16 men aged 22-51 of unspecified race/ethnicity (Only 11 included in final study)
 - **METHODS:** Compared calcium absorption of extrinsically labeled 2%-fat cow milk or calcium-fortified 2% fat soy milk
 - Tricalcium phosphate was added to unfortified soymilk and blended
 - Measured serum calcium concentrations 5 hours after either soymilk or cow's milk was ingested
 - **RESULTS:** Estimates the absorption rate of soymilk is approximately 75% of the absorption of calcium from cow's milk

Fortified Soymilk and Bone Health

REMAINING QUESTIONS FROM HEANEY'S STUDY :

- Was calcium excretion equal in the two groups?
- Were there any differences in bone turnover or bone formation?
- Are these results indicative of calcium absorption in women? Minorities? Children? Older adults?

Calcium Retention and Resorption: The Missing Links!

- Arjmandi et al examined bone resorption (resorption = destruction) and urinary calcium excretion¹
 - SUBJECTS and METHODS: 71 women randomly assigned to receive 40 g soy protein or milk-based protein for 3 months
 - RESULTS: Soy protein had a more pronounced effect on bone formation than milk protein

¹ Arjmandi BH, Khalil DA, Smith BJ, Lucas EA, Juma S, Payton ME, Wild RA. Soy protein has a greater effect on bone in postmenopausal women not on hormone replacement therapy, as evidenced by reducing bone resorption and urinary calcium excretion. *J Clin Endocrinol Metab*, 2003; 88(3): 1048-54.

Calcium Retention and Resorption: The Missing Links!

Other results in Arjmandi study:

- Bone resorption was reduced by soy protein but not by milk protein
- Women on milk protein experienced a **33% increase** in urinary calcium excretion whereas soy protein did not have such an effect
- Positive effects of soy were more pronounced in women who were not on HRT

Calcium Fortification and Biomarkers of Bone Metabolism

- Braun, Weaver et al examined biomarkers of bone turnover in resorption (resorption = destruction) and urinary calcium excretion
 - SUBJECTS and METHODS: 31 white adolescent male received two levels (700 and 2000 mg) of calcium fortification in orange drink for two random order, crossover metabolic periods for 6 weeks.
 - RESULTS: Calcium retention (intake-excreta) increased at higher intakes. 21% variance of retention explained by intake, 25% explained by circulating hormones and turnover. IGF-1 and IGF-BP most important determinants in boys.

Study of Calcium Fortificant Effect on Absorption

- Current Weaver study: comparison of the calcium absorption, excretion and retention of soy milk fortified with two different fortificants and of cow's milk
- Method: Study using labeled calcium has been done in rats and menopausal women. Data are currently being analyzed.

WHO Position on Calcium Balance

Summary of evidence linking diet to osteoporotic fractures

Evidence	Decreased risk	No relationship	Increased risk
Convincing Older people	Vitamin D Calcium Physical activity		High alcohol intake Low body weight
Probable Older people		Fluoride	
Possible	Fruits and vegetables Moderate alcohol intake Soy products	Phosphorus	High sodium intake Low protein intake (in older people) High protein intake

Literature review on soy and bone health

- Review article in the American Journal of Clinical Nutrition on soy isoflavones (phytoestrogens) and bone health¹
 - 17 in vitro studies of cultured bone cells,
 - 24 in vivo studies of animal models for postmenopausal osteoporosis,
 - 15 human observational/epidemiologic studies,
 - 17 dietary intervention studies.
- [“The] collective data suggest that diets rich in phytoestrogens have bone-sparing effects in the long term” although further research is needed to elucidate the magnitude of this effect and the mechanisms responsible for these actions.

1 Setchell K, Lydeking-Olsen E. Dietary phytoestrogens and their effect on bone: evidence from in vitro and in vivo, human observational, and dietary intervention studies. Am J Clin Nutr, 2003; 78(suppl):593S-609S.

Potential Mechanisms: Soy protein containing Isoflavones

- Study by Potter et al showed that soy protein diets with higher isoflavone content (but not lower isoflavone content) protected against spinal bone loss¹
- Recent review estimated that 30 to 40 grams of soy protein (90-100 mg isoflavones) may be needed to have a positive impact on bone health²

1 Potter SM, Baum JA, Teng H, Stillman RJ, Shay NF, Erdman JW. Soy protein and isoflavones: their effects on blood lipids and bone density in postmenopausal women. *Am J Clin Nutr* 1998; 68(suppl): 1375S-9S

2 Harkness L. Soy and Bone: Where do we stand? *Orthopaedic Nursing* 2004; 23 (1) 12-17

Calcium, Protein, Weight Control

What are the Interactions

- Calcium and Dairy Enhance Weight and Fat Loss (Zemel)
 - 12 week randomized study on 93 overweight adults fed 500 kcal/day deficit on low(600 mg)or high calcium (1400mg) and high dairy (3 svgs, 1400 mg) found enhanced dairy intake caused greatest increase in lean body mass and 2-fold decreases in fat loss.
 - Explanation for increased weight and fat loss:
 - No effect on resting energy expenditure
 - Increase calcium suppresses calcitriol mediated adipocyte Ca^{+} signaling, resulting in increased lipolysis, lipid oxidation.
 - Increase satiety

Proteins Effect on Calcium Absorption and Weight Control

- Kerstetter from U of Conn at Storrs studied 10 young and 3 menopausal women fed medium (1g/kg) and high (2.1g/kg) protein, 800 mg calcium and calories to maintain weight for 10d
- Findings:
 - Urinary calcium increased with protein load
 - No difference in bone resorption or bone formation
 - Intestinal calcium absorption for every subject –
16% for MP and 26% for HP

Proteins Effect on Calcium Absorption and Weight Control

- Roughead from Grand Forks HNRC studied 40 ovariectomized rats to determine effects of diets high or low in soy (aglycone/g protein) and high in meat for 8 weeks.
- Findings:
 - Calcium retention increased with larger amt of protein (20-10%) and 30% higher with meat protein
 - IGF-1 increased 31% with high protein intake, regardless of source
 - Meat intake resulted in greater Ca retention and larger body and bone size without changing the intrinsic bone quality (bone density or breaking stress)
- Possible mechanism of action of protein on calcium retention – increased calcium absorption or increased IGF-1

Upcoming Research

- Spence and Weaver (Submitted for publication)
 - Calcium retention in menopausal women from soy (with and without isoflavone) and dairy. Found no difference in calcium retention with soy+ or – isoflavones. Dairy increased calcium excretion by 40%.
- Connie Weaver et al (Planned research for summer)
 - Effects of soymilk versus cow's milk on body composition, bone mass, calcium turnover, fat metabolism, in adolescent girls fed dairy, soy calcium at 650 and 1200mg, and unfortified soy at steady caloric level for 6 weeks (3 wk washout period)

Remaining Questions

- What are the effects of soy protein on developing bones of children?
- Do all soy proteins (isolates vs. whole bean) have the same effect on calcium excretion?
- What are the mechanisms that cause soy to strengthening bones?
- How much soy is needed to have a positive effect?
- Do the positive effects of soy protein on bone health hold for African American populations?
Hispanic American populations?