Interpreting Hair Tissue Mineral Analysis (HTMA) reports can sometimes be a challenging task for practitioners, especially when we see unexplainable elevated results showing for some minerals. One element that has caused lots of questions over recent years in our HTMA results is Boron. In Australia, it is not unusual to see HTMA reports with unexplainable levels of Boron appearing in an otherwise normal test. Interestingly, it should be noted that based on HTMA studies conducted by Trace Elements Inc and InterClinical Laboratories, Boron levels in Australian HTMA samples are approximately 10 times higher than the world average. (See chart 3).

In order to de mystify the Boron results we need to take a look at the mineral itself, the role it plays in the environment and how it behaves in the body.

Boron is a naturally occurring element. It is found in the environment, combined with oxygen and other elements in compounds called borates. Borates are widely found in nature, and are present in oceans, sedimentary rocks, coal, shale and some soils. Boron is released to the atmosphere via volcanic activity and from geothermal steam. It is estimated that natural weathering is a significant source of environmental boron.

There are several commercially important borates, including borax, boric acid, sodium perborate, and the minerals ulexite and colemanite. Industries that can release boron include glass manufacturing, cement works and leather tanning. Sodium Borates and Boric acid can be widely used in cosmetics and are commonly found in make up, skin and hair care preparations and shaving creams.

Functions...Our need for Boron
Boron has not been proved conclusively to be an essential nutrient in humans, however there is substantive information that it may be important for mineral metabolism, brain function and performance, hormone regulation, to assist calcium absorption and to help prevent bone related disorders, such as osteoporosis, arthritis and tooth decay.

Apparent deficiency symptoms of Boron include the following
- Arthritis
- Osteoporosis
- Degenerative Joint Problems
- Hormonal Imbalance
- Carpal tunnel
- Weak cartilage
- Low libido
- Receding Gums

Boron contamination usually occurs through ingestion or inhalation. It is unlikely to be absorbed directly through the skin when the skin is intact, however rapid absorption occurs through broken or damaged skin.

Boron's Essentiality
Although no specific biochemical function for Boron has been discovered in humans it appears that dietary deficiency results in adverse changes to biological functions.

According to the NHMRC there is no RDI for Boron. The RDI’s do not include food components that are believed to be but not yet proved to be essential. Patterns of usage however indicate that according to available evidence Boron is essential for human beings with food sources providing the most exposure. The average daily intake from dietary sources is 2.02mg/day (with a urinary excretion of 1.9mg/day).

Dietary Sources
Rich dietary sources of Boron can be found in plant based foods including apples and pears, carrots, grapes and green leafy vegetables. Nuts, honey and dried fruits and especially dates are good sources of boron. The edible marine algae Dunaliella salina is a particularly rich source of dietary Boron.

Boron – A Clinical Review
Studies conducted by Trace Elements Inc and InterClinical Laboratories based on HTMA results indicated Boron levels in Australian HTMA samples are approximately 10 times higher than the average. See chart page 3.
Data supports the hypothesis that boron is an essential element and that it is involved in regulating parathyroid hormone action. It is believed to help convert Vitamin D. Therefore, it is likely that boron influences the metabolism of calcium, phosphorus, magnesium, and cholecalciferol.

According to Darren Wise (2000), “Boron has influence on blood and serum mineral and has shown to produce a positive retention of calcium, magnesium and phosphorus that would be beneficial to bone metabolism”

The combinations of magnesium and boron deficiency seem to worsen the effects of osteoporosis, suppress bone building and reduce the concentrations of magnesium in bones.

**Boron toxicology**

Boron is rapidly absorbed and excreted, mainly in urine. Urinary recoveries depend on the dietary intake and may range from 30-90%.

Boron appears rapidly in the blood and tissues of mammalian species. Up to 95% absorption appears after oral ingestion.

Kidney problems reduce excretion, causing potential boron accumulation in the heart, lungs, kidneys, brain, reproductive glands and adipose tissues.

It would appear that there is no evidence supporting the theory that Boron accumulates in human tissues when consumed at normal dietary or supplemental dosages. Tissue homeostasis is maintained by the rapid elimination of excess boron through urine, and perspiration. Homeostatic control is maintained by the kidneys with up to 84% recovery in urine obtainable from oral dosage.

Chronic or toxic human exposure to Borates can result in diarrhoea, vomiting, weight loss, skin rash, anorexia, convulsions and muscle weakness. The mean lethal dosage of boric acid or sodium borate probably exceeds 30g.

