NUT041 REV. 3/98 13M
CLINICAL NUTRITION INSIGHTS

Vol. 5, No. 3

The Importance of Optimal Nutrition

BY DR. MARK PERCIVAL

ABSTRACT: *Balanced and optimal macro- and micro- nutrient intake provides an important foundation for good health. Micronutrients are essential for a myriad of body functions, playing indispensable and diverse roles as coenzymes, structural components, pro-hormones, components of body fluids, antioxidants, and many more. Today's lifestyles and eating habits often result in "unbalanced" diets with many people not even meeting RDA levels of all essential nutrients. Also, because each individual has his or her own "biochemical individuality," or distinct nutritional needs which must be met for optimal well-being, the RDAs may not be adequate. Many factors can further increase individual nutrient requirements, such as smoking, alcohol abuse, chronic dieting, use of prescription or other drugs, chronic illness, etc. Marginal nutrient deficiencies can be found in all segments of the population, often manifesting vague, non-classic symptoms that make it difficult to recognize and supplement the deficiency. Eating a well-balanced diet rich in fruits and vegetables and taking a high-quality, scientifically balanced multiple vitamin/mineral supplement is an excellent way to ensure that our individual nutrient needs are met.*

VITAMIN AND MINERAL FUNCTIONS

Why is it vital that we ensure our bodies receive optimal and regular intake of all micronutrients? Because the body requires readily available supplies of these nutrients for a myriad of body functions, providing an indispensable foundation for overall health. Each vitamin or mineral can be vital for a variety of functions and because micronutrients frequently work synergistically, even a single deficiency can interfere with many different body processes. Described below are the major areas of vitamin and mineral dependent functions in the body:

- **Coenzymes**

Vitamins and minerals play essential roles as coenzymes, which are responsible for activating enzymes. Enzymes are the catalysts that drive all metabolic processes, contributing to proper growth, digestion, energy metabolism, hormone synthesis and regulation, immune system function, homeostasis, detoxification, nerve and muscle function, and reproduction.

Coenzymes can be likened to keys that start the ignition for *every* metabolic process in the body. For example, the B vitamins are central to the energy metabolism of all cells, acting as coenzymes in glycolysis and oxidative phosphorylation, breaking down carbohydrates, protein, and fat for energy, and converting excess carbohydrates to fat for storage. Vitamin B_2 (riboflavin), when converted to its coenzyme forms, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD), act as hydrogen carriers to help make energy as adenosine triphosphate (ATP) through the metabolism of carbohydrates and fats.[1]

Pantothenic acid is the key vitamin component of the highly active metabolic compound acetyl coenzyme A (CoA), which lies at the heart of energy production in the cell's mitochondria. Pantothenic acid is vital to overall body metabolism. As a part of acetyl CoA, it is involved in the release of energy from carbohydrates and in the degradation and metabolism of fatty acids. Besides functioning in the citric acid cycle, CoA is involved as an acceptor acetate group for amino acids, vitamins, and sulfonamides. It also is involved in the synthesis of cholesterol, phospholipids, steroid hormones, and porphyrin for hemoglobin and choline.[2]

- **Structural Components**

Vitamins and minerals play vital roles in the structural components of the body and are required for proper growth, maintenance, and repair of tissues. As examples, calcium, phosphorous, and magnesium are essential components of bones; vitamin A helps develop and maintain moist, healthy epithelial tissue; iron and vitamin B_6 are involved in the manufacture of hemo-globin in red blood cells; the formation of the myelin sheath around nerve cells requires vitamin B_{12}; and vitamin C functions in the formation and maintenance of collagen, the protein that forms the basis for connective tissue. These are just a few examples of the varied roles that micronutrients play in structural components.

- **Pro-hormones**

Vitamin D is now known to function as a pro-hormone, a precursor to an active hormone. As this active hormone (calcitriol), vitamin D works in conjunction with parathyroid hormone (PTH) and the thyroid hormone calcitonin to influence the absorption of calcium and phosphorous and their deposition in bone tissue.

