The Role of Boron in Human Nutrition

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Abstract:

Objective: To review the current scientific literature pertinent to the role of boron as a nutrient in human metabolism, and to comment on the validity of clinical applications of boron by the doctor of chiropractic.
Data Source: Index Medicus was used as a bibliographic source, with indexing terms of *boron*, exclusive of *neutron* (recapture theory) used for retrieval for dates 1990 to present. Previous to 1990, retrieval terms included *boron* and one of the following: *nutrition, human, arthritis, bone, and health.* A predominant amount of information came from the International Symposium on the Health Effects of Boron and its Compounds, held in September 1992 at the University of California in Irvine, CA.
Study Selection: All papers retrieved were included in this review unless they had no pertinence to the topic. Exclusionary topics included (most) toxicity data and pharmaceutical use of complex boronated compounds.
Data Extraction: This is a summary of information from a topic in its exploratory infancy. No abstraction or analysis of data is performed. Some commentary is made on interpretation of data.
Data Synthesis: It is evident that boron is linked to mineral, bone and steroid metabolism. Boron 'deficiency' may play a role in osteoporosis and arthritis and may decrease brain function in the elderly.
Conclusions: Evidence suggests that boron may be an essential human nutrient, however more research into its actual physiologic mechanisms and nutrient essentiality is required. Possible therapeutic and preventative applications for types of arthritis and osteoporosis offer potential benefit and also warrant investigation.

Introduction:

In the last few years, the author has noted the promotion of boron as an ingredient in nutritional supplements marketed in various chiropractic magazines. Although no direct claims are made in the advertisements, there is an obvious implication that boron is somehow beneficial in treating or preventing osteoporosis. As osteoporosis is frequently encountered in chiropractic practice and is also a prevention concern for many patients, the author chose to investigate the literature to evaluate what is known about boron as a human nutrient, and to comment on whether boron can yet be clinically useful to the chiropractor. In this paper the current state of animal and human research on boron as a nutrient will be presented. Some commentary will be made on interpretation of study results, but mainly the data and conclusions will be presented in objective summarization.

Boron is nearly universally present in the rock, soil, waters and atmosphere of our planet. There is, however, considerable variability in concentration of boron in rock, soil and water supplies, ranging from minimal trace amounts in some regions to possibly toxic levels in some locales. It is an essential nutrient for plants, but until recent decades evidence for the importance of boron in animal and human physiology was scant and could not be verified. [1]

In 1981, Hunt and Nielsen[2] performed studies on experimental chicks that were suffering retarded growth and leg abnormalities despite receiving the "usual" standard feed. The chicks began to recover when supplemented with boron, which indicated the possibility of boron being an essential nutrient. However, it was later discovered that the original feed was vitamin D deficient. Chicks fed the faulty diet plus vitamin D were healthy, and boron supplementation produced only slight benefit in these chicks. The field of boron nutritional research was now triggered, but already a question was raised. Is boron a true essential nutrient, or does it merely substitute when another deficiency is present?

Discussion:

Animal Studies:

In 1992, five significant papers were published regarding boron in animal nutrition. Dupre et al. [3] published results of a study that duplicated the condition of vitamin D deficiency and low boron supplementation, this time in rats rather than chicks. The response of the rats to boron supplementation was varied, probably because of different rates of depletion of vitamin stores. However it was clear that boron supplementation raised apparent-balance values of calcium, magnesium and phosphorous.

Nielsen and Schuler[4] reported on their study of mineral metabolism in rats deprived of either boron or calcium. These two groups of rats were further subdivided to include either magnesium or potassium deprivation, in addition to control groups. Analysis was made of body weight and femur mineral concentrations, with significant results to varied to mention here and impossible for the researchers to completely interpret. Important results, however, included the fact that a level of boron deficiency was achieved that induced reduced body weight without concurrent vitamin D deficiency. Also, boron status affected calcium and magnesium status, and visa versa.

Curtiss Hunt noted in lab studies that boron seemed to have an effect on energy metabolism via elevating plasma glucose in vitamin D deprived rats[5]. Hunt and Herbel

proceeded to study boron deprivation and supplementation in rats with induced diabetes mellitus[6]. Their rationale focused on further elucidation of boron's role in both mineral and energy metabolism by including the interactions of vitamin D with insulin. The metabolic effects of inducing diabetes were profound and masked any effect boron may have had. However, the non-diabetic control groups, fed 0 and 2.4 mg/kg boron daily, showed remarkable differences. The boron-supplemented group showed depressed plasma insulin and pyruvate concentrations, increased T4(thyroxine) and decreased creatine kinase activity. Growth, however, was not affected. Of particular note was decrease in plasma aspartate transaminase activity, which the authors suggest shows a protective influence over liver metabolism.

