

# Mercury and SUOX

- Mercury inhibits sulfite oxidase
- Excess sulfur dioxide (SO<sub>2</sub>) leads to decreased blood pressure
- Increased SO<sub>2</sub> leads to tupor

Boron needed for balanced blood sugar levels. Boron levels tend to be low with SUOX. This also affects testosterone and estrogen levels. (Hunt et al)

Supplemental Material can be found at:  
http://ajph.apubpub.org/cgi/content/full/93/11/1667/DC1

## Nutrient Interactions and Toxicity

### Dietary Boron Decreases Peak Pancreatic In Situ Insulin Release in Chicks and Plasma Insulin Concentrations in Rats Regardless of Vitamin D or Magnesium Status<sup>1-3</sup>

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**ABSTRACT** Because dietary boron deprivation induces hyperinsulinemia in vitamin D–deprived rats, the influence of dietary boron on insulin metabolism as modified by nutritional stressors was examined in two animal models. Male weaning Sprague-Dawley rats were assigned to each of four (Experiment 1) or 8 (Experiment 2) dietary groups for 35 d: the basal diet (< 0.2 mg B; < 1.0 mg Mg/kg) was supplemented with boron (as orthoboric acid) to contain < 0.2 or 2.0 (a physiologic amount) mg B/kg; with magnesium (as magnesium acetate), at 100 (inadequate) or 300–400 (adequate) mg/kg; and with cholecalciferol [vitamin D-3; 25 µg/kg for study length (Experiment 2), or, depleted for 10–17 d then repleted until end of experiment (Experiments 1 and 2)]. In the rat model, boron reduced plasma insulin (Experiment 1,  $P < 0.002$ ; Experiment 2,  $P < 0.03$ ), but did not change glucose concentrations regardless of vitamin D-3 or magnesium status. Cockarels (1 d old) were fed a ground corn, high protein casein and corn oil–based basal diet (low boron; 0.3 mg B/kg) supplemented with boron as orthoboric acid to contain 0.3 or 1.85 mg/kg (a physiologic amount) and vitamin D-3 at 5.13 (inadequate) or 15.00 (adequate) µg/kg. In the chick model, boron decreased ( $P < 0.045$ ) in situ peak pancreatic insulin release at 26–37 d of age regardless of vitamin D-3 nutriture. These results suggest that physiologic amounts of boron may help reduce the amount of insulin required to maintain plasma glucose. *J. Nutr.* 133: 8577–8583, 2003.

**KEY WORDS:** • boron • vitamin D • insulin • chicks • rats

The trace element boron is essential for all higher plants (1,2) and is beneficial or established as essential (3–11) for four animal models of human nutrition. It appears to be beneficial to humans (12,13) and to be under homeostatic control (14). Dietary boron influences energy substrate metabolism in a wide variety of biological species including humans. At the molecular level, boron influences the activities of at least 26 enzymes (15), and many of these enzymes are essential in energy substrate metabolism. For example, in plants, a

serious outcome of boron deficiency is the accumulation of starch in chloroplasts and acceleration of the pentose phosphate cycle (2). In vitamin D–deficient chicks, dietary boron decreases the abnormally elevated plasma concentrations of pyruvate,  $\beta$ -hydroxybutyrate and triglycerides that are typically associated with vitamin D deficiency (16). Vitamin D–deprived rats exhibited significant decreases in plasma triglyceride concentrations and increases in plasma pyruvate concentrations when they were deprived of boron (8). In older volunteers (men and women) fed a low magnesium, marginal copper diet, dietary boron deprivation induced a modest but significant increase in fasting serum glucose concentrations (17).

It has been demonstrated repeatedly in the chick model that physiologic amounts of dietary boron can attenuate the rise in plasma glucose concentration induced by vitamin D deficiency (6,9,16). However, it is not understood how boron deprivation perturbs energy substrate metabolism in humans and animal models, particularly when other nutrients are provided in suboptimal amounts. Even so, there is evidence that dietary boron affects insulin metabolism. For example, our group reported hyperinsulinemia in vitamin D–deprived rats that were concurrently deprived of boron (8).

Because boron deprivation can increase fasting serum glucose concentrations in volunteers fed a low magnesium diet (17) and can induce hyperinsulinemia in the vitamin D–de-

<sup>1</sup> Presented in part at the New Approaches, Endpoints, and Paradigms for RDA of Mineral Elements Workshop, USDA-ARS Grand Forks Human Nutrition Research Center and the School of Medicine, University of North Dakota, September 1995, Grand Forks, ND [Bakken, N. A. & Hunt, C. D. (1995). Dietary boron affects plasma 1,25-dihydroxyvitamin D (1,25 vD) concentrations and peak pancreatic insulin secretion in the chick. *Book of Abstracts*, p. 30.]

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<sup>3</sup> The portion of this work related to the in situ chick model was done in partial fulfillment of the requirements for the degree of Master of Science in the Department of Anatomy and Cell Biology at the University of North Dakota.

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# Effect of dietary boron on mineral, estrogen, and testosterone metabolism in postmenopausal women<sup>1</sup>

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## ABSTRACT

A study was done to examine the effects of aluminum, magnesium, and boron on major mineral metabolism in postmenopausal women. This communication describes some of the effects of dietary boron on 12 women between the ages of 48 and 82 housed in a metabolic unit. A boron supplement of 3 mg/day markedly affected several indices of mineral metabolism of seven women consuming a low-magnesium diet and five women consuming a diet adequate in magnesium; the women had consumed a conventional diet supplying about 0.25 mg boron/day for 119 days. Boron supplementation markedly reduced the urinary excretion of calcium and magnesium; the depression seemed more marked when dietary magnesium was low. Boron supplementation depressed the urinary excretion of phosphorus by the low-magnesium, but not by the adequate-magnesium, women. Boron supplementation markedly elevated the serum concentrations of 17 $\beta$ -estradiol and testosterone; the elevation seemed more marked when dietary magnesium was low. Neither high dietary aluminum (1000 mg/day) nor an interaction between boron and aluminum affected the variables presented. The findings suggest that supplementation of a low-boron diet with an amount of boron commonly found in diets high in fruits and vegetables induces changes in postmenopausal women consistent with the prevention of calcium loss and bone demineralization. — NIELSEN, F. H.; HUNT, C. D.; MULLEN, L. M.; HUNT, J. R. Effect of dietary boron on mineral, estrogen, and testosterone metabolism in postmenopausal women. *FASEB J.* 1: 394–397; 1987.

*Key Words:* boron • calcium • 17 $\beta$ -estradiol • testosterone • magnesium

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CONCERNS ABOUT OSTEOPOROSIS, THE most common bone disorder in elderly women, have stimulated much interest in the nutrient calcium. Although most evidence reported indicates that massive intakes of calcium do not prevent bone loss in postmenopausal women (1), calcium intakes difficult to achieve through diet alone, those of up to

1500–2000 mg/day, are being recommended to women (2). These recommendations seem inappropriate because high-calcium intakes could lead to other disorders through effects on the metabolism of other nutrients. Surprisingly, these recommendations are made even though it is known that certain population groups with a low incidence of osteoporosis consume relatively low amounts of calcium (3). Thus, we decided to examine the possible effect on major mineral metabolism of some dietary substances other than the usual cholecalciferol, calcium, and fluoride. We chose to examine aluminum, magnesium, and boron. There are reports that pharmaceutical doses of aluminum elevate urinary calcium content (4). Also, Spencer et al. (4) found that subjects consuming a low-calcium diet and antacids containing aluminum salts excreted an elevated amount of calcium in the feces. In several animal species, variation in dietary magnesium alters the calcium content of urine and plasma (5). Recent studies with rats and chicks showed that boron affects major mineral metabolism and the response to high aluminum and low magnesium in the diet (6).

In the present study aluminum and magnesium treatments had no marked effects on calcium metabolism; thus, those findings will be presented elsewhere. Only the marked effects of dietary boron on selected indices of calcium metabolism in postmenopausal women will be presented in this brief communication.

## METHODS

The study was done with 13 postmenopausal Caucasian women between ages 48 and 82. Two of the women were on estrogen therapy throughout the study. After medical, psychological, and nutritional evaluation established that they were in good health and emotionally suited for the study, each volunteer signed an informed consent after receiving both oral and written presentations of the nature of the research. The study protocol was approved by the Institutional Review Board of the University of North Dakota and the Human Studies Committee of the U.S. Department of Agriculture. The protocol followed the

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