CYCLING PERFORMANCE TIPS

NUTRITION FOR TRAINING AND PERFORMANCE

by Richard Rafoth, M.D.

- **Nutritional building blocks of all foods**
- **What the muscle needs**
- **Your total energy stores**
- **Factors affecting digestion and absorption**
- **Effects of exercise on the digestive tract**
- **Additional considerations**
  - carbohydrate loading
  - **potential** hypoglycemia from pre race carbohydrates
  - post exercise glycogen loading window
  - vegetarian diet
- **Optimal cycling diet**
- **Basic Nutrition Plan**

THE THREE BASIC BUILDING BLOCKS IN ALL FOOD (Carbohydrates, protein, and fats)
Aside from being a pleasant reward after a hard ride, food is a necessity for the cyclist to provide the energy to move man and bicycle. All foods are made up of the nutritional building blocks of carbohydrates, fats, and protein plus a certain amount of water and fiber (undigestible and without any food value). Carbohydrates contain 4.1 Calories per gram and are the primary source of energy for most cyclists as well as athletes involved in short, maximum performance events. Fats are more important for slower endurance events. Protein, is used to maintain and repair cells, and is rarely a source of energy except in certain unique situations (such as malnutrition).

HOW MUCH ENERGY DO YOU GET FROM WHAT YOU EAT (What is a Calorie?)
Some foods provide more energy per ounce or gram than others. Not only does the fiber content (which is a filler and has little or no Caloric value) of foods vary, the energy contained in equal weights of the basic ingredients - carbohydrate, fat, and protein - is not equivalent.
In the nutritional literature, the energy content of foods is, by convention, expressed in Calories (note the capital "C") as opposed to the use of calories or kilojoules (kj) in the scientific literature. The energy contained in one nutritional Calorie is the equivalent of a kilocalorie (1000 calories, lower case "c") or 4.18 kilojoules. Carbohydrates and protein each contain a little more than 4 Calories of energy per gram while a gram of fat has more than double the energy value at 9 Calories per gram.

HOW DOES WHAT YOU EAT POWER THE MUSCLE CELLS?
Although carbohydrates supply the majority of the energy for muscles during vigorous activity, fats can be a major contributor for less strenuous activities. Carbohydrate is stored as glycogen in muscle and liver cells. On a normal diet there is enough glycogen to support 2 hours of aerobic exercise before the bonk occurs. These internal stores can be extended by using oral carbohydrate supplements for events expected to last more than 2 hours. It is best to begin the carbohydrates at the start of the event as they are much less effective after the bonk has occurred. A well trained cyclist will need slightly more than 1 gram of carbohydrate per minute to sustain maximum performance, and oral supplementation (started at the beginning of the exercise, not after glycogen depletion has occurred) should replace carbohydrate at that rate.

In addition to extending the time to fatigue in longer, moderate activity events, several studies have also suggested that maximal performance in a 1 hour, high intensity (time trial, ~80% VO2max) event can be improved with oral carbohydrate supplementation. Drinking a total of 1 liter of a 7% carbohydrate solution at the beginning and during the event improved times by 2%. Skeletal muscle oxidizes carbohydrate in the form of glucose, and other sugars must be converted to glucose by the liver before they can be used as fuel by the muscle. Studies have demonstrated no additional benefit for glucose polymers, fructose, or sucrose (common table sugar) which is a dimer of glucose and fructose, for carbohydrate replacement - aside from palatability. In large amounts, fructose can cause diarrhea.

Although carbohydrates are superior to fats in supporting maximal performance, there is some controversy over the relative benefits of simple vs complex carbohydrates as the ideal supplement to be used during prolonged exercise. Examples of complex carbohydrates are rice (200 Cal per cup), spaghetti (180 Cal per cup), and baked potatoes (140 Cal per large spud).

A shift toward fat metabolism may be the physiologic explanation for the "second wind" that occurs during exercise (internal carbohydrate stores have been used, fatigue sets in, the body shifts to fat metabolism, and the "second wind" or feeling of a renewed source of energy returns). However, the trade off is the inability to maintain performance at the same %VO2 max. that is possible with carbohydrate supported metabolism.

Muscle fatigue (the "bonk" in cycling, "hitting the wall" in running) generally occurs when the body's internal carbohydrate stores are depleted and there is a shift towards fat metabolism as the prime energy source for the exercising muscle (with maximum energy output limited to approximately 50% VO2 max.). It would be logical to assume that if adequate carbohydrates (to offset those expended) were replaced during a ride, the cyclist could maintain his or her pace indefinitely. Unfortunately this is not the case. Cyclists with low muscle glycogen stores but high blood glucose levels still experience fatigue at some point, even though the time to onset of fatigue was delayed by taking the carbohydrate supplements. **Unknown factors, perhaps related to physical changes in the muscle cell itself, are thought to be responsible** as this type of fatigue is more common in the untrained athlete.(see also Overtraining)

Fats provide over 50% of the Calories expended during moderate exercise (less than 50% VO2 max.) even when adequate carbohydrates (glycogen) are available. As the level of exercise increases towards 100% VO2 max., the proportion of the total energy expenditures replaced by fats diminishes. And in maximum performance events, where metabolism becomes anaerobic (greater than 100% VO2 max.), fat metabolism ceases and only carbohydrates are available as an energy source. Although there has been speculation that using fats in a dietary program both during training and as supplements during competitive events might improve athletic performance, the only hard evidence to date suggests that it may help endurance (performing at <50%VO2 max) athletes involved in long events while there has been **no evidence of a benefit at higher performance levels** ie 90 to 100% VO2max.

Protein is a maintenance material being used to repair muscle (and other) cell injuries - including the microtrauma that occurs with exercise. It is NOT used by the body as an energy source except in very malnourished states. Even in endurance activities such as the Tour De france, **protein needs of 1.5 gms protein/kg body wt/day were easily met by a normal (unsupplemented) diet** that replaced the total Calories expended. A review of the literature failed to demonstrate any advantage to protein supplements (assuming an adequate daily protein intake) over pure carbohydrate supplements alone. And one study actually demonstrated a **DECREASE in overall performance** from the appetite suppressing effects of a high protein diet, decreased carbohydrate intake, and as a result diminished pre event muscle glycogen stores.

HOW LONG CAN YOU EXERCISE WITHOUT EATING? (What are your total internal energy stores?)

In the well fed and rested state, the human body contains approximately 1500 carbohydrate Calories (stored as glycogen) in the liver and muscle tissue, and over 100,000 Calories of energy stored as fat. This is adequate carbohydrate for several hours of brisk cycling, and enough fat to continue to support cycling at a reduced speed (50 - 60% VO2@max) for days. In order to avoid the "bonk" (the shift to fat metabolism with an accompanying deterioration in performance), supplemental carbohydrates need to be eaten during the early stages of rides that will be more than longer than 1 to 2 hours in length to supplement (and thus spare) the body's own glycogen stores.

OVERVIEW OF FACTORS AFFECTING DIGESTION AND ABSORPTION

Before we go any further, let's take a minute to discuss the role of the various parts of your digestive tract.

- Mouth - important to begin the **mechanical breakdown of food** and add some digestive enzymes in saliva
- Esophagus - **transportation** to the stomach
- Stomach - further mechanical and **enzyme breakdown**; no absorption
- Small intestine - completes enyzme breakdown and **absorption of nutrients**
- Colon - **storage and dehydration** of residual from processed food; no absorption of nutrients

When designing a nutritional program to supplement the body's energy stores for an athletic event, the rate of digestion and absorption of foods must be taken into account. The time needed for the stomach to start the digestive process, empty its contents into the small intestine, and have the food components absorbed into the bloodstream will directly affect how quickly any food will be available to the muscle to provide the supplemental Calories for exercise.

You have some control over four major factors influencing the digestive process.

- **Solid versus liquid** - liquids are emptied from the stomach more quickly than solids.
- **Fat content of the food** - fat slows the digestive process and delays the availability of any Calories in the food to the muscles.
- **Sugar concentration** - especially in liquids, a sugar content of more than 10% will slow stomach emptying. (The use of complex carbohydrates, due to the decreased osmotic effect, will offset this to some degree and offers an alternative strategy to maximize Caloric intake to offset the metabolic needs of exercise.)
- **Physical activity level of the cyclist** - the mechanical activity of digestion is slowed by any vigorous activity, usually starting at 70% VO2 max. Except in short, all out events, this is rarely an issue, and it is much less so for cycling than for running where the additional component of mechanical stimulation of abdominal contents from the sport itself slows digestive tract functioning.

From the above four points, it is easy to see that the **optimal food for a rapid, high energy boost during a ride would be a semi-liquid or liquid carbohydrate with minimal if any fat.** On the other hand, an **endurance athlete, competing at a lower VO2 max., might prefer a complex carbohydrate with some fat added to improve taste** (and generally in a solid form), in order to slow emptying from the stomach and even out absorption over a longer period of time.

Carbonation does not appear to affect the emptying rate of the stomach. Three independent studies found no difference in the gastric emptying rates of water, carbonated water, and carbonated carbohydrate drinks. Carbonated colas, which contain 160 Calories per 12 ounce can and the caffeine equivalent of half a cup of coffee, remain a favorite drink of many cyclists.

EFFECTS OF EXERCISE ON THE DIGESTIVE TRACT
Serious athletes often develop gastrointestinal (GI) disorders during training and competition - generally cramps, diarrhea, and nausea (although constipation has been reported). Cramps and diarrhea reflect an overactivity of the lower intestinal tract or colon, and are much more common in runners (and thus triathletes) than in cyclists. A recent survey of triathletes participating in a half iron man event revealed that 50 % complained of belching and flatuence (gas), and more symptoms occurred while running than at other times.

Studies have demonstrated a reduced blood flow to the digestive system during vigorous exercise - an 80% reduction after 1 hour cycling at 70% VO2max. And there was a direct relationship in that individuals with the most severe symptoms had the greatest decrease in blood flows.

The type of exercise also plays a role, and it is speculated that the mechanical trauma (a jostling effect) to the abdominal organs may explain why runners have more symptoms than cyclists or swimmers. Changes in GI hormone levels have been noted with vigorous exercise, but a cause and effect relationship to symptoms has not been proven. Stress factors are probably more important as a cause of pre competition symptoms such as nausea, vomiting, and diarrhea (which in one study were present in 57% of the participants).

Heartburn (or esophageal reflux)is more frequent when exercising within 2 hours of eating. The current feeling is that this increase in reflux is related to a combination of meal effects (especially fats) on the esophageal sphincter pressure (which prevents reflux of stomach contents into the esophagus), the increased volume of food and acid in the stomach available to reflux, and the mechanical jostling that occurs (especially with running). This is usually a minor problem for cyclists and is best handled by delaying exercise after eating or using an antacid of one of the over the counter acid reducing medications such as Tagamet or Zantac. Exercise delays stomach emptying, and the more vigorous the exercise, the greater the delay.

Running once again appears to have a greater effect than cycling, presumeably because of the mechanical jostling of the stomach as well as other abdominal organs. In addition to the increase in esophageal reflux (noted above), the delay in stomach emptying can cause a sensation of fullness and nausea as well as limitign the immediate availability of Calories from the food eaten (as will be discussed shortly). In the survey referred to above, there appeared to be an additive effect from a high fat and protein pre event meal and the use of hypertonic drinks before and during the event. 40% of those drinking a hypertonic beverage had severe complaints compared with only 11% of those who had used isotonic drinks.

An increase in small and large intestinal activity is the cause of abdominal cramps and is reflected in an increase in the frequency of defecation as well. It has been speculated that there might be changes in digestive hormones associated with exercise which then stimulate the colon. But it is more likely that once again the mechanical factor of jostling the bowel is a more important factor. A fiber rich, pre race meal can also play a role. In a recent post race survey, almost all the triathletes who had eaten a high fiber meal suffered from cramps. Minimizing cramps requires a focus on:

- avoiding electrolyte imbalance (including dehydration)
- avoiding riding too soon after eating
- training at a level closer to your event (the more your event exceeds the maximum levels of your training, the more likely you will develop crampy abdominal pain).

Most of these issues are more problematic for runners (and thus triathletes) than cyclists.

Except for competitive cyclists, the effects of exercise on the GI tract are minimal.

- If heartburn is a problem, timing of the ride to assure an empty stomach needs to considered (and for the competitive rider a 3 to 4 hour fasting period is already the recommendation to minimize a feeling of fullness and nausea).
- Slow gastric emptying is generally not a problem for a recreational rider, but those with an especially sensitive stomach should plan to eat their last pre ride meal at least 3 to 4 hours before the ride. Small, frequent snacks while on the bike are recommended for rides of greater than 2 hours, and if it is going to be a vigorous workout, avoiding hypertonic sports drinks is recommended.
- Stay hydrated. If you are dehydrated, the stomach will empty more slowly and there will be an accentuation of the decrease in blood flow to the small intestine.
- Although some racers will eat a low residue diet for several days before an event to minimize cramps and the "call to stool", this greatly complicates diet planning, and for the rest of us, slowing the pace will usually decrease the urge until a bathroom is located.

So let's review the tips to decrease GI problems:

- **pace yourself** - the stomach empties better at <75%VO2max
- **hydrate** - dehydration leads to decreased stomach emptying and nausea
- **avoid concentrated (hypertonic) solutions**
- **determine which foods work for you** on your training rides
- **eat on your training rides** - your digestive tract will adapt to eating while exercising
- **train** - if you are in better shape, more blood will go to the digestive tract at any given level of exertion

ADDITIONAL CONSIDERATIONS IN PLANNING YOUR DIET PROGRAM

- Carbohydrate loading
- The **insulin surge** and **potential hypoglycemia** that is theorized to occur if sugary drinks are taken in the minutes before a competitive event is a potential in sedentary individuals eating sweets, but rebound hypoglycemia does **not** appear to be a **practical** problem for athletes. However, choosing to err on the side of caution, most authorities recommend avoiding all simple carbohydrates for the several hours before an event, starting carbohydrate supplementation in the few minutes immediately preceding the start of the activity.
- Even though it appears that simple carbohydrates should be avoided in the hour or two immediately preceeding your ride, there is almost unanimous support for the benefits of a **pre ride meal** of complex carbohydrates 3 or 4 hours before the event. These carbohydrates not only "top off" your muscle and liver glycogen stores, the slow digestion and absorption of the complex carbohydrates may provide an ongoing glucose supplement from your intestinal tract even after the ride has started. And recent studies have demonstrated that using commercial energy bars or a high fat meal offer no

performance advantages over a more traditional and less expensive complex carbohydrate such as oatmeal.

- **Maximizing liquid carbohydrate replacement** while riding is a very important strategy for events lasting more than 2 hours. 1 to 2 grams of carbohydrate per minute can be absorbed and utilized to sustain prolonged exercise. In extreme events such as the Tour de France, as much as 50% of the daily energy expenditures can be replaced while on the bike. Although the sugar concentration has an effect on the rate of stomach emptying, the volume of fluid in the stomach plays a role as well. Keeping the stomach filled by frequent drinks will enhance the rate of gastric emptying.

  As sugar concentration increases, the risk of nausea and bloating rises as well. Almost everyone can tolerate a 7 to 10% concentration of glucose, but many cyclists will tolerate solutions of up to 15% to 20%. And the use of polymers will allow more carbohydrates to be ingested and absorbed while limiting to some degree the overall concentration of the solution. Fluid replacement rates of 500 ml per hour are appropriate for the majority of cyclists during prolonged exercise, but rates of up to 1 to 2 liters per hour have been reported in the Tour de France. The risk here is hyponatremia with the larger volumes. As an example, starting an event with 400 ml of an 18% glucose polymer solution in the stomach and drinking 100 ml every 10 minutes will deliver 108 grams of carbohydrate with 600 cc of fluid every hour.

- Take advantage of the " **glycogen window**" that is open in the 4 hours immediately following vigorous exercise. During this interval, ingested carbohydrate will be converted into muscle glycogen at about 3 times the normal rate (and "the earlier the better" as some data suggests a 50% fall in the conversion rate by 2 hours and a complete return to normal repletion rate by 4 hours). Muscle glycogen repletion (after a 2 plus hour ride) usually proceeds at a rate of 5% per hour, and although it may require up to 48 hours for complete muscle glycogen replacement, most is accomplished during the first 24 hours post event. The athlete who is training daily, or is in a multiday event, can use this glycogen window to their advantage to get a jump on the normal repletion process and minimize the chance of chronic glycogen depletion (and the fatigue that goes along with it). There is also suggestive evidence that the muscle stiffness that occurs after vigorous exercise is related to muscle glycogen depletion, so rapid repletion may have an added benefit of minimizing this day after effect. One caution though - many simple carbohydrate snacks such as chocolate chip cookies are more than 30% fat and if eaten in large quantities might exceed your planned daily fat intake of 20-30% of Calories. In contrast, complex carbohydrate foods such as pasta, bread, and rice offer significantly more carbohydrate per gram or ounce. And there are even special "recovery drinks" available.

- **Vegetarian diet.** A growing number of cyclists are moving toward meatless meals or a completely meat free nutritional program. Not only are **vegetarians** healthier, with lower rates of chronic diseases such as heart disease, obesity, and colon cancer, but the fact that their diets are high in carbohydrates means they are constantly "carbo loaded".

  There are a few tips to remember if you are considering a life style change.
  - Vegans, who eat no animal products whatsoever including dairy, need to be certain they get enough
    - vitamin B12 (from supplements and fortified foods such as cereal, bread, pasta, and brewer's yeast)

    - iron (from beans, kale, dried fruit, and collard greens). *Don't use supplements unless recommended by your physician because of the potential toxicity of too much iron.*
    - calcium (dark leafy vegetables, brocoli, citrus fruits)

- Eat "balanced" protein (because of the mix of amino acids, non meat protein foods need to be eaten in combinations - same meal or in consecutive meals - to have the right balance of amino acid building blocks to allow the body to use them to build and repair tissue).
    - pinto beans and rice
    - grains (rice, bread, cereal) and legumes (peas or beans)

- Eat a bit more than if you were eating meat as a protein source. For example a 3 ounce piece of meat contains about 21 grams of protein and is can be substituted with a cup of cooked grain and a cup of cooked beans.

OPTIMAL CYCLING DIET

Is there an optimum diet for the cyclist?? There is overwhelming evidence that adequate dietary carbohydrates are needed for maximum performance. At least 10 grams per kilogram of body weight per day. What is unclear is whether more carbohydrate (beyond 600 to 700 grams per day) will provide additional benefits.(Note that it is the absolute amount of carbohydrates that appear to be important, not the % of total daily Calories that are carbohydrates).

And Fat?? If you are interested in multiday endurance events, there may be some advantage to several weeks of a moderate fat intake equivalent to 30% of total Calories. But there is no evidence this helps in single day, high performance (%VO2max greater than 60%) activities and there may be long term health consequences. As total Caloric needs increase, the only reason to consider a high fat (more than 15 to 20% of total Caloric needs) diet would be maintenance of a positive Caloric balance IF carbohydrates alone were not meeting the challenge.
And finally, there is NO evidence tha more than 2 grams per kg per day of protein are beneficial in endurance, sprint, or power training/performance.

There are three additional practical points for the cyclist (or other athlete) to remember.
First, the **body's normal liver and muscle glycogen will support the first 1 or 2 hours of exercise at 70% VO2 max.** without any need for supplementation. And both a good training program to improve the form and muscle efficiency of the individual as well as riding (or exercising) at a reasonable pace will postpone the onset of glycogen depletion and fatigue.
Second is that **taking in carbohydrates during the event** provides an additional source of glucose "fuel" that will **extend the length of time before the bonk occurs**. This becomes important in rides of greater than 2 hours duration. As a general rule, the body can utilize 60 grams of ingested carbohydrate per hour to supplement muscle glycogen stores, and the stomach can handle between one and two quarts of fluid before nausea occurs. This does put an upper limit on carbohydrate supplementation during a ride but gives you some guidelines for developing your own program. And there is no problem in using solid food supplements as well, as long as enough fluids are taken along with them.

Finally, eating a **high carbohydrate diet for several days prior** to the event will maximize your internal glucose (glycogen) stores, and will **prolong the duration of activity until fatigue occurs**. (But it will not increase the muscle's maximum energy output during that time.)
Over the last 10 years there has been a notable interest in **ultraendurance** events. These include runs of more than 24 miles (ultramarathons), cycling events of 100 miles or more

(double centuries), and combination events such as the Ironman triathlon. The principles of training nutrition are similar to those for any athletic event of 2 hours or more, with the exception that attempts to bend the "physiologic rules" outlined above have the potential for a much larger negative effect on performance.