- **Antioxidants**

The antioxidant properties of several vitamins are well known. Oxygen is a highly reactive atom that is capable of becoming part of potentially damaging molecules commonly called "free radicals." Cell damage caused by free radicals is believed to play a central role in the aging process and in disease progression.[3] Antioxidants are capable of stabilizing, or deactivating, free radicals before they attack cells. Vitamin C, vitamin E, and beta-carotene are among the most widely studied dietary antioxidants and play an important role in free radical protection. In addition to beta-carotene, other carotenoids, such as alpha-carotene, cryptoxanthin, zeaxanthin, lutein, and lycopene, are now also recognized as having powerful antioxidant properties.

NUTRIENT DEFICIENCIES

So what are the consequences of vitamin and mineral deficiencies? Classic vitamin-deficiency diseases such as scurvy (vitamin C deficiency) and beriberi (vitamin B_1 deficiency) were prevalent at the turn of the century. But these diseases, the result of long-term and severe vitamin or mineral deficiencies, are rare today in the United States. Common, yet often unrecognized today, is the fact that nutrient deficiency occurs gradually in progressive stages. Long before the identifiable symptoms of deficiency diseases are observable, a series of harmful, yet subtle, effects have taken place in the body. This gradual sequence of nutrient depletion was explained in the *Journal of the American Medical Association* (Table 1).[4]

Table 1: Development of Vitamin Deficiency

Deficiency Stage	*Symptoms and Comments*
1. Preliminary	Inadequate availability of vitamin.
2. Biochemical	Enzyme-coenzyme activity depressed.
3. Physiological	Appetite loss, general malaise, insomnia, and increased irritability.
4. Clinical	Increased malaise, loss of body weight, with the appearance of deficiency syndromes.
5. Anatomical	Specific deficiency disease established with specific tissue pathology. Without repletion, death may result.

The first 3 stages are referred to as a marginal deficiency, a condition in which specific biochemical and metabolic effects result from vitamin depletion but without classic clinical signs of deficiency. The symptoms of marginal deficiency are vague and often are described as "feeling under the weather," with general feelings of lethargy, irritability, insomnia, poor concentration, or depression.[5] During this state of marginal deficiency, we are not functioning optimally and our quality of life is compromised; we have greater susceptibility to colds and infections; our mental functions may be reduced; and our personality and emotions can be affected. The non-specific nature of these symptoms makes it difficult to lead to a diagnosis of nutritional deficiency and so the nutritional problem may progress undetected. Long-term nutrient deficiencies may be associated with the development of degenerative diseases such as diabetes, heart disease, osteoporosis, and cancer. The clinical stage (#4) is when more classic symptoms of deficiency syndrome occur.

Marginal nutrient deficiencies are found in all segments of the population, but especially in pregnant women, children, the elderly, alcoholics, and drug abusers. Marginal nutrient deficiencies are also common in hospitalized patients who consume inadequate diets during illness and stress — when nutrient needs are highest. Poor nutrition during times of illness and stress can weaken the immune system and hamper the healing process.[5]

Proper nutrition is especially important during pregnancy to meet the critical nutritional demands of the fetus and the mother. Increased quantities of calcium, iron, vitamins A, C, D, and the B vitamins are needed to meet these demands. Vitamin and mineral deficiencies before and during pregnancy can have long-term effects on the health of the newborn. For example, a deficiency in folate appears to play a role in neural tube defects such as spina bifida. Several studies have shown that nutritional supplements containing folate given before conception markedly reduce the occurrence of neural tube defects, even in children born to mothers who previously had a child with such a defect.[6]

In another study, the long-term effects of zinc deficiency, which has been associated with impaired immune responses, were demonstrated. Pregnant mice were fed a diet that provided adequate levels of zinc for the first trimester, but was moderately deficient in zinc the second and third trimesters. The offspring of these mice showed depressed immune function through 6 months of age, despite being fed the normal control diet adequate in zinc since birth. More significantly, the second and third filial generations, all of which were fed the normal control diet, continued to manifest reduced immune responses, although not to the same degree as in the first generation. The authors of the study concluded that "this study has important implications for public health and human welfare, as the consequences of fetal impoverishment may persist despite generations of nutritional supplementation. Dietary supplementation beyond the levels considered adequate might allow for more rapid or complete restoration of immunocompetence."[7]

MEETING OUR NUTRIENT NEEDS: ARE THE RDAs ENOUGH?

