2006

B-complex vitamins' role in energy release

Kathleen M. Laquale
Bridgewater State College, klaquale@bridgew.edu

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 Recently, even infomercials have rescinded the opinion that carbohydrates are the nemesis of physically active individuals.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:*

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 prevent anemia. Therefore, energy-yielding nutrients should always be part of an athlete's diet as long as the B-complex vitamins from a variety of food sources are also present in the body.

B-complex vitamins clearly play a significant role in athletes' physiological status during athletic performance, but this does not mean that athletes need to purchase individual B-complex vitamins to improve their performance. According to Dr. Louise Burke, "Many athletes are not able to translate nutrient needs into food choices and are swayed by the advertisements for vitamin and mineral supplements that claim that our food supply is unable to supply us with our dietary requirements."[3(p333)] No substantial research has been done that supports the concept that consuming more B-complex vitamins than the known requirements improves performance. Accordingly, meeting the daily requirements for the B-complex vitamins through food will provide athletes the coenzymes needed for normal physiological function. Athletic trainers should provide athletes examples of food choices containing the B-complex vitamins that fit into their meal planning and training routine. Table 1 provides lists of high and good food sources of the various B-complex vitamins, and Table 2 provides good food sources of the B-complex vitamins following the food-exchange list. In many

Table 1. Sample List of High and Good Food Sources of the B-Complex Vitamins

B-Vitamin	High Food Source	Good Food Source
Thiamin (B1)	Wheat germ, pork, oatmeal, sunflower seeds, ham, turkey (dark meat), cornflakes, rice, Brazil nuts	Spaghetti (enriched), orange juice, carrots, grits, corn (enriched), soybeans, watermelon, black beans, pecans, salmon, navy beans, whole-wheat bread, oysters, lentils
Riboflavin (B2)	Beef liver, chicken liver, yogurt, Cheerios®, corn flakes, milk, oatmeal, clams	Pork, eggs, mushrooms, herring, almonds, ground beef, turkey (dark meat), cottage cheese, chicken (dark meat), beef (porterhouse steak), ham, soy milk, enriched white bread
Niacin	Beef liver, chicken, tuna, oatmeal, halibut, turkey (light meat), salmon, All-Bran®, cornflakes, pork, peanut butter, ground beef	Mushrooms, chicken liver, salmon (with bones), porterhouse steak, ham, T-bone steak, turkey (dark meat), barley, spaghetti (enriched), shrimp, brown rice, cod, enriched white bread, rice
Pyridoxine (B6)	Beef liver, oatmeal, banana, garbanzo beans, chicken (light meat), All-Bran, wheat-bran cereal, cornflakes, Cheerios, chicken liver, turkey (light meat), watermelon	Pork, ham, halibut, potato, turkey (dark meat), porterhouse steak, herring, tomato juice, sweet potato, sesame seeds, sunflower seeds, ground beef, carrots, brown rice
Folate (B9)	Chicken liver, beef liver, spinach, lentils, pinto beans, black beans, oatmeal, asparagus, okra, romaine lettuce, black-eyed peas, cornflakes, artichokes, turnip greens, Cheerios, soybeans, spaghetti (enriched), spinach, All-Bran	Collards, enriched corn grits, enriched white rice, sunflower seeds, beets, kidney beans, mustard greens, wheat germ, tomato juice, broccoli, enriched white bread, orange juice, Alaska king crab, oranges
Cobalamin (B12)	Beef liver, clams, oysters, chicken liver, herring, crab, salmon, sardines, lobster, ground beef, T-bone steak, tuna, wheat-bran cereal, All-Bran, yogurt, shrimp, halibut	Squid, milk, cod, cottage cheese, beef bologna, beef frankfurter, pork
Pantothenic acid	Widespread in all foods	*Pantothenic* comes from the Greek word *pantothen*, meaning "from every side"
Biotin	Cauliflower, liver, peanuts, cheese, cooked egg yolks	*Poor sources:* fruits and meats. Raw egg white binds biotin and prevents its absorption.

TABLE 2. GOOD FOOD SOURCES OF THE B-COMPLEX VITAMINS FOLLOWING THE FOOD-EXCHANGE LIST

Vitamin	Grain	Vegetable	Fruit	Meat	Milk	Other
Thiamin (B1)	Whole-wheat bread, spaghetti	Carrots, lentils	Watermelon, orange juice	Pork, salmon, oysters		Sunflower seeds
Riboflavin (B2)	Enriched breads and cereals	Spinach, mushrooms		Turkey, beef, pork, eggs	Milk, cottage cheese, yogurt, milk	
Niacin	Product 19®, Total®, rice			Chicken liver, tuna, peanut butter		
Pyridoxine (B6)	Oatmeal, cornflakes, Cheerios®	Tomato juice, sweet potato, carrots	Watermelon, banana	Chicken, turkey, pork, ham, halibut		Sunflower seeds
Folate	Cornflakes, All-Bran®, spaghetti, oatmeal, rice	Spinach, lentils, asparagus, romaine lettuce, turnip greens	Orange, orange juice	Tuna, ground beef, T-bone steak		
Cobalamin (B12)	Wheat-bran cereal			Clams, ground beef, shrimp, beef bologna, beef frankfurter	Yogurt, milk, cottage cheese	

Note. The table does not include pantothenic acid or biotin.

cases, athletes use vitamin pills as a "safety net" when they think they are not eating enough food. Vitamins require food in order to be processed in the body. The body responds very favorably physiologically when the vitamins come from food rather than in pill form. In addition, high intakes of vitamin supplements could cause physiological imbalances, especially when an athlete's energy intake is low. Consequently, athletes need guidance on time management to ensure that their food intake is adequate for their training regimen. Athletes will then better understand the role of vitamins and how a variety of foods containing the B-complex vitamins will meet their daily requirement for these vitamins. ▮

References

1. Insel P, Turner R, Ross D. *Discovering Nutrition*. Boston, Mass: Jones & Bartlett; 2003.
2. Mittleman K, Ricci M, Baily S. BCAA prolong exercise during heat stress in men and women. *Med Sci Sports Exerc*. 1998;30:89-91.
3. Burke L, Deakin V. *Clinical Sports Nutrition*. 2nd ed. Boston, Mass: McGraw-Hill; 2000.

Kathleen Laquale is an associate professor in the Department of Movement Arts, Health Promotion and Leisure Studies. She is a licensed and certified athletic trainer and a licensed dietary nutritionist. at Bridgewater State College in Massachusetts.