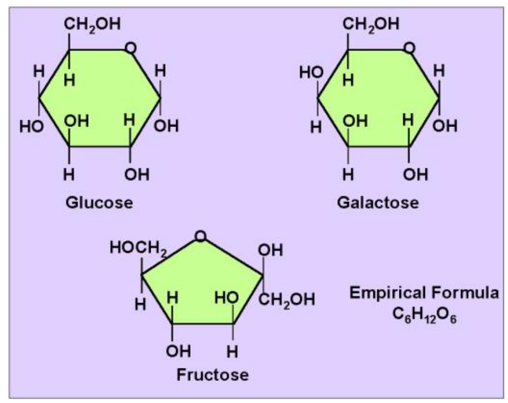
The Discussion and Analysis of Carbohydrates in the Context of Athletes and Athletic Nutrition

Justin Bakhshai, Emily Herren, Mark Hucks, Marisa Long, and Jaclyn Lyman
Goucher College
December 3, 2006

As the most abundant type of biomolecule on earth, carbohydrates serve as a dietary staple in most parts of the world. It is recommended that 65-75% of a person's total caloric intake comes from carbohydrates (Department of Exercise, 2006). Carbohydrates are carbon chains with

hydrogen and hydroxyl groups attached. Chains that are five or six carbons long have a tendency to form rings. All sugars are classified into three different groups based on the length of their chains. Monosaccharides are single chain sugars, or simple sugars. The most common and abundant monosaccharides are glucose, fructose, and galactose.



When two monosaccharides are linked together they form disaccharides. Some disaccharides formed by the three common monosaccharides include sucrose, lactose, and maltose. The third level of organization is when multiple unit chains of monosachharides are linked together to form polysaccharides, commonly called starches or complex carbohydrates. These are chains reaching lengths anywhere from 20 to hundreds or thousands of units (Nelson 2005). The properties and uses for these polysaccharides in biological systems are based on the types of linkages between the many subunits of monosaccharides.

The oxidation of carbohydrates is the central energy-yielding pathway in most nonphotosynthetic cells of organisms. It is therefore important that we ingest a sufficient amount of sugars through our diet to keep up with the energy needs of our body. Foods that contain high levels of carbohydrates include pastas, potatoes, rice, beans, and bananas. Other fruits have high levels of simple sugars, too. As well as being an energy source, carbohydrates are also used by the body as a form of energy storage, a key component in the synthesis of other biomolecules, structural elements, and attachments to proteins that serve in molecular communication within the body.

When starches and other complex carbohydrates are ingested, enzymes found in the digestive tract break them down into their monosaccharide building blocks. From there they are shipped to all parts of the body for different uses depending on the sugar. Glucose and galactose are generally stored as glycogen in the blood and in muscles (Department of Exercise, 2006). Fluctuations in concentration of carbohydrates in the blood act directly to influence metabolic pathways. This then alters levels of hormones and other signaling molecules in the body and the rate of expression of genes critical in energy metabolism (Leahy et al, 1999). For example, when sugars are eaten, insulin is released in the body. This is a hormone that helps facilitate the movement of sugars into cells where they can then be used as an energy source, accelerating energy producing metabolic pathways.

Although both fats and carbohydrates are stored forms of energy, when compared to fats, carbohydrate's main use in the body is for energy needs, either immediate or future. Although there are storage forms of sugars, carbohydrates hardly compare to fat as a storage depot for energy. A sedentary person can store about 1700 calories as glycogen while the same amount of fat stores up to 35000 calories (Department of Exercise, 2006). Given this property of carbohydrates, athletes use this to their advantage when it comes to the need for large bursts of energy. They increase the amount of energy-packed carbohydrates in their diet before an athletic event as a source of quick energy (as opposed to storage), a technique called carb-loading. Along with dietary changes, athletes have learned to control their blood glucose levels through sports drinks and selectively distinguishing between good and bad sugars in their diet.