The Recommended Dietary Allowance (RDA) is said to be the level of intake of essential nutrients adequate to maintain health for "practically all healthy persons." These levels are based on the "average" woman or man with an average body weight, body fat percentage, nutrient absorption and excretion rate, stress level, and heredity pattern.[5] Who are the people who don't meet this "average" definition?

***People who*:**

- have very high or low body weight
- have chronic illnesses
- have heavy physical work stress
- are taking medications
- have digestive problems
- have wounds, burns, or injuries
- have a metabolic abnormality

In other words, many of us do not meet the "average" definition and may need more than the RDA of nutrients.

EATING A BALANCED DIET

We are all familiar with the oft-repeated recommendation for good health, "eat a well-balanced diet of wholesome, nutritious foods to meet your daily nutritional requirements." But the fact is, despite the best intentions, few people actually manage to eat a well-balanced diet for a variety of reasons. Our busy lifestyles, dual-career households, tendency to skip meals, and frequent dieting all play a role in the "unbalanced" American diet.

Many people succumb to eating highly processed fast food and junk foods, which tend to be high in fat and sugar and contain few of the vitamin and mineral nutrients that our bodies need. In addition, the tendency to refine whole grains and other carbohydrate sources, a reduction in consumption of fresh fruits and vegetables, and methods of food preparation that overcook or leach the vitamins from foods are some of the factors responsible for vitamin deficiencies in the United States.

Even those of us who frequent the fruit and vegetable section of our grocery stores may be shortchanged nutritionally. A study reported in the *Journal of Applied Nutrition* compared the difference in nutritional value of organic foods with commercial foods and found that there are significant differences between the two. Apples, pears, potatoes, corn, and wheat were purchased in the Chicago area and analyzed for 22 nutrients and 4 toxic elements over a period of two years. The analysis showed that "the organic pears, apples, potatoes, and wheat had, on average, over 90% more of the nutritional elements than similar commercial food."[8] The researchers did not include corn in the average because the nutrient difference was over 2 1/2 times greater for the organic corn. Many factors, such as soil nutrients, use of chemical fertilizers, harvesting times, or post-harvest differences in handling, can impact the nutrient levels in food.

Many of us do not receive even the RDA levels of all essential nutrients from the foods we eat. The Total Diet Study found that intakes of calcium, magnesium, iron, zinc, and copper are, on average, less than 80% of the RDA or below the low end of the Estimated Safe and Adequate Daily Dietary Intake range.[9] The second Health and Nutrition Examination Survey of 1977-78 (HANES-II) showed that only 9% of U.S. residents eat five daily servings of fruits and vegetables and up to 50% of the population was below the RDA levels for some vitamins and minerals, especially calcium, iron, vitamin A, and vitamin C.

The Public Health Service states that 4 of the 10 leading causes of death in the United States are associated with diet and nutrition (heart disease, cancer, strokes, and diabetes), representing two-thirds of all deaths in 1991.[2] Dietary imbalances also contribute to health problems such as atherosclerosis, high blood pressure, osteoporosis, and gastrointestinal diseases.[10]

VARIABLE NUTRIENT NEEDS

We each have our own "biochemical individuality," a theory first proposed by Roger J. Williams in 1956 which states that "every individual organism that has a distinctive genetic background has distinctive nutritional needs which must be met for optimal well-being." Even closely related individuals (e.g., identical twins) can have profound biochemical differences. Therefore, those people who feel that they meet the RDA of nutrients by eating a well-balanced diet may be at risk for a deficiency because their biochemical individuality requires more than the RDA of certain vitamins and minerals. What's worse, those people that may need more than the RDA and who eat a poor diet can be at serious risk for vitamin and mineral deficiencies.

