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B-Complex Vitamins' Role in Energy Release

CARBOHYDRATES HAVE long been touted as an excellent source of energy for physical activity. This is categorically true. Recently, even infomercials have rescinded the opinion that carbohydrates are the nemesis of physically active individuals. If carbohydrates do provide energy, how are they broken down from a food to energy for the body to use during activities? The answer lies in the three non-energy-yielding nutrients: vitamins, minerals, and water. The purpose of this column is to specifically address the B-complex vitamins that have a vital role in the extraction of energy from carbohydrates, fats, and protein.

All foods are a mixture of chemicals, some of which are essential (and must come from the diet) for normal body function. These essential chemicals are called nutrients. The minimum diet for human growth and development and maintenance must supply about 45 nutrients.[1] In general, of the six basic nutrients—carbohydrates, fats, protein, water, minerals, and vitamins—only carbohydrates, fats, and protein are energy sources. They supply potential energy to power muscle contractions and cellular functions, both critically important to the physically active. Vitamins, especially the B-complex vitamins, act first and foremost as coenzymes. According to *Stedman's Medical Dictionary,* a coenzyme is a substance that enhances or is necessary for the action of enzymes. An enzyme is a protein that acts as a catalyst to induce chemical changes in other substances while remaining apparently unchanged itself by the process. Enzymes regulate numerous life-sustaining chemical reactions. Unless a coenzyme is present, however (e.g., B vitamins), an enzyme cannot function.

In essence, the B-complex vitamins act as coenzymes in energy metabolism. The B complex of vitamins includes thiamin (vitamin B1), riboflavin (vitamin B2), niacin, vitamin B6 (pyridoxine), folate (folic acid), vitamin B12 (cobalamin), pantothenic acid, and biotin.

The Function of the B-Complex Vitamins

Thiamin (B1) is part of the coenzyme thiamin pyrophosphate, which plays a critical role in the breakdown of glucose for energy and acts as a coenzyme in the metabolism of branch-chain amino acids (leucine, isoleucine, and valine). Thiamin also plays a role in the synthesis and regulation of neurotransmitters, chemical agents that help nerve cells communicate. Thiamin also helps reactions make RNA and DNA, energy-rich molecules that generate protein synthesis (build-up). *Translation:*

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Thiamin helps break down glucose for energy, which is an end product of carbohydrate metabolism; helps branch-chain amino acids metabolize or undergo chemical changes; and helps maintain cognitive ability. A low level of branch-chain amino acids can lead to central fatigue during endurance training.[2]

Riboflavin (B2) is a part of two coenzymes (flavin mononucleotide and flavin adenine dinucleotide). The two coenzymes participate in the oxidation-reduction reactions during energy production within the metabolic pathways. Riboflavin also is part of the antioxidant enzyme glutathione peroxidase. *Translation:* Riboflavin helps extract energy from glucose, fatty acids, and amino acids. As an antioxidant, riboflavin helps counter free-radical damage. Free radicals form as a by-product of many of our bodies' physiological functions and can potentially damage our cells.

Niacin, also known as nicotinamide or nicotinic acid, is a coenzyme (in over 200 metabolic pathways) that assists in the metabolism of carbohydrates and fatty acids, especially during increased energy expenditure. It also plays an important role in DNA replication and repair and in the process of cell differentiation. *Translation:* Niacin is critical to breaking down carbohydrates and fatty acids during exercise. Its other role is to repair and replicate cells postexercise.

Pyridoxine (B6) is a group of six compounds, three with a phosphate group and three without. Digestion strips the phosphate group and sends the remaining compounds to the liver, which converts them to pyridoxal phosphate, the primary active coenzyme form (from discussion at the 1998 board meeting of the Institute of Medicine, Food and Nutrition). Pyridoxal phosphate is a coenzyme for more than 100 different enzymes involved in the metabolism of amino acids. It is crucial in the process known as transamination: It assists in the metabolism of carbohydrates, helps synthesize the oxygen-carrying hemoglobin, and helps produce neurotransmitters. It also lowers blood levels of the amino acid homocysteine. *Translation:* Pyridoxal phosphate helps change one amino acid into another (transamination). Without adequate pyridoxine, all amino acids become essential (from our diet), because our bodies cannot make them in sufficient quantities. Pyridoxine helps deliver oxygen throughout our body and helps nerve cells communicate. Pyridoxine also works with folate and vitamin B12 to lower blood levels of the amino acid homocysteine, elevated levels of which are linked to an increased risk of heart attack.

Folate is involved with DNA synthesis, the maturation of red blood cells and other cells, and amino-acid metabolism. It helps lower blood levels of homocysteine. Low levels of folate have been linked to birth defects because of its role in cell division during the first few weeks of pregnancy. *Translation:* Folate helps the cells' DNA, which contains the instructions that the cell uses to make certain proteins. By having mature red blood cells, one can prevent iron-deficiency anemia. Folate also helps break down protein.

Cobalamin (B12) assists with the formation of blood, transforms folate into an active form, and maintains the myelin sheath (a protective coating that surrounds nerve fibers). *Translation:* Without cobalamin, folate cannot function in DNA or blood-cell synthesis, nor can it metabolize homocysteine. People deficient in cobalamin will have symptoms of folate deficiency. In addition, a deficiency will eventually destroy nerve cells. Because pyridoxine, folate, and cobalamin work so closely together, a deficiency of all three can cause anemia.

Pantothenic acid is a component of coenzyme A, which is part of acetyl coenzyme A. *Translation:* Through coenzyme A, pantothenic acid is involved in many metabolic reactions that extract energy from fatty acids.

Biotin is a coenzyme in over 40 reactions, primarily the metabolism of carbohydrate, fat, and protein, including gluconeogenesis (the formation of glucose from noncarbohydrates such as protein). *Translation:* Biotin is critical to the breakdown of carbohydrates to glucose, fat to fatty acid, and protein to amino acids. It also helps in the conversion of amino acids to glucose (gluconeogenesis).

Conclusion

The B-complex vitamins act primarily as coenzymes; that is, they are substances that enhance or are necessary for the action of enzymes. Without coenzymes, enzymes cannot function in the body. As discussed earlier, each of the B-complex vitamins plays a major function in the metabolism of carbohydrates, fats, and protein. Thiamin, riboflavin, niacin, pantothenic acid, and biotin help extract energy from carbohydrates, fats, and protein. Niacin also breaks down carbohydrates and fat, but this breakdown occurs for the most part during exercise. Finally, pyridoxine, folate, and cobalamin assist red blood cells and collectively