Carbohydrate loading (CHO loading) is common practice among many athletes. The positive effects of eating a large bowl of pasta the night - or even for a few, consecutive nights – before an important game or meet have long been observed. Most commonly, CHO loading has been observed in athletes who train for endurance as opposed to speed and power, such as long distance runners and cyclists. Recently, the physiological specifics of CHO loading have become better understood: CHO loading leads to the supercompensation of glycogen stores in both liver and skeletal muscle cells. Glycogen storage in the liver leads to free glucose production and release into the bloodstream – ready for uptake into the body's cells in order to undergo glycolysis and, eventually, either aerobic or anaerobic respiration. The glycogen that is stored in skeletal muscle cells, however, is never released back into the bloodstream, as these cells lack the ability to release glucose and instead metabolize the glycogen for themselves. Therefore, CHO loading can be seen as beneficial in two ways: through the use of liver glycogen storage, increasing glucose supply to all of the body's cells, needed when blood glucose levels are depleted from exercise, as well as through an increase in direct glycogen supply to the skeletal muscles.

Quantitative studies have been done focusing on the effect CHO loading has on the body's cells. One such study was done by the Naval Academy, as endurance training is important to both the military and navy. The study focused on the length of time the positive effects of CHO loading last before they begin to noticeably deplete (Goforth et al., 1997). Fourteen male athletes (runners and cyclists) were subjected to six days of CHO loading, followed by various forms of exercise and moderate CHO diet. It was found that this loading increased muscle glycogen levels by 1.79 times their baseline levels and, furthermore, these levels remained approximately the same for three days after intense CHO loading had ceased for only the moderate CHO diet. Therefore, not only does CHO loading have a direct and immediate effect on an athlete's endurance, this effect can be prolonged over the course of a few days.

Gatorade is also used by athletes for a variety of physiological reasons. It is a non-carbonated sport drink that was originally designed for athletes but is also commonly consumed as a snack beverage. The drink is intended to rehydrate and to replenish carbohydrates in the form of sugars sucrose and glucose. It also replenishes electrolytes such as sodium and potassium salts that are depleted during aerobic exercise, especially in warmer climates.

Glycogen depletion in skeletal muscle and low blood glucose levels are factors contributing to fatigue during prolonged exercise. Ingesting carbohydrates increases blood glucose levels, increases the utilization of exogenous fuel by increasing glucose oxidation in working muscles and spares muscle glycogen (Hargreaves). Therefore, carbohydrate ingestion in the form of Gatorade before and during exercise can delay fatigue and improve exercise performance during prolonged activity.

Sodium lost to sweat must also be replenished through fluid intake to maintain electrolyte balance. Levels of sodium, a major electrolyte in sweat, can vary from 15 to 120 mEq/L. If sweat rate reaches 2 to 3 L/h during intermittent exercise, sodium loss could amount to 45 to 360 mEq, which may affect the maintenance of plasma sodium within a normal range. Although plasma sodium levels probably remain within a normal range during most forms of intermittent exercise, it is still important to include sodium in a rehydration solution during exercise, as well as during recovery, to enhance the desire to drink and to retain body fluid (Robinson). This desire to drink is a major advantage to drinking Gatorade over consuming water.

Although it has been established that carbohydrates are essential to our energetic and metabolic welfare, the structures and biochemical characteristics of the respective carbohydrates significantly affect their metabolic fate within our bodies. Essentially, there are two types of carbohydrates: simple and complex. These are often referred to as bad and good carbohydrates.

Good carbohydrates are usually those made with whole grains. A grain that has the entire original kernel intact, meaning it contains the fiber-rich bran, the nutrient-rich germ, and the starchy endosperm, is considered a whole grain. In the production of refined grain, the bran and the germ are removed and the flour is then made using the endosperm. Even though the endosperm does contain some nutrients, it does not hold nearly as much as the bran and the germ. The nutrients found in the bran and germ play important roles in our health. These include but are not limited to vitamins and minerals such as iron, folic acid, Vitamins E, K, and B-6, magnesium, manganese, riboflavin, and zinc. The fiber found in whole grains is not digested in our intestinal system, so it passes through, helping with digestion and making you feel full. It also helps to raise blood sugar more slowly, increasing the amount of time that you receive energy from your food.

Besides whole grains, complex sugars are a healthier choice than simple sugars. Complex sugars known as starches and fibers are made up of many polysaccharides. Starch is a plant-based sugar that can be found in food such as rice, corn, beans, and grains. Each of these foods has a differing amount of each monosaccharide in its sugar chain. When eaten, each of the sugars enters into our bloodstream increasing blood glucose levels at different times. This difference in time occurs because different organs break down each of the sugars. For example, glucose can immediately enter into the bloodstream, but fructose and galactose have to be sent to the liver to be converted into glucose. Having more than one type of sugar can give you an extended amount of energy. Fruits such as cherries, apples, pears, and plums can give you long-term energy because they contain more fructose than glucose.