Environmental and lifestyle stressors and other physiological factors can increase the need for essential nutrients beyond what may be supplied by a balanced diet. A list of some of these include:

- Regular alcohol use
- Regular intake of caffeine
- Chronic dieting
- Use of prescription or other drugs
- Oral contraceptive use
- Infection or illness
- Pregnancy
- Heavy exercise
- Exposure to radiation (sun, x-rays, etc.)
- Cigarette smoke
- Old age
- Poor digestion
- Surgery
- Injuries or wounds
- Exposure to pesticides
- Exposure to air/water pollution
- Increased emotional or occupational stress

As an example, people who smoke often have low serum levels of antioxidants like vitamins C, E, and beta-carotene, up to 30% lower than non-smokers. In fact, the suggested RDA for smokers is 100 mg of vitamin C per day, compared with 60 mg for non-smokers. This relative deficiency in smokers may in part be due to poorer eating habits, but it may also indicate that these substances are doing their job against the oxidative burden imposed by smoking and are being consumed in the process.[11]

The elderly frequently have nutrient deficiencies due to decreased caloric intakes, poor absorption of nutrients, and long-term use of prescription drugs.

Taking prescription and nonprescription drugs and exposure to pesticides, food additives, industrial chemicals, and environmental pollutants can adversely affect vitamin and mineral status. Our bodies deal with these xenobiotics (foreign chemicals) by detoxification, a process in which metabolizing enzymes convert toxins into more polar, water-soluble compounds that are then more readily eliminated by the body. The increased load on these nutrient-dependent enzymes caused by the prolonged use of a drug, for example, will increase the demand for nutrients and drain the body's reserves. If that increased nutrient requirement is not met, a deficiency will ensue, followed by decreased enzyme induction and decreased rate of drug metabolism, leading to drug toxicity.[12] The resulting nutrient deficiency not only compromises the detoxification process, but the other physiological roles of the nutrients as well.

VITAMIN AND MINERAL SUPPLEMENTS

The previous data provides strong justification for augmenting the diet with at least a broad spectrum multiple vitamin/mineral supplement to help ensure that each individual's nutrient requirements are met. Important vitamin/mineral supplement features consistent with the latest nutritional science include:

- **Broad Spectrum Antioxidant Support with Mixed Carotenoids**

Recent research suggests that a diverse selection of antioxidants functions synergistically and offers better protection against free radicals than do excessive amounts of single antioxidants. Going one step further, it has been suggested that under certain conditions an excess of one type of antioxidant, in the absence of balance with the others, may actually inhibit the protective effects of antioxidants.[13] For example, two recent cancer studies showed that smokers who were given high dose synthetic beta-carotene supplements actually had a higher incidence of lung cancer than those who did not receive the supplements.[14-15] However, several other long-term cancer studies, such as the 19-year Western Electric Study, have shown that a high *dietary* intake of beta-carotene rich *foods* and higher beta-carotene blood levels are associated with a reduced risk of developing lung cancer.[16] Several authors have pointed out that the studies associating beta-carotene supplements with increased lung cancer risk did not incorporate any of the other carotenoids and antioxidants found in fruits and vegetables.[17-19]

Voicing criticism of applying "pharmacologic doses of a single carotenoid," Klaus Pietrzik, M.D., from the University of Bonn, stated that this could possibly ". . . result in competition at the receptor with the other 50 naturally occurring dietary carotenoids and thus inhibit their protective effects." He further stated ". . . the data justify the conclusion that a balanced mixture of antioxidants, as found in fruits and vegetables, provides the best protection against cancer and that excessive intake of a single antioxidant may impair that protection. Population groups with low levels of fruit and vegetable consumption may be able to obtain similar protection by taking moderate amounts of a combination of several antioxidants (e.g., various carotenoids and vitamin C), *provided that the consumption and doses of the combination conform to a physiologic pattern*."[17] (emphasis added)