The Hunt and Herbel work also revealed influences on mineral metabolism in the non-diabetic rats[7]. The boron-supplemented group had increased urinary excretion of calcium, though plasma calcium an calcium levels in certain tissues were unaffected. Boron supplementation also affected cardiac copper, calcium, manganese, molybdenum and phosphorous concentrations, without affecting boron concentration itself.

Interactions with vitamin D, calcium and magnesium suggested involvement with bone metabolism. McCoy et al. explored this concept in their study of boron's effect on bone composition and mechanical properties in rats[8]. Higher amounts of boron supplementation caused changes in both bone mineral status and biomechanical properties. These changes were often detrimental, but the authors point out that the level of supplementation was high compared to other studies.

Boron and human nutrition:

. Boron is known to be toxic in large quantities, with rapid absorption and excretion, and accumulation only in bone. Toxic levels are not concretely established, but seem to be on the order of at least 600 to 800 mg/kg body weight.[9] The average human intake of boron is several milligrams daily, although this varies regionally and with diet.[9] Until animal studies began to spark greater interest, most data on boron and human metabolism consisted of toxicity data or pharmaceutical use of complex boronated compounds[2]. Once boron was seen as a possible nutrient, research on human subjects began.

The first human studies, reported by Nielsen in 1990[10], involved inducing boron 'deficiency' in human subjects through diet. The group ingested .25mg boron daily for 119 days then 3mg of boron daily for 48 days. The lower boron supplementation resulted in depressed plasma ionized calcium and calcitonin as well as elevated total plasma calcium and urinary excretion of calcium. These effects were similar to those seen in osteoporosis, which prompted an investigation of this specific disorder.

Boron in female metabolism

Nielsen followed up in 1991 with a paper on two studies of post-menopausal women[11]. The women were fed a low boron diet for a period, then had a period of increased boron intake, with the same dosages and time factors as the previous experiment. Boron supplementation decreased total plasma calcium, urinary excretion of calcium and magnesium, and elevated plasma estradiol and testosterone. Some of the second study group were also given estrogen injections; those with the greater boron supplementation had increased impact of estrogen on physiologic parameters. These findings suggested a possible role for boron deficiency in osteoporosis.

A study of boron supplementation on sedentary and athletic females looked further at the role of boron in bone-related metabolism in women[12]. Boron supplementation of 3 mg/day for ten months was shown to decrease serum phoshorous levels compared to placebo. The study found no overall differences in bone density with boron supplementation. It is interesting to note that the published paper only commented on bone density as an all-inclusive comparison. This is in contrast to the fact that their data table shows a clear increase in bone density with boron supplementation if one compares only the sedentary supplemented and control groups. Perhaps the athletic group masked this effect because their greater activity level stimulated bone development to an extent that minimized benefits of boron.

Boron for bodybuilders?

The fact that boron seems to be involved in steroid metabolism, including cholecalciferol, estradiol and testosterone, sparked interest in athletes and bodybuilders, who are constantly seeking ways to boost anabolic steroid levels to enhance performance. Boron supplements were promoted as testosterone boosters, based on the study of menopausal women. Ferrando and Green performed a study on 19 male bodybuilders in which ten were given daily 2.5mg boron supplements and the rest were given placebo pills[13]. After 7 weeks, there was no difference between groups in testosterone levels, lean body mass, or strength. It should be noted that a 'deficiency' was not induced, and these subjects may well have already had adequate dietary boron, with no significant effect of additional boron.

Boron and the brain:

Based on the suspicion that boron may be important for membrane function, James G. Penland carried out 3 studies of brain function and cognitive performance in the elderly with low and high boron diets[14]. In each study, subjects were consumed only .23mg boron per day for 63 days, then were switched to 3 mg boron per day for 49 days. While in the boron 'deficient' stage, the subjects showed increased low frequency and decreased high frequency brain waves, similar to the effects of general malnutrition or heavy metal toxicity. Also, the subjects showed decreased manual dexterity (studies 2 & 3), attention (all studies), eye-hand coordination (study 2), perception (study 3), encoding and short term memory (all studies), and long term memory (study 1), in comparison to the boron supplementation phase.