Years ago, boric acid was administered at 0.5 g/day to achieve weight loss. This dosage caused boric acid diarrhoea, in addition to considerable deterioration of nutrient absorption.

Boron toxicity results in a Vitamin B2 deficiency by antagonising and increasing urinary losses. Magnesium is also antagonised by excess Boron and may be useful in supplementation for Boron toxicity.

**Environmental Boron in Australia**

Borates are released to the air from natural and industrial sources. According to the National Pollution Inventory, Boron and compounds were ranked as 52 out of 400 based on environmental hazards and human environmental exposure to the substance. It registers 1.7 on a hazard rating of between 0-3 where 3 represents a high hazard, 2 represents medium hazard and 1 is harmful to health.

High concentrations of boron can tend to occur in soils which have formed with the addition of marine sediments. In regions experiencing low rainfall the soluble boron salts can accumulate to much higher concentrations in the root zone affecting plant growth.
Hair Tissue Mineral Analysis and Boron

Although the evidence suggests that human bioaccumulation of boron is minimal, the storage areas tend to be mainly bones and dental enamel. It appears that the boron content found in hair is similar to that of soft tissue. According to World Health Organisation recommendations, the best technique for measurement of boron present in biological samples is Inductive Coupled Plasma, Mass Spectrometry (ICP-MS). This method is the most sensitive allowing for lower detection limits. This recommendation supports the use of Hair Tissue Mineral Analysis, using ICP MS as an effective indicator of tissue boron levels.11

Hair Tissue Mineral Analysis: International populations comparative test results for Boron, courtesy of Trace Elements Inc.

Clinical finding: This graph shows that boron levels in Australian hair samples are approximately 10 times higher than the world average.

Conclusions

High soil boron present in many of the fruit, vegetable and grain growing areas of Australia may be a contributing factor to increased oral consumption of Boron. Increasing soil salinity in drought prone areas has added to this accumulation in soils and water supplies. With no methods of removing toxic levels of boron from the soil, boron resistant crops are being grown and developed in order to combat this problem. Although this provides a benefit for the grower, one can assume that we will see growing levels appearing in our food sources. Increasing levels of environmental boron may appear to contribute to this increasingly potentially toxic load of boron appearing in the atmosphere and water supply.

High levels of boron in HTMA results may be reflecting total excretory amounts of Boron via skin and perspiration.

High HTMA Boron may also be indicative of low kidney clearance rates.

Based on the results of Australian HTMA results, Boron deficiency among samples tested is low in Australia. Excess levels of boron found in patients may be attributed to both environmental and dietary sources in Australia; however the usage of various medicines, cosmetic products and pesticides could be another significant contributing factor.

Water supplies in drought affected areas are potentially high sources of Boron. In South Australia, drinking water levels have a reported range of between 0.02 mg/L and 1.3 mg/L and it is easy to see that the Australian average intake of 2.232mg/day will be easily exceeded in these areas.

The safe level for drinking water nationally has been set a maximum of 0.3 mg/L (NHMRC and ARMCANZ, 1996):

According to Dr David Watts, based on results from Australian Hair Tissue Mineral Analysis results, the incidence of Boron deficiency in Australia is quite low (approx. 0.5% of samples tested). Unless there is good clinical evidence that Boron deficiency exists in a patient, routine supplementation of Boron should not be part of the Australian prescribing regime. The best sources of nutritional Boron are from food based sources.

In the case of high Boron, magnesium, Vitamin B6 and Vitamin B2 may be useful in antagonising excessive Boron, however elimination of the source of contamination should remain a priority.

References available on request.

Boron contamination in the laboratory

Boron contamination of samples can occur during the HTMA hair digestion process. Borosilicate glass test tubes are not recommended for digesting hair samples, as the concentrated nitric acid can over time leach boron from the inside of the glass and deposit it as a contaminant in the patient sample aliquot. Due to the known potential of boron contamination in the laboratory, Trace Element’s uses only disposable polypropylene test tubes for sample preparation and digestion. Each patient sample is prepared in a disposable test tube that is used only once before being discarded. To further minimize boron contamination, the Trace Element’s laboratory has also eliminated the use of borosilicate glassware for preparation and storage of all other solutions needed for analysis such as calibration standards, rinse solutions, internal standard, etc. In the case of boron and other contaminants that could be introduced from leaching and reuse, these additional laboratory analysis measures, although expensive are completely justified and indeed necessary for a quality-oriented analysis of HTMA patient samples.

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