What logical conclusion might be drawn from this recent science? Eat a balanced diet rich in fruits and vegetables and choose a multiple vitamin and mineral supplement that provides a broad spectrum antioxidant profile, rather than beta-carotene alone. Vitamin E, vitamin C, and selenium, classically known to help protect one another from oxidative damage, should be combined with a variety of natural-source carotenoids that equal the ratio found in fruits and vegetables. This would include alpha-carotene, cryptoxanthin, zeaxanthin, lutein, lycopene, etc., in addition to beta-carotene. Phytonutrients, such as quercetin, with their powerful antioxidant activity can further ensure that broad spectrum antioxidant protection is provided. A heavy smoker might still prefer to choose a multiple that does not contain any beta-carotene.

- **An Adequate and Balanced Vitamin Profile**

Ensuring adequate levels of important B vitamins is a topic of growing scientific interest. One example of the benefits of adequate vitamin B nutrition was highlighted in a review of the scientific literature, where researchers examined 27 studies and confirmed elevated plasma levels of the amino acid homocysteine as a risk factor for vascular disease.[20] The authors of this study, along with other researchers, concluded that supplementation of the diet above the RDA with folate, as well as vitamins B_6 and B_{12}, reduces homocysteine levels.

The *Journal of the American Medical Association* recently published the results of a 14-year (1980-1994) study of 80,082 women enrolled in the Nurses' Health Study in which the relation of intakes of folate and vitamin B_6 to risk of coronary heart disease (CHD) were examined.[21] Risk of CHD was lowest (relative risk 0.55) among women with the highest intake of both folate and vitamin B_6 compared to women with the lowest intake of both nutrients. Vitamin supplements were by far the largest contributor to total folate and vitamin B_6 intake. The researchers concluded that maximum benefit would be achieved at intakes of at least 400 µg/day folate and at least 3 mg/day vitamin B_6, stating that the current RDAs for folate (180 µg/d) and vitamin B_6 (1.6 mg/d) may not be sufficient to minimize risk of coronary disease.

The studies cited earlier in this paper confirm that the collective diet of our society has progressively become inadequate, with many people not receiving even the RDA levels of all essential nutrients. In addition, "biochemical individuality" may dictate the need for a level of vitamin B nutrition well above RDA levels. Therefore, choosing a multiple that maintains the balanced ratio of one B vitamin to another as established by the RDA, yet provides a quantity of B vitamins that are well above RDA levels, is considered advantageous by many.

- **The Importance of Mineral Form, Balance, and Absorption**

The benefit derived by a mineral supplement is largely determined by the balance of the total number of minerals the supplement contains, by the mineral ratios, and by the form of the minerals. When multiple minerals are consumed, competition for mineral absorption may occur. Providing minerals in a balanced ratio will help reduce that competition.

Another novel approach to minimizing mineral absorption difficulties and maximizing mineral uptake is by providing minerals in a specialized form; bound to two amino acids in a bicyclic, dipeptide-like structure that resists gastric acid and intestinal enzyme breakdown. As a true mineral chelate it has a neutral charge and, therefore, resists complexing with other substances, such as phytates, which can bind to minerals and impede their absorption. It is typically absorbed as an amino acid-like compound by active transport at dipeptide absorption sites in the small intestine. Additionally, mineral chelates may be better tolerated by some individuals. The use of true mineral chelates may also reduce the degradation of vitamins contained in the same supplement over time.[21]

There are varying qualities among chelated minerals. A 100% fully reacted amino acid chelate is a form where each mineral ion is complexed with two amino acids with no other form of residual mineral present in the material. Others that are not 100% fully reacted may have residual forms of lesser quality mineral or may be simple admixtures where protein and minerals are simply mixed together in a blending drum.