Genetic regulation?

R. D. Barr et al. published a retrospective analysis of plasma boron levels of natives in remote areas of Chile from data collected in the 1970s [15]. The regions they had collected in had widely varying boron levels in the water supplies, and so offered a unique opportunity to look for evidence of physiological regulation of boron in the body. While plasma boron levels varied directly with levels of boron in the local water, the analysis revealed an interesting phenomenon. Boron levels varied less within families than between families with the same water supply. The authors interpreted this as evidence of genetic regulation of boron, which lends support to the idea of boron as a physiologic nutrient. However, the authors did not mention any consideration of differences in food preparation or water consumption habits between families, which could contribute to such differences.

Boron and Arthritis:

A unique voice on the topic of boron is that of Rex Newnham, MD[16]. Newnham reports anecdotally that he has helped thousands of patients with osteoarthritis and rheumatoid arthritis (including himself) by prescribing 6 mg of boron supplemented daily. When his native Australian government made boron supplementation illegal in 1981, he began a quest to document the effectiveness of boron supplementation. Through his own research and that of others he reports the following - 1) lower boron concentrations in arthritic femur heads as compared to normal femur heads, 2) lower boron concentrations in bones and synovial fluid of those with rheumatoid arthritis than those without this disorder, 3) anecdotal reports by orthopedic surgeons that bones of patients who use boron supplements are much harder to cut, and 4) effectiveness of boron in alleviating arthritis in a double-blind study of rats. In addition, Newnham has two especially strong arguments for looking further into this topic, namely some intriguing epidemiological data and a double blind placebo-controlled study of human subjects.

The controlled study of twenty patients with osteoarthritis found a statistically significant ($p<0.05$) benefit of boron supplementation of 6 mg/day for 8 weeks. Benefits included fewer joints affected, less pain on movement, less swelling and less movement restriction. No side effects were apparent. The epidemiological study compared geological and agricultural survey data of soil and water boron levels throughout the world with epidemiological data on the occurrence of rheumatoid arthritis and osteoarthritis. Newnham found a strong relationship between very low regional levels of boron (resulting in less than 1mg intake per day) and unusually high rates of both types of arthritis. Conversely, areas of low incidence of arthritis had much higher local boron availability and average daily intakes of 3-10 mg.

Summary:

It is evident through the research presented here that boron has a significant interaction with mineral metabolism, especially calcium and magnesium. Bone metabolism in particular seems affected by boron, but details on the actual mechanisms must be worked out in future research, along with the apparent relationship of boron to steroid metabolism. Both animal and human studies suggest that boron is an essential nutrient, but the evidence is not yet overwhelming, and there is still the possibility that boron merely boosts certain physiologic processes when other nutrients are deficient or pathological processes are present.[17]

As for boron 'deficiency' being causally related to arthritis, the evidence is strong, with the caveat that it comes mainly from one source. But as Ernest Mastromatteo pointed out in his summary of the International Symposium on the Health Effects of Boron and its Compounds:

> "since boron is not a patentable compound, it is unlikely that any drug company will spend the money necessary to develop compounds like borates for promoting health."[18]

Is there enough evidence to support clinical applications of boron for doctors of chiropractic? While it normally would be prudent to wait for more thorough investigations of a substance before clinical application, this author feels that use of boron by the chiropractic clinician may be warranted because

1) boron is apparently quite safe in the treatment doses used so far (2-6 mg/d)
2) research on boron will probably be slow in coming for the reason noted above
3) the supplemental levels are very similar to normal dietary levels[9]
4) many arthritis medications have significant side effects; none have been seen with boron at trial therapeutic levels

5) boron need not add additional expense or time for the patient: postmenopausal women who would take calcium anyway can simply purchase a calcium with boron included, and other patients could simply use a multivitamin with boron included.
6) if no other supplementation is desired, boron supplements are very inexpensive.

So far the benefits of boron have been seen mainly in the elderly, therefore this is the group for which there is the greatest rationale for boron supplementation. Candidates for supplementation would include postmenopausal women (for prevention or treatment of osteoporosis, in conjunction with more established protocols) and those with osteoarthritis and rheumatoid arthritis. More research is certainly warranted on using boron earlier in life to prevent osteoporosis. Overall, none of the health benefits are soundly proven, and clinicians should proceed conservatively with use of boron.

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