In the supermarket, several products say that they are whole-grain, but in actuality, they are not. With bread, the first ingredient must say whole wheat, whole rye or some other type of whole grain. Breads that say 12-grain stoned wheat, enriched wheat, and pumpernickel don't necessarily mean whole grain. Crackers that are whole grain are Rye Krisp, Rye Vita, Triscuit, and Kavli Whole Grain Crispbread. The most deceiving food category is cold cereals. Corn Flakes, Special K, and even Kellogg's Raisin Bran are not whole-grain because they are made with corn meal. Corn meal removes nutrients from the corn in the refining process. Cereals that do contain whole grains are Cheerios, Total, Wheaties, Post Raisin Bran, Shredded Wheat, Quaker Toasted Oatmeal Squares, and General Mills Wheat Chex.

Simple carbohydrates—or monosaccharides as they are formally referred to—are sweet in taste and are broken down quickly in the body to release energy. As was previously mentioned, the three most commonly discussed monosaccharides are glucose, fructose, and galactose (Carpi 2). Glucose is the primary molecule through which energy is derived physiologically. It is the precursor to significant energy-producing mechanisms such as glycolysis, which subsequently feeds into the TCA cycle and the electron transport system. One does not need to understand the relevant biochemistry of these respective metabolic pathways to simply recognize the utility of glucose in the human body.

The method in which glucose is delivered to the blood and, consequently, the cells is invariably significant with respect to whether or not the carbohydrate of interest will positively or negatively affect the individual. In other words, while glucose and its closely related structural relatives (isomers) are used by the body for energy, they must be delivered to the cells in a controlled and timely manner, or there will be a significant risk of fluctuating blood-sugar levels; this is characteristically unsafe for the human body.

Unfortunately, simple sugars (monosaccharides) such as glucose, fructose, and galactose have been termed “bad” sugars. This is because of their dramatic effect on blood-sugar levels when administered incorrectly. While it is true that the sucrose (a disaccharide consisting of glucose and fructose) in an orange is chemically the same as the sucrose in the much-maligned table sugar, the fact that the sucrose in the orange is packaged along with other nutrients causes it to behave, biochemically, more safely and efficiently. Eating fruits and vegetables that contain sucrose not only delivers sugar to the body, but it delivers fiber and other complex carbohydrates that effectively stabilize the absorption of the sugar. Yet, take the sugar away from the rest of the fruit and vegetable and refine it into a powder, and it is this processing that downgrades sucrose from the healthy to the junk food category. Therefore, it is the sugar’s molecular surroundings that that affects its absorption from the intestines and its consequent behavior in the body (Sears 1). This is predominantly the reason why refined sugars, as well as foods that contain only refined sugars, such as sodas and honey, are referred to as unhealthy foods. High consumption of these foods can result in physiologically unsafe conditions. When simple sugars are ingested with no fibers and complex carbohydrates present to effectively stabilize the rate of glucose absorption, the glucose is absorbed extremely rapidly; this causes high levels of insulin to be secreted, which consequently decreases the glucose level of the body and concomitantly provides a quick burst of energy. However, because the glucose is often absorbed too quickly, too much insulin is excreted and the body can become hypoglycemic (Macrobiotics 3). This condition occurs when the rapid increase in insulin levels results in a lower-than-normal blood-glucose level. A physiologically normal individual will secrete certain hormones which help bring the glucose levels in the blood back to normal. However, the observed blood-glucose level fluctuation is harmful and often taxing to the body. It is for this reason that the consumption of various foods such as white bread, breakfast cereal, mayonnaise, peanut butter, ketchup, spaghetti sauce, and a plethora of microwave meals which contain high levels of refined sugar and low levels of complex carbohydrates and fibers should be minimized or ideally eliminated.

For all of these reasons, it is important to maintain a proper balance of “good” carbohydrates in your diet. Although carbohydrate loading has positive effects on an athlete’s endurance, it is not appropriate for those who do not need it (and vice versa, as with the Atkin’s diet). With carbohydrates being the majority of the recommended diet, it is important to understand the effects that they have on your body and the right way to consume them.

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