- **The Importance of Digestibility and Purity**

It is common knowledge that the manner in which a nutritional formula is tableted can determine how much of that supplement is available for absorption. It is important that a supplement be designed to break down, or disintegrate, within 30 minutes in the stomach allowing for quick and more thorough absorption of nutrients. A multivitamin should also be free of common allergens including yeast, soy, milk, egg, wheat, corn, artificial colorings, etc.

REFERENCES

1. Linder MC. Nutritional Biochemistry and Metabolism. 2nd ed. Norwalk, CN: Appleton & Lange, 1991:114-118.
2. Mahan KL, Escott-Stump S. Krause's Food, Nutrition, and Diet Therapy. 9th ed. Philadelphia: W.B. Saunders, 1996:108,118, 338-339.
3. Sies H, et al. Antioxidant functions of vitamins. *Ann NY Acad Sci* 1992;669:7-20.
4. Brin M. Erythrocyte as a biopsy tissue for functional evaluation of thiamine adequacy. *JAMA* 1964;187:186-190.
5. Somer E. The Essential Guide to Vitamins and Minerals. New York: Harper Collins, 1992:10-15, 229-230.
6. Ziegler EE, Filer LJ. Present Knowledge in Nutrition. 7th ed. Wash DC:ILSI Press, 1996:206-216.
7. Beach R S, et al. Gestational zinc deprivation in mice: persistence of immunodeficiency for three generations. *Science* 1982;218:469-471.
8. Smith B L. Organic foods vs supermarket foods: element levels. *J Appli Nutr* 1993;45:35-39.
9. Pennington J, et al. Nutritional elements in U.S. diets: Results from the Total Diet Study, 1982-1986. *J Am Dietetic Assoc* 1989;89:659-664.
10. Public Health Service, DHHS. Surgeon General's Report on Nutrition and Health. Publ No 88-50211;1988.
11. Blumberg J. Mighty vitamins. *Medical World News* 1993;34:24-32.
12. Parke, Ioannides. Nutrition in toxicology. *Ann Rev Nut* 1981;1:207-234.
13. Bland JS. Oxidants and antioxidants in clinical medicine: past, present, and future potential. *J Nutr Environ Med* 1995;5:255-280.
14. Omenn GS, Goodman G, Thornquist M, et al. The beta-carotene and retinol efficacy trial (CARET) for chemoprevention of lung cancer in high risk populations: smokers and asbestos-exposed workers. *Cancer Res* 1994;54:suppl:2038s-2043s.
15. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study Group. The effect of vitamin E and beta-carotene on the incidence of lung cancer and other cancers in male smokers. *NEJM* 1994;330;1029-1035.
16. Shekelle RB, et al. Dietary vitamin A and risk of cancer in the Western Electric study. *Lancet* 1981;1185-1189.
17. Pietrizk K. Antioxidant vitamins, cancer, and cardiovascular disease. *NEJM*, letters to the editor. 1996; 335 (14):1065-1066.
18. Von Eggers Doering W. Antioxidant vitamins, cancer, and cardiovascular disease. *NEJM*, letters to the editor. 1996;335 (14):1065.
19. Bland J. Guest Editorial: Beta-carotene controversy. *J Advance Med* 1996;9 (2): 91-94.
20. Boushey CJ, et al. A quantitative assessment of plasma homocysteine as a risk factor for vascular disease; probable benefits of increasing folic acid intakes. *JAMA* 1995; 274 (13):1049 1057.
21. Rimm EB, et al. Folate and vitamin B_6 from diet and supplements in relation to risk of coronary heart disease among women. *JAMA* 1998;279:359-364
22. Marchetti M, et al. Degradation of vitamins A, E, B_1, C, and K_3 in zootechnic additives (premix) as a function of the type of trace elements present. *Zootechnics and Animal Nutr* 1995;21